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Emotional Education as a Means of Developing Social Competence in Primary School Students in Wartime

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Abstract

Emotional education is key for primary school children, as it promotes their emotional development and successful socialization. Specialized mobile software, which are integrated into psychological and pedagogical support programmes for primary school students, can help in the development of children's emotional intelligence (EI). The aim of the research was to analyse the effectiveness of using two mobile applications (Emotional, and Bouncy the People Trainer). They were designed to stimulate the EI growth among children aged 6-9. The research methods included psychological methods from the EQ.app kids computer software, emotional education programmes developed on the basis of socio-emotional learning (SEL) methods, mathematical statistics methods (correlation analysis, Pearson correlation coefficient, Student's t-test). Analysis of the dynamics of EI indicators revealed significant differences between the experimental group (EG) and control group (CG) on pre-tests and post-tests. In the EG, a statistically significant improvement (p-value = 0.000) was observed in the indicators of emotional praxis by 8.57 points, in perceptual and language components by 10.63 points. This gives grounds to conclude that working in two mobile applications helped to develop children's EI. At the same time, the CG remained at their pre-test scores, showing no improvement. Research prospects include a deeper study of the impact of different methods of emotional education on the children's mental state and social skills, as well as an analysis of the long-term consequences of such programmes. It is important to study the integration of digital technologies in the process of emotional education, evaluate the effectiveness of various mobile applications, online platforms and other digital tools for the development of EI and social competence.

Keywords:

Primary School Students, Emotional Intelligence (EI), Child Development, Mobile Applications, Wartime.

Introduction

Emotional support helps children facing additional stressors because of wartime to better adapt and maintain psychological resilience. Communication skills are essential to facilitate children's social interaction and emotional development. Dialogic interaction, being

an objective and universal form of development, determines the existence and structural organization of any system (Wang et al., 2024). However, social adaptation can be particularly difficult for children with severe developmental disabilities and emotional mental disorders caused by war (Ishchenko et al., 2024; Kucherenko et al., 2024). Therefore, social adaptation of children with emotional disorders is one of the most important tasks of special pedagogy and psychology (Thorius et al., 2024). Given that emotional intelligence involves recognizing and managing emotions effectively, it becomes a foundational skill in helping children with emotional disorders navigate social situations, thereby enhancing their adaptability in social contexts (Truba et al., 2024).

The concept of EI means the ability to recognize one's feelings and the emotions of others, as well as the ability to manage them and use this information to regulate thoughts and actions (Ahsen et al., 2023). Early development of EI plays a key role in a child's social adjustment, academic success, and long-term well-being (Iqbal & Noor, 2023). By fostering EI from an early age, educators and caregivers can better equip children to handle the emotional and behavioral challenges associated with volitional disorders, ultimately aiding in their social adjustment and academic success.

Emotional and volitional disorders encompass a range of conditions that create problems in regulating children's emotions, impulses, and behaviour (Bryant et al., 2019). These disorders come in many forms and can significantly affect a child's ability to communicate effectively and maintain positive relationships. For example, children with attention deficit hyperactivity disorder (ADHD) may have difficulty staying focused, controlling impulsive behaviour, and managing their emotions, which impairs their communication skills (Wolraich et al., 2019). In wartime, behavioural disorders are manifested by defiant and disobedient behaviour in relation to authoritative persons, which further complicates constructive dialogue with peers and adults.

Autism spectrum disorders (ASD) are primarily manifested as deficits in social communication and interaction. However, individuals with ASD may also experience emotional dysregulation and difficulty with volitional control, further complicating their communication skills (Moulton et al., 2019). Similar to individuals with ASD, children with emotional and volitional disorders often struggle with emotional regulation and volitional control, impacting their communication abilities and complicating social interactions.

Children with emotional and volitional disorders have problems in communication and social interaction, which can hinder their ability to navigate effectively in social situations (Tarver et al., 2019). Given these social challenges, developing emotional intelligence becomes crucial, as it equips schoolchildren, especially those with emotional and volitional disorders, with the skills needed to manage interactions and adapt as they grow.

This research contributes theoretically by deepening the understanding of emotional intelligence's role in supporting social adaptation among children with emotional and volitional disorders, a relatively underexplored area in educational psychology. By highlighting how EI can serve as a foundation for improved social skills and emotional regulation, this study offers insights that can inform evidence-based educational practices tailored for these children. Furthermore, it enriches the literature by identifying specific EI competencies that are most impactful for social adaptation, providing a framework that future studies and interventions can build upon. The importance of EI in schoolchildren in the context of their growing up and development is difficult to overestimate (Pauletto et al., 2023). Children with higher EI levels feel better in society, less susceptible to stress and more adaptable (Mohammadi Orangi et al., 2023). That is why specialists in the field of psychology and education should use different techniques for its development and improvement, and parents should be informed about it (Brady et al., 2023; Ciolan & Florescu, 2023). Technological progress of the 21st century opens up a number of new prospects for the educational sphere, which include specialized mobile applications (Subiyantoro et al., 2024; Zhylin et al., 2024). At the same time, it is extremely important that the programmes do not carry a threat in the form of uncontrolled consumption or poor quality (Meyer et al., 2021; Paramita et al., 2023).

The aim of the study is to analyse the effectiveness of using mobile applications in the context of psychological and pedagogical support aimed at improving the EI of children aged 6-9 years in wartime.

Research objectives:

1. Conduct an analysis of the dynamics of EI levels of the CG and EG children by comparing the studied indicators.
2. Determine the statistical significance of the identified differences.
3. Compare the EG and CG with each other and draw a conclusion about the effects of the experiment.

Literature Review

EI helps a person to recognize, understand, accept, control, and make sense of his/her feelings and emotions, as well as apply this knowledge in relation to everyone around him/her (Samara et al., 2024).

Effective interaction with other people requires empathy, self-control, and nonviolent communication, which emphasizes the importance of developing emotional intelligence (Anand et al., 2024; Gao et al., 2023). The ability to understand the feelings of peers and the ability to manage emotions can help a child to adequately express his/her feelings and experiences, not to use destructive conflict resolution methods (Perry et al., 2020; Sánchez-Núñez et al., 2022).

The difficulty of conducting an effective dialogue is one of the main communication problems faced by children with emotional and volitional disorders. This problem is often associated with insufficient consideration of the interlocutor's wishes and readiness for communication (Woodgate et al., 2020). However, in wartime, it is even more difficult for children with emotional and volitional disorders to understand the point of view of their interlocutors because of their inherent difficulties with empathy.

The second communication problem observed in children with emotional and volitional disorders in wartime is their poor orientation in feedback from communication partners. In wartime, children may engage in one-sided conversations, focusing solely on their own interests or topics of conversation, without acknowledging and responding appropriately to the contributions of others (Yamamoto, 2021).

A third significant communication problem faced by children with emotional-volitional disorders in martial law is social saturation, which means a reduced tolerance for social interaction. In wartime, children with emotional and volitional disorders, including such conditions as anxiety disorders causing oppositional defiant disorder (ODD) or ASD, have a further reduced ability to tolerate stress or frustration, which further complicates their social interaction and communication (Tarver et al., 2019). In wartime, these problems become even more acute, requiring a comprehensive approach to the development of interventions and modern technology tools. There is a limited number of practical developments to improve the quality of communication of children with emotional and volitional disorders. The need for such tools becomes even more urgent in wartime. However, it is necessary to continue research on the development of social competence in children in wartime.

Methods and Materials

Research Design

Empirical research was conducted in several stages.
The first (preparatory) stage:
- determination of the sample;
- selection of mobile applications.
The second (initial) stage:
- collection of basic data: conducting primary testing of the EI level;
- learning how to use mobile applications.
The third (experimental) stage:
- implementation of mobile applications in the education of the EG children.
The fourth (final) stage:
- repeated testing;
- data analysis.

In this research, measuring the placebo effect was deemed unnecessary because the focus was specifically on examining the impact of targeted interventions—in this case, emotional intelligence (EI) training—on social adaptation and behavioral outcomes in children with emotional disorders. The study's design involved a clear comparison between the intervention group and a control group that did not receive EI training, providing a straightforward assessment of the intervention's efficacy without the need for a placebo condition. Furthermore, since the observed outcomes (e.g., improved social skills and emotional regulation) are directly linked to the specific mechanisms of EI development rather than general expectations of improvement, the placebo effect was unlikely to influence these behavioral and emotional outcomes significantly.

The CG did not experience any changes in their activities; the EG studied with two specialized mobile applications that were aimed at developing their EI: Emotionary (Funny Feelings, 2023) and Bouncy the People Trainer (Ripple Effects, 2023). Examples of their interfaces are presented in Appendixes A and B.

Furthermore, emotional education programmes developed using social-emotional learning (SEL) methods were used (Table 1).

Sample

The empirical study was conducted during seven months, from September 2023 to January 2024. The sample included 60 children aged 6 to 9 years of the Specialized School No. 155 with in-depth study of the English language of the Shevchenkivskyi district of Kyiv. Only one educational institution in the city of Kyiv was chosen for the study for several reasons. First, focusing on one educational institution allows for a deeper and more detailed study of the social competence and emotional state of children in specific conditions. Second, it makes it possible to carefully control all variables and factors that can affect the results of the study, which increases the reliability and accuracy of the obtained data. More detailed information about the study participants is given in Table 2.

The sample used in this study is a purposive sample, specifically selected based on specific characteristics and the unique context provided by a single institution, Specialized School No. 155, in Kyiv. This type of sample allows for in-depth exploration of social competence

and emotional states within a controlled educational environment. Purposive sampling is commonly used in studies where researchers aim to understand phenomena in a specific context or with a particular group, allowing for detailed observations and reliable control over influencing factors.

The sample size is explained by the fact that it is this number that makes the sample representative and the results valid. Children 6-9 years old were chosen based on their psychological characteristics, when they intensively learn to communicate, understand themselves and others, and build relationships in the school environment. The experimental study was conducted by 8 psychologists on the basis of children's medical and psychodiagnostic centres in Kyiv: KinderKlinik, MottyLotty, Open World Centre for Children Rehabilitation and Development.

Research Methods

The computer programme EQ.app kids (https://eq-ap.com/en/) was used as a method for determining EI. The underlying methodology includes four subtests aimed at assessing different components of EI, including emotional praxis, perceptual and linguistic components, a semantic component, and a regulatory component.

Emotional education programmes were used, developed on the basis of social emotional learning (SEL) methods, which included trainings for the EI development, as well as games and exercises for the development of empathy. These programmes were aimed at developing children's ability to recognize and manage their emotions, as well as to better understand other people's emotions.

Mathematical statistics methods were used for data processing and analysis. Descriptive statistics included the calculation of means, medians, and standard deviations to assess general trends in the data.

Instruments

The study covers four stages, such as subtests:

1. assesses elementary emotional praxis through facial expressions, pantomime, and prosody, offering 16 tasks;
2. aimed at assessing perceptual and language components, including identification and correlation of emotions, contains 56 tasks;
3. assesses the semantic component of EI, focusing on understanding the meaningful aspects of basic emotions, which includes 16 tasks;

Table 1.
Programmes of emotional education of children developed on the basis of methods of social emotional learning (SEL)

Name of the programme	Programme description	Target audience	The main components of the programme	Use in wartime
Second Step	The programme is aimed at developing EI and social skills	Children 6-9 years old	Teaching empathy, emotional regulation, conflict resolution	emotional support, helps children to cope with stress
PATHS (Promoting Alternative Thinking Strategies)	The program is designed to develop emotional and social competencies	Children 6-9 years old	Anger management, decision making, social interaction	Helps to reduce the level of anxiety and aggression in conditions in wartime
RULER	The programme is designed to integrate emotional learning into everyday life	Children 6-9 years old	Recognizing, understanding, marking, expressing, and regulating emotions	Supports children's emotional stability during a crisis
MindUP	The programme is based on mindfulness practices to improve emotional resilience	Children 6-9 years old	Mindfulness practices, stress reduction strategies, emotional regulation	Helps children to focus and cope with stressful situations

Source: Developed by the author on the basis of collected data on the participants of the experiment

Table 2.
Data on research participants

Group	Total	Boys	Girls	Average age	SD
CG	30	12	18	7.87	0.19
EG	30	14	16	7.63	0.24
Total/Mean	60	26	34	7.75	0.21

Source: Developed by the author on the basis of collected data on the participants of the experiment

4. is designed to assess the regulatory component, that is, the ability to regulate emotional states, which includes 15 tasks.

SPSS Statistics 26 was used for the analysis, which involved comparing data on EI before and after the experiment. The Student's t-test for paired samples was applied to determine the statistical significance of these changes, and comparisons between groups used the same instrument but from independent samples.

Results

The first objective of the research was to analyse the dynamics of EI indicators of the EG and CG children by comparing the studied indicators. Tables 3 and 4 contain parameters of analytical statistics that reflect the studied four subtests of EI.

In the CG, the difference between the average values of the EI indicators before and after the test showed weak variability.

The EG shows a significant increase in the average values for various EI components. For emotional praxis, the value increased by 8.57, which may indicate an improvement in children's ability to use emotions in their activities and interactions. The perceptual and linguistic components increased by 10.63, indicating an improvement in the ability to recognize and verbalize

Table 3.
Analysis of the dynamics of EI indicators of the CG children

		pre-test emotional praxis	post-test, emotional praxis	pre-test perceptual and linguistic components	post-test perceptual and linguistic components	pre-test semantic component	post-test semantic component	pre-test regulatory component	post-test regulatory component	pre-test integral indicators	post-test integral indicators
CG	Mean	22.33	23.20	95.07	95.27	21.63	21.53	8.00	8.27	147.03	148.27
	N	30	30	30	30	30	30	30	30	30	30
	Standard deviation	3.367	3.112	4.323	4.234	3.567	3.104	1.531	1.258	7.000	6.119
	Standard error of the mean	.615	.568	.789	.773	.651	.567	.280	.230	1.278	1.117
	Variance	11.333	9.683	18.685	17.926	12.723	9.637	2.345	1.582	48.999	37.444
	Excess	-1.750	-1.483	-1.172	-1.284	-.919	-.998	-1.517	-.606	-.377	-.859
	Asymmetry	.242	.154	.105	.084	-.527	-.242	-.123	-.432	.545	.015

Source: Developed by the author on the basis of collected data on the participants of the experiment

emotions. The increase in the semantic component by 7.4 indicates that children have become better aware of the meaning of their emotions and their influence on behaviour. The regulatory component increased by 3.37, indicating an improvement in children's ability to control and regulate their emotions. The obtained indicators can be explained by the integrated approach of mobile applications that combine educational tasks with game elements, which makes the learning process more interesting and effective for children.

Integral indicators increased by 29.97, demonstrating the positive impact of the experiment on the respondents' general level of EI. The second task of the study was to calculate the Student t-test for paired samples to determine the statistical significance of the found differences (Table 5).

In the CG, changes between pre-tests and post-tests in all subtests were not statistically significant, p-values in all cases were higher than the threshold of 0.05. Statistically significant differences are noted in the EG (p-value = 0.000). This gives grounds to conclude that working with two mobile applications helped to develop children's EI. At the same time, the CG remained at their pre-test scores, showing no improvement. The third task of the study was to apply the Student's t-test for independent samples to compare the EG and CG with each other and to draw conclusions about the effects of the experiment. The results are presented in Table 6.

Therefore, the current calculations confirm the proposed hypothesis that regular use of mobile applications can significantly develop EI indicators in children of this age group.

Discussion

The findings (Booton et al., 2023) indicated the need to integrate digital tools into the educational process to promote both learning and child development, which is consistent with the findings of this study. Another

Table 4.

Analysis of the dynamics of EI indicators of the EG children

		pre-test emotional praxis	post-test, emotional praxis	pre-test perceptual and linguistic components	post-test perceptual and linguistic components	pre-test semantic component	post-test semantic component	pre-test regulatory component	post-test regulatory component	pre-test integral indicators	post-test integral indicators
EG	Mean	23.30	31.87	95.87	106.50	21.23	28.63	7.93	11.30	148.33	178.30
	N	30	30	30	30	30	30	30	30	30	30
	Standard deviation	3.164	1.871	4.607	4.385	3.115	1.159	1.461	1.489	7.685	4.815
	Standard error of the mean	.578	.342	.841	.801	.569	.212	.267	.272	1.403	.879
	Variance	10.010	3.499	21.223	19.224	9.702	1.344	2.133	2.217	59.057	23.183
	Excess	-1.156	-1.362	-1.290	-1.323	-.806	-1.478	-1.437	-1.345	.385	-.822
	Asymmetry	-.281	-.267	-.314	.012	-.269	-.063	-.019	-.287	-.714	.237

Source: Developed by the author on the basis of collected data on the participants of the experiment

Table 5.

Calculation of the statistical significance of the differences between pre-tests and post-tests for the CG and EG

		Pairwise differences					T	Degrees of freedom	Value (double sided)
		Mean	Root mean square deviation	Root mean square error of the mean	95% confidence interval for the difference				
					Lower	Higher			
				CG					
Subtest 1	emotional praxis	-.867	4.718	.861	-2.628	.895	-1.006	29	.323
Subtest 2	perceptual and linguistic components	-.200	5.714	1.043	-2.334	1.934	-.192	29	.849
Subtest 3	semantic component	.100	4.649	.849	-1.636	1.836	.118	29	.907
Subtest 4	regulatory component	-.267	1.911	.349	-.980	.447	-.764	29	.451
Total	integral indicators	-1.233	8.597	1.570	-4.444	1.977	-.786	29	.438
				EG					
Subtest 1	emotional praxis	-8.567	3.757	.686	-9.970	-7.164	-12.489	29	.000
Subtest 2	perceptual and linguistic components	-10.633	5.262	.961	-12.598	-8.668	-11.068	29	.000
Subtest 3	semantic component	-7.400	3.701	.676	-8.782	-6.018	-10.952	29	.000
Subtest 4	regulatory component	-3.367	1.938	.354	-4.090	-2.643	-9.513	29	.000
Total	Subtest 1	emotional praxis	8.704	1.589	-33.217	-26.717	-18.858	29	.000

Source: Developed by the author on the basis of collected data on the participants of the experiment

Table 6.

Determination of experiment's effects by calculating the level of significance using the Student's t-test for independent samples

		Levene's test for the equality of variances		t-test for equality of means						
									95% confidence interval for the difference	
		F	Significance	T	Degrees of freedom	Value (double sided)	Average difference	The root mean square error of the difference	Lower	Higher
pre-test emotional praxis	Equal variances are assumed	1.553	.218	-1.146	58	.256	-.967	.843	-2.655	.722
	No equal variances are assumed			-1.146	57.778	.256	-.967	.843	-2.655	.722
post-test, emotional praxis	Equal variances are assumed	14.320	.000	-13.075	58	.000	-8.667	.663	-9.994	-7.340
	No equal variances are assumed			-13.075	47.538	.000	-8.667	.663	-10.000	-7.334
pre-test perceptual and linguistic components	Equal variances are assumed	.589	.446	-.694	58	.491	-.800	1.153	-3.109	1.509
	No equal variances are assumed			-.694	57.766	.491	-.800	1.153	-3.109	1.509
post-test perceptual and linguistic components	Equal variances are assumed	.004	.949	-10.095	58	.000	-11.233	1.113	-13.461	-9.006
	No equal variances are assumed			-10.095	57.929	.000	-11.233	1.113	-13.461	-9.006

Source: Developed by the author on the basis of collected data on the participants of the experiment

study focused redesigning a mobile content model to develop mathematical skills in schoolchildren. The mobile applications were found to be beneficial due to their potential to increase engagement, interaction and personalized experiences for young learners (Ismail et al., 2023). This complements our findings, showing that mobile applications can be effective not only for the development of EI, but also for the acquisition of specific knowledge and skills.

Another paper (Meng et al., 2023) examines the impact of digital literacy on children's school readiness and mental health. The study (Paramita et al., 2023) discovers the potential duality of the effects of electronic devices on children, pointing to the potential for improved social and communication skills with moderate use. The results of our experiment are related to these studies, as they also indicate the importance of digital literacy and moderate use of electronic devices for the development of children's social competence and emotional well-being.

One of the articles (Pauletto et al., 2023) emphasizes that targeted learning can significantly contribute to the development of key aspects of EI, which is reflected in the current study through the use of specialized mobile applications. As in this article, the results of our study support the conclusion that carefully designed educational interventions can improve EI.

Another study emphasizes the importance of quality and content of mobile education programmes. It is noted that not all apps meet educational standards, especially free versions with distracting elements (Meyer et al., 2021). Another study (Vanbecelaere et al., 2020) examines adaptive and non-adaptive games in the context of reading instruction, indicating no significant differences between different instructional methods. The results of our experiment are related to these studies, as they also emphasize the importance of the quality and content of mobile educational programmes for the development of social competence and emotional education of children.

One paper (Santos et al., 2021) discusses the League of Emotions Learners (LoEL) project, which uses a gaming application to develop emotional competence in a younger generation. These results are directly related to our research, confirming the positive impact of digital tools on the emotional development of children, provided that their educational and developmental goals are well organized.

The article (Liu et al., 2021) show that educational programmes for tablets based on the theory of multiple intelligences can significantly improve attention in schoolchildren. The results of our experiment are related to this study, as they also demonstrate the improvement.

Another study (Arzone et al., 2020) emphasizes the importance of gamification and emotional intelligence in the learning environment. The article (Al-Saadi & Al-Thani, 2023) covers the use of a specific mobile application, EmoTEA, for children with ASD. The results of our experiment are related to these studies, as they confirm the importance of integrating gamification and the development of EI in the educational environment for improving children's social competence. The obtained results confirm the achievement of the set aim and objectives of the research. Children who completed the emotional education programme showed significant improvements in social competence and the ability to manage their emotions. The positive impact of high-quality educational programmes for tablets and mobile applications on children's attention and social skills was established.

Conclusions

Military conflicts and associated social upheavals significantly affect the psycho-emotional state of children, especially of primary school age, when the foundations of their social competence and EI are being laid. In such conditions, emotional education becomes a critically important tool for supporting and developing children's ability to adapt, communicate, cooperate, and maintain emotional balance. Analysis of the dynamics of indicators of EI revealed significant differences between the EG and CG on pre-tests and post-tests. The academic value of the work is that it enriches the knowledge base in the fields of pedagogy and psychology, the conclusions can be used by other researchers in their studies. The spheres of application of the results relate to educational programmes of school institutions of various profiles.

The results of this study offer several contributions to educational practices, especially in fostering social competence and emotional well-being among children with emotional and volitional disorders. First, they highlight the critical role of emotional intelligence (EI) training in improving children's ability to navigate social interactions, suggesting that incorporating EI-focused curricula or targeted programs within schools can directly support social adaptation. Furthermore, the findings demonstrate the value of structured, controlled interventions, encouraging educators to adopt evidence-based approaches for enhancing social skills in children with specific emotional needs. By showing measurable improvements in social competence and emotional regulation, this research provides a practical framework for developing tailored educational programs that cater to students' emotional and social requirements, potentially leading to more inclusive and supportive learning environments.

Research Limitations

Only 60 respondents were included in the sample, which is related to the difficulties of involving children in research similar to this one. Furthermore, the limitation is only one educational institution for primary school students, which complicates data extrapolation. The mobile applications were adapted to the target language, but this still remains a certain limitation, which causes the need for developers to adapt such mobile applications to wide geographical and linguistic contexts.

Research Prospects

- Development of emotional education programmes adapted to wartime.

- Development and implementation of methods for evaluating the effectiveness of emotional education in primary school children.

- Determination of effective methods of psychological support for children experiencing stressful situations.

Recommendations

It is recommended to create emotional education programmes adapted to the students' individual needs taking into account their emotional state and level of development. Such programmes should include exercises to develop EI, including recognizing and expressing emotions, managing stress, and developing empathy. Special trainings on methods of emotional education will help teachers and psychologists to more effectively support students and introduce appropriate programmes into the educational process.

References

Ahsen, S., Hassaan, H. M., & Amna, H. (2023). Impact of Emotional Intelligence on Academic Performance among Young Adults: Moderating Role of Parenting Style. *Journal of Policy Research, 9*(1). https://doi.org/10.5281/zenodo.7979549

Al-Saadi, A. M., & Al-Thani, D. (2023). Mobile Application to identify and recognize emotions for children with autism: A systematic review. *Frontiers in Child and Adolescent Psychiatry, 2*, 1118665. https://doi.org/10.3389/frcha.2023.1118665

Anand, N., Gorantla, V. R., Ranjan, R., & Morcos, H. (2023). Emotional intelligence: An important skill to learn now more than ever. *F1000Research, 12*, 1146. https://doi.org/10.12688/f1000research.134752.1

Arzone, C., Mottan, K., & Saad, K. M. (2020). The relationship between gamification and emotional intelligence among children with autism spectrum disorder. In International Conference on Special Education In: *International Conference on Special Education In South East Asia Region 10th Series 2020* (Vol. 4, pp. 424-433). Redwhite Press. https://series.gci.or.id/article/320/15/icsar-2020-2020

Booton, S. A., Hodgkiss, A., & Murphy, V. A. (2023). The impact of mobile application features on children's language and literacy learning: a systematic review. *Computer Assisted Language Learning, 36*(3), 400-429. https://doi.org/10.1080/09588221.2021.1930057

Brady, R. G., Donohue, M. R., Waller, R., Tillman, R., Gilbert, K. E., Whalen, D. J. ... Luby, J. L. (2023). Maternal emotional intelligence and negative parenting affect are independently associated with callous-unemotional traits in preschoolers. *European Child & Adolescent Psychiatry, 32*(11), 2303-2311. https://doi.org/10.1007/s00787-022-02074-8

Bryant, L., Brunner, M., & Hemsley, B. (2019). A review of virtual reality technologies in the field of communication disability: implications for practice and research. *Disability and Rehabilitation: Assistive Technology, 15*(4), 365-372. https://doi.org/10.1080/17483107.2018.1549276

Ciolan, L. E., & Florescu, D. M. (2023). Training of Early Childhood Teachers to Develop Socio-Emotional Skills in Pre-Schoolers. *Revista Romaneasca pentru Educatie Multidimensionala, 15*(1), 564-574. https://doi.org/10.18662/rrem/15.1/711

Funny Feelings. (2023). *Emotionary by Funny Feelings* [Mobile app]. Mac App Store. Retrieved from https://apps.apple.com/ru/app/emotionary-by-funny-feelings/id515860459

Gao, Q., Tang, W., Yang, Y., & Fu, E. (2023). Children's emotional intelligence and aggressive behavior: The mediating roles of positive affect and negative affect. *Heliyon, 9*(10). https://doi.org/10.1016/j.heliyon.2023.e20366

Iqbal, S., & Noor, F. (2023). Emotional Intelligence among the Teachers of Special Needs Children: A Systematic Review. *Journal of Academic Research for Humanities, 3*(2), 78-92. Retrieved from https://jar.bwo-researches.com/index.php/jarh/article/view/225

Ishchenko, Y., Rusnak, A., Artemov, V., Syniavskyi, P., & Soroka, I. (2024). Psychological and Pedagogical Aspects of Adaptation of Students Who Received Temporary Shelter to the Educational Environment of another Country. *Journal of Higher Education Theory and Practice, 24*(1). https://doi.org/10.33423/jhetp.v24i1.6766

Ismail, I. M., Sanmugam, M., Hassan, H., Nadzeri, M. B., Abdul Rahim, A. A., & Khamis, N. Y. (2023). Redesigning of Mobile Content to Enhance Learning Activities Preparation by Preschool Experts. *International Journal of Interactive Mobile Technologies, 17*(15). https://doi.org/10.3991/ijim.v17i15.39325

Kucherenko, I., Raievska, Y., Verzhihovska, O., Hnoievska, O., & Savitskaya, M. (2024). Building reading skills in junior schoolchildren with autism spectrum disorders in the context of inclusive education. *International Electronic Journal of Elementary Education, 16*(3). https://iejee.com/index.php/IEJEE/article/view/2187

Liu, W., Tan, L., Huang, D., Chen, N., & Liu, F. (2021). When preschoolers use tablets: The effect of educational serious games on children's attention development. *International Journal of Human–Computer Interaction, 37*(3), 234-248. https://doi.org/10.1080/10447318.2020.1818999

Meng, Q., Yan, Z., Abbas, J., Shankar, A., & Subramanian, M. (2023). Human–computer interaction and digital literacy promote educational learning in pre-school children: mediating role of psychological resilience for kids' mental well-being and school readiness. *International Journal of Human–Computer Interaction*, 1-15. https://doi.org/10.1080/10447318.2023.2248432

Meyer, M., Zosh, J. M., McLaren, C., Robb, M., McCaffery, H., Golinkoff, R. M. ... Radesky, J. (2021). How educational are "educational" apps for young children? App store content analysis using the Four Pillars of Learning framework. *Journal of Children and Media, 15*(4), 526-548. https://doi.org/10.1080/17482798.2021.1882516

Mohammadi Orangi, B., Lenoir, M., Yaali, R., Ghorbanzadeh, B., O'Brien-Smith, J., Galle, J., & De Meester, A. (2023). Emotional intelligence and motor competence in children, adolescents, and young adults. *European Journal of Developmental Psychology, 20*(1), 66-85. https://doi.org/10.1080/17405629.2022.2034614

Moulton, E., Bradbury, K., Barton, M., & Fein, D. (2019). Factor analysis of the childhood autism rating scale in a sample of two year olds with an autism spectrum disorder. *Journal of autism and developmental disorders, 49*, 2733-2746. https://doi.org/10.1007/s10803-016-2936-9

Paramita, P. E., Zulkifli, Z., Aziz, F., & Supendi, D. (2023). Analysis of the influence of gadgets on children's emotional intelligence. *Journal Scientia, 12*(01), 132-137. https://doi.org/10.58471/scientia.v12i01.1057

Pauletto, M., Grassi, M., Pellizzoni, S., & Penolazzi, B. (2023). Fostering emotional intelligence in preadolescence: Effects of a pilot training on emotions, coping and psychological well-being. *Clinical Child Psychology and Psychiatry, 28*(2), 567-579. https://doi.org/10.1177/13591045221105189

Perry, M. A., Creavey, K., Arthur, E., Humer, J. C., Lundgren, P. J., & Rivera, I. (2020). Cultivating emotional intelligence in child welfare professionals: A systematic scoping review. *Child Abuse & Neglect, 110*, 104438. https://doi.org/10.1016/j.chiabu.2020.104438

Ripple Effects. (2023). *Bouncy the People Trainer* [Mobile app]. Mac App Store. Retrieved from https://apps.apple.com/us/app/bouncy-the-people-trainer/id899624210?ign-mpt=uo%3D4

Samara, O., Zhylin, M., Mendelo, V., Akopian, A., & Bakuridze, N. (2024). The role of emotional intelligence in the diagnosis and psychotherapy of mental disorders: an analysis of practical approaches. *Georgian Medical News, (348)*, 47-53. https://pubmed.ncbi.nlm.nih.gov/38807390/

Sánchez-Núñez, M. T., García-Rubio, N., Fernández-Berrocal, P., & Latorre, J. M. (2020). Emotional intelligence and mental health in the family: The influence of emotional intelligence perceived by parents and children. *International Journal of Environmental Research and Public Health, 17*(17), 6255. https://doi.org/10.3390/ijerph17176255

Santos, J., Jesmin, T., Martis, A., Maunder, M., Cruz, S., Novo, C. ... Carvalho, C. V. D. (2021). Developing emotional intelligence with a game: The league of emotions learners approach. *Computers, 10*(8), 97. https://doi.org/10.3390/computers10080097

Subiyantoro, S., Degeng, I. N. S., Kuswandi, D., & Ulfa, S. (2024). Developing Gamified Learning Management Systems to Increase Student Engagement in Online Learning Environments. *International Journal of Information and Education Technology, 14*(1), 26-33. https://doi.org/10.18178/ijiet.2024.14.1.2020

Tarver, J., Palmer, M., Webb, S., Scott, S., Slonims, V., Simonoff, E., & Charman, T. (2019). Child and parent outcomes following parent interventions for child emotional and behavioral problems in autism spectrum disorders: A systematic review and meta-analysis. *Autism, 23*(7), 1630-1644. https://doi.org/10.1177/1362361319830042

Thorius, K. K., Lindo, E. J., Martínez-Álvarez, P., & Sullivan, A. L. (2024). Editorial Perspectives on Critical Issues Affecting Special Education to be addressed by Exceptional Children. *Exceptional Children, 90*(2), 100-109. https://doi.org/10.1177/00144029231219344

Truba, H., Khrapatyi, S., Harashchuk, K., Shvets, D., & Proskurnia, A. (2024). Psycholinguistic underpinnings of image formation: Suggestion and manipulation in the educational network discourse. *Thinking Skills and Creativity, 52*, 101496 https://doi.org/10.1016/j.tsc.2024.101496

Vanbecelaere, S., Van den Berghe, K., Cornillie, F., Sasanguie, D., Reynvoet, B., & Depaepe, F. (2020). The effectiveness of adaptive versus non-adaptive learning with digital educational games. *Journal of Computer Assisted Learning, 36*(4), 502-513. https://doi.org/10.1111/jcal.12416

Wang, L.-C., Liu, D., Lin, H.-H., Chung, K. K.-H., & Xu, Z. (2024). Effectiveness of Diverse Designs of Chinese Stem-Deriving Instruction for Chinese Children with Dyslexia. Exceptional *Children, 90*(3), 295-312. https://doi.org/10.1177/00144029231220308

Wolraich, M. L., Hagan, J. F., Allan, C., Chan, E., Davison, D., Earls, M. ... Zurhellen, W. (2019). Clinical practice guideline for the diagnosis, evaluation, and treatment of attention-deficit/hyperactivity disorder in children and adolescents. *Pediatrics, 144*(4). https://doi.org/10.1542/peds.2019-2528

Woodgate, R. L., Gonzalez, M., Demczuk, L., Snow, W. M., Barriage, S., & Kirk, S. (2020). How do peers promote social inclusion of children with disabilities? A mixed-methods systematic review. *Disability and Rehabilitation, 42*(18), 2553-2579. https://doi.org/10.1080/09638288.2018.1561955

Yamamoto, M. (2021). How children with autism spectrum disorder perceive themselves: A narrative research. *Japan Journal of Nursing Science, 18*(4), e12420. https://doi.org/10.1111/jjns.12420

Zhylin, M., Tormanova, A., Poplavska, Y., Chernov, M. M., & Druz, O. (2024). Study of digital approach in education and psychology among selected users in Ukraine. *Multidisciplinary Reviews, 6*, 2023spe007. https://doi.org/10.31893/multirev.2023spe007

Appendix A. An exampof the interface of the Emotionary mobile application

Appendix B. An example of the interface of the Bouncy the People Trainer mobile application

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The Landscape of Mathematics and Mathematics Education Research in Special Education: A Bibliometric Analysis

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Abstract

The main purpose of mathematics education in special education is to enable each student to learn and apply mathematical concepts by taking into account their individual needs. The aim of the study is to determine the place of publications including "special education and mathematics", "special education and mathematics education" in the literature and to present a panoramic perspective by revealing the dynamics of the field. In the study, bibliometric analysis was used, which offers an approach to accurately measure and analyse the publications examined in the database. Within the scope of the study, mathematics and mathematics education publications in special education provided important diagnostic data by presenting trends in past, present and future perspectives in the field. In this context, 487 articles were systematically analysed. It is a remarkable result of the study that most of the publications including "special education and mathematics", "special education and mathematics education" are found in special education journals. Another result is that the participants of the majority of the studies are students and children. In general, author collaborations between different groups are very few.

Keywords:

Mathematics, mathematics education, special education, bibliometric, Web of Science (WoS) database

Introduction

Mathematics is an indispensable communication tool that develops high-level thinking skills such as analytical thinking, reasoning and problem solving both within itself and in other disciplines. Mathematics plays a more important role today than ever before in understanding and exploring the world around us, and it is obvious that this importance will increase even more in the future (Özdemir & Kılıç, 2023). Baykul (2011) emphasises that mathematics is a vital tool not only in scientific fields but also in solving the problems we face in daily life. Mathematical competence is considered as one of the basic skills necessary for students to be successful both in their school life and in the future (Hatisaru, 2020). Being competent in mathematics is of great importance in terms of developing thinking skills (Özdemir & Kılıç, 2023). Even fields such as social sciences, music, literature and

art require mathematical knowledge to understand concepts. This central role of mathematics makes it a critical discipline at every stage of the education system. For this reason, the teaching of mathematics in schools has been of considerable importance for many years (Schubring & Karp, 2014).

The rapid progress of science and technology in the world has changed the type of knowledge that individuals need in order for societies to achieve success. What is now expected from education is to provide individuals with the necessary competences to adapt to change, to be open to development, to adopt the spirit of entrepreneurship, to develop problem solving skills and to apply knowledge to new and real problems. Austin (1955) drew attention to the importance of developing comprehension in mathematics and emphasised that in addition to teaching vocabulary and problem solving methods, it is useful to have students read mathematical expressions. Similarly, Fuentes (1988) stated that learning mathematics depends on how it is read. Fuentes (1988) stated, 'In order for my students to realise their potential as mathematicians, they need to learn to understand mathematical texts consisting of numbers, abstract symbols and words'. Fuentes (1988) emphasises that every student can be successful with appropriate and timely corrective feedback. In line with this approach, the mathematics education programme in Turkiye is based on the principle that 'every child can learn mathematics' (Tatar & Dikici, 2008). Mathematics is considered to be one of the most important subjects that students should learn; however, it is seen as a difficult subject by many students due to its abstract nature. According to Abbasi et al. (2013), students' mathematics anxiety is an important factor that prevents them from developing their mathematical skills. Similar results and cultural problems are observed in the Turkish education system (Aydın & Doğan, 2012; Hatısaru & Erbaş, 2012).

Yıldızlar (2012) argues that the reason why mathematics is important at every stage of education and in all countries is that mathematics is an indispensable tool for scientific research and individuals' daily lives. Miller and Mercer (1997) emphasise that it is wrong to expect all children with similar intelligence levels in the same class to have equal abilities and learning speeds, because this would mean shaping the curriculum according to the children, not the curriculum according to the children. This approach is contrary to the basic principles of special education. The Ministry of National Education's 2006 Regulation on Special Education defines children with special needs as 'individuals who show significant differences from their peers in terms of their personal characteristics and educational competences for various reasons'. Children with special needs is a broad concept that includes children with learning and behavioural difficulties, emotional or physical disabilities as well as those with intellectual differences (Özdemir & Kılıç, 2023). Children with special needs, like many children with normal development, may have difficulties in learning, applying and problem solving basic mathematical concepts and skills. Therefore, inadequate progress in mathematics skills becomes an important issue in terms of establishing appropriate educational programmes especially for students with special educational needs. In this context, measurement and assessment of mathematics skills are of great importance in terms of obtaining the necessary information (Glick et al., 1990; Mercer & Pullen, 2009). In addition, mathematics is a critical tool to enable individuals with special needs to cope with various situations they encounter in their daily lives. In particular, skills such as shopping in daily life require the ability to perform mathematical operations. Therefore, mathematical skills of individuals with special needs contribute significantly to their independent living (Karabulut & Yıkmış, 2010).

According to the NCTM (2000) principle of equality in teaching mathematics, all individuals are supported and individuals with special needs should be taken into consideration. This principle is designed to ensure that every student has equal opportunities to develop mathematical thinking and problem solving skills. In particular, taking into account the educational needs of individuals with special needs requires appropriate support and adjustments to be made in the teaching process. This can be achieved by using different teaching strategies, tools and resources to meet individual needs. Furthermore, ensuring the accessibility of teaching materials and assessment methods creates a favourable learning environment that can help all students understand and apply mathematical concepts. Applying the principle of equity in mathematics teaching contributes to the creation of an inclusive and equitable educational environment that supports students to maximise their potential. Mathematics helps to improve mathematical performances in special education and provides equality in access to quality education for students with special needs by addressing learning and behavioural difficulties. However, it is known that there are significant inequalities in mathematics achievement between students with special needs and typically developing students (Hunt et al., 2022). For example, data from US and international assessments show that students with special needs experience persistent and pervasive inequalities of opportunity in mathematics learning. This situation reveals that over time, students with special needs have made only limited progress in mathematics achievement (National Assessment of Educational Progress, 2018; Programme for International Student Assessment, 2018). The inadequacy of special education teachers' mathematics preparation and lack of expertise are

related to the inequalities of opportunity that students face in the educational process (Rosas & Campbell, 2010). This is because the teacher is one of the most important school-based factors that positively affect student achievement (Rand, 2012). Therefore, research on teachers' mathematical knowledge is of great importance for the achievement of students with learning difficulties. However, research in the field of mathematics and special education generally focuses on the findings on improving students' performance rather than the effects of teachers' mathematical thinking knowledge and pedagogical skills on student performance. From this point of view, the study aimed to determine the place of studies on mathematics and mathematics education in special education in literature and it was thought that it would provide guidance for both students and teachers with special needs and for future research.

The study aims to answer the following questions in order to determine the place of publications including 'special education and mathematics', 'special education and mathematics education' in the literature and to present a panoramic perspective by revealing the dynamics of the field:

1. What is the general information about the publications on special education and mathematics and mathematics education?
    1. What are the findings about the number of publications?
    2. What are the findings about the researchers of the publications?
2. What is the structural and thematic development of publications on special education and mathematics and mathematics education?
    1. What are the most influential articles, sources and keywords in published studies?
    2. What is the thematic development and trend of keywords?
    3. What is the structure of cross-country and university co-operation networks?

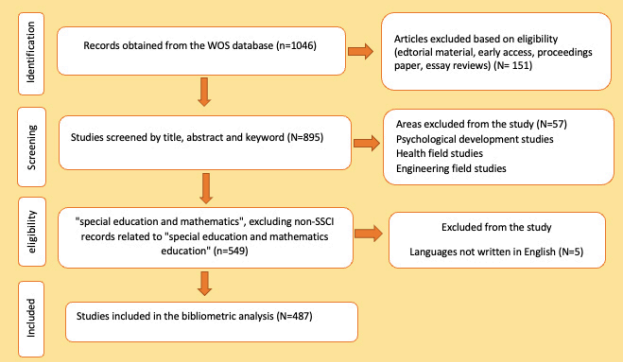
Considering the lack of studies in this field in literature and the potential for new ways by revealing certain characteristics and criteria of the studies, the study is considered to be important.

Method

In the study, bibliometric analysis was used, which offers an approach to accurately measure and analyse the publications examined in the database (Carmona Serrano et al., 2020a, 2020b). Bibliometric analysis, which has been used since the 1960s, allows systematic examination of studies with techniques such as keyword analysis, co-occurrence analysis, cluster analysis and bibliometric maps, and provides information about the change of retrospective research over time (Pritchard, 1969; Song & Wang, 2020). It is also a method used to visualise trends in various research areas and to visually identify terms that are frequently used in studies on a particular topic or population (Bolaños et al., 2022). In order to provide comprehensive analyses in the study, the open source bibliometrix R-Studio program package and R software were used (Aria & Cuccurullo, 2017; Aria & Cuccurullo, 2022). The bibliographic data in the study were obtained by using the advanced search feature in the Web of Science (WOS) database until January 2024. In the database search, parameters were determined by using the keywords "special education and mathematics", "special education and mathematics education". English-language publications were preferred in the studies and a search was made in the article section. English-language publications were preferred. The flow chart of the article selection process of the 487 data collected is shown in Figure 1.

Figure 1

Article process workflow chart



Findings

General Information

When the growth data of mathematics and mathematics education studies in special education are analysed, it is noteworthy that the first significant increase was in 2017 (Figure 2). In 2018 and 2019, there was a certain decrease in the number of studies published, but a high rate of increase occurred again in 2020. It is also noteworthy that there were no studies on the subject between 1981-1986 and 1988-1990.

According to Table 1, 887 different keywords were found in the studies published in 120 different sources (journals, conference proceedings, etc.) and these publications were cited at an average rate of 24.94. It was seen that 1093 authors contributed to these studies. 54 single-authored studies were published 45 times. The number of co-authors per study is (3.11). There are a total of 17813 references in the studies.

Figure 2

Changes in publications over the years

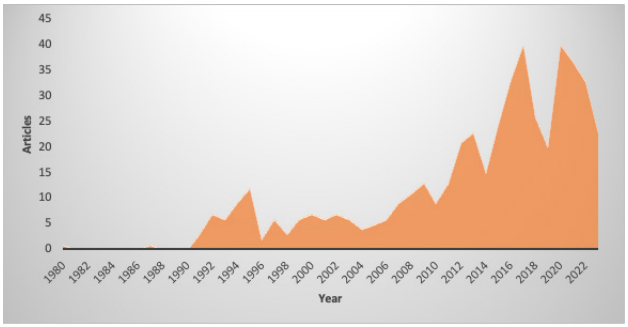


Table 1

Main Information

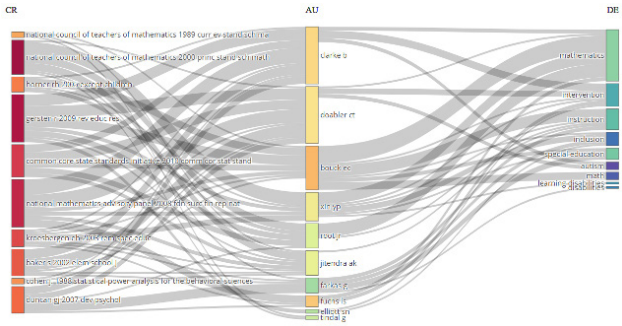
Description	Results
Articles	487
Period	1980-2023
Sources (Journals, Books, etc)	120
Annual Growth Rate %	7.56
Document Average Age	11
Average citations per doc	24.94
References	17813
Keywords Plus (ID)	887
Author's Keywords (DE)	1010
Authors	1093
Authors of single-authored docs	45
Single-authored docs	54
Co-Authors per Doc	3.11
International co-authorships %	9.035

Structural and Thematic Development

Three-fields diagram was used to provide an overview of mathematics and mathematics education studies in special education between 1980 and 2023. The Three-fields diagram visually presents the relationship between three main elements: authors, keywords and journals(Figure3).

Figure 3

Three-field diagram



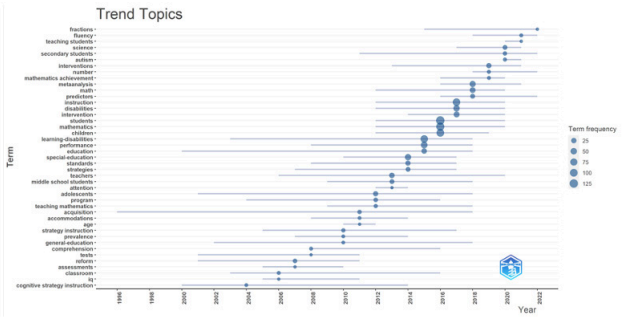
In the three-field diagram in Figure 3, the left column is journals, the centre column is authors, and the right column is keywords. The number of items in each field was chosen as 10 to make the graph more understandable. With the three-field diagram, the relationship between the authors who contribute the most to the field in the data set, the keywords they use the most and the most popular journals are presented. When the analysis of the studies is analysed, it is seen that the majority of the published studies are found in special education journals. It is noteworthy that the journals with the highest number of publications in the field are "Journal of Special Education" and "Remedial and Special Education". Bouck Ec is one of the most influential authors in the field and it is seen that the majority of the influential authors in the field use the keyword "mathematics" the most. The findings also show that Xin Yp and Root Jr have contributed significantly to the studies on special education and mathematics, special education and mathematics education.

Words Analysis

In the keyword trends analysis (trend topics), keywords, abstracts and titles are used to show the changes of publications over the years with a coordinate plan. With this analysis, it is revealed in which years the topics of the published studies have been realised. The correct selection of keywords, abstracts and titles is important and useful in terms of defining the framework of the research area. Researchers can easily access the publications they want in the literature with the help of keywords, titles and abstracts (Grant, 2010). By analysing trend topics, it is possible to observe the changes in the area and frequency values on the coordinate system (Figure 4).

Figure 4

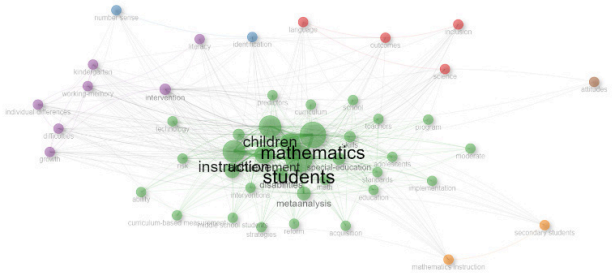
Analysing the trending topics of the field



When the frequency of using keywords according to the years of the studies is examined, it is noteworthy that the words "students", "mathematics" and "children" were popular in 2016, respectively. Then, it is seen that the words "instruction" in 2017 and "learning disabilities" in 2015 are frequently preferred in the studies.

Co-occurrence analysis is used to reveal the relationship between the most frequently used keywords in the studies more clearly and to visualise the frequency of co-occurrence of keywords and the network map. Figure 5 shows the network map analysis of 100 keywords in special education and mathematics, special education and mathematics education studies.

Figure 5
Co-occurrence network analysis



In the co-occurrence analysis given in Figure 5, it is seen that the keywords are classified in six different clusters. The large number of link thicknesses indicates the co-occurrence of keywords, and the size of the size indicates the size of the number of links. When the word network map is examined, it is seen that the cluster with the highest co-occurrence with other keywords, the largest size and the cluster with the highest number of elements is the green cluster. The most remarkable words of this cluster are "students", "mathematics" and "children" respectively. The network map of keywords in Figure 5 supports the keyword trends analysis in Figure 4.

Collaboration Networks

Collaboration networks reveal social networking and partnerships between individuals such as authors, countries and universities, or between organisations. When creating the collaboration network map, the biblioshiny parameter network layout for authors, countries and universities was set to automatic layout, 50 nodes, minimum two edges, 50 labels based on authors.

Figure 6
Authors collaboration network

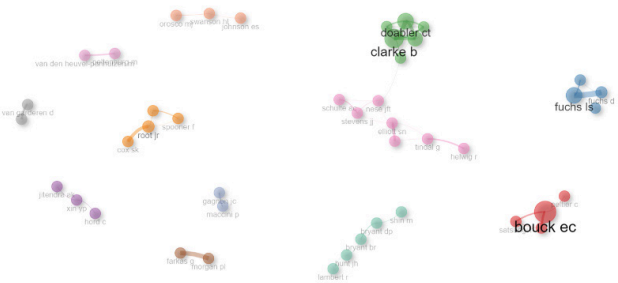


Figure 6 shows the authors' collaboration network. Collaborating authors are shown in the same colour. Considering the number of collaborations, the first three authors are Nese Jft, Shanley I and Elliott Sn, respectively. When evaluated according to the link thickness, the closeness of the collaboration between Fuchs Ls and Luchs D in the grey cluster draws attention.

Figure 7 shows a map of the cooperation network of countries working on mathematics and mathematics education in special education.

Figure 7
Country collaboration network

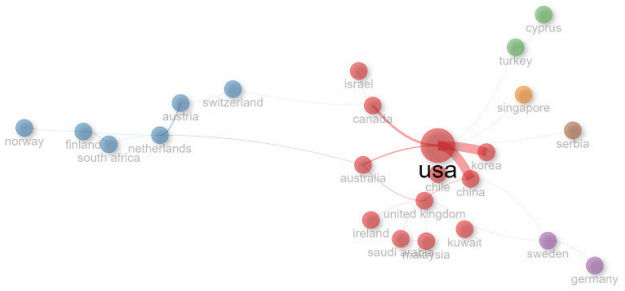
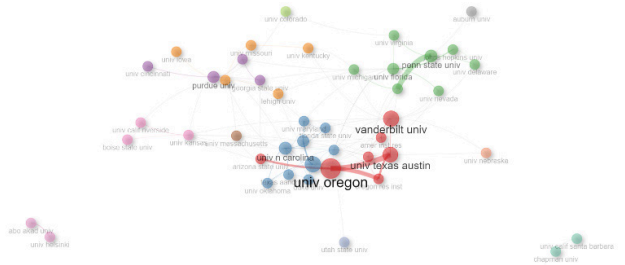


Figure 7 shows that many countries are in co-operation when we look at the studies on mathematics and mathematics education in special education. In the network map, the link thickness indicates the frequency of publication of the countries and the colours indicate the cluster they belong to. USA is seen as an active country with a high level of co-operation among other countries. At the same time, the cluster with the most cooperation between countries is the red coloured cluster. After USA, another country that is active in the co-operation network is United Kingdom. Clusters with at least two links consist of 24 countries in total.

Figure 8 shows the collaborations of universities or institutions working on mathematics and mathematics education in special education. University of Florida, Purdue University and Vanderbilt University are among the universities that stand out in terms of collaboration. When the collaboration network is analysed, there are clusters with at least two connections.

Figure 8
University collaboration network



Discussion and Conclusions

Mathematics and mathematics education studies in special education contribute to various advances in the field of education. This study is of great importance as it is the first comprehensive study that addresses the field of special education in a holistic manner in terms of mathematics and mathematics education studies in terms of subject and time. Looking at the growth rate of published studies, it is noticeable that there is a remarkable increase especially in 2017. When the development of publications is analysed in general, it can be said that studies have been progressing in recent years. This may be due to new research areas, educational reforms and the academic impact of special education on research on mathematics and mathematics education. In addition, the increasing interest in mathematics and mathematics teaching in the field of special education can also be shown as a reason. For example, as the foundations of inclusive education were laid in the 1950s, it became important to integrate students with special needs or disabilities into the 'normal' education system instead of 'special' education (Şimşek et al., 2019). With this approach, it is emphasised that students, teachers, learning environment, school management and families should develop sensitivity for students with special needs and be prepared in accordance with the needs of these students (Aktekin et al., 2017). Today, inclusive education is a process that aims to ensure that all children with special needs and those who have difficulty in accessing social, cultural, educational or vital opportunities have equal access to educational opportunities that can support their personal development with their peers and to eliminate the obstacles they face on this path (Aktekin et al., 2017; Çelik, 2017; UNESCO, 2005). In addition to these developments, the pandemic period in particular has caused learning losses in maths for disadvantaged students. For example, a study conducted in Belgium revealed that there was a significant decrease in the maths school averages of disadvantaged students (Maldonada, De Witte, 2020). It can be said that these situations have prepared the ground for many national and international studies conducted periodically. In addition, STEM (science-technology-engineering-mathematics) education is one of the subjects that has been frequently discussed worldwide in recent years and is thought to be effective in providing students with various skills. STEM education is an important approach that enables the development of competences such as creativity, critical thinking, problem solving and collaboration, which are defined as 21st century skills (Kennedy & Odell, 2014; Yıldırım & Altun, 2015). Considering that students with special needs need these skills throughout life, it is thought that the STEM approach will make a significant contribution to gaining many skills (Balçın & Yıldırım, 2020). When the literature is examined, it is seen that the developments in STEM education contributed to the increase in awareness, especially in special education, and the popularisation of the STEM approach affected the studies conducted after 2018. In conclusion, based on these developments, it is possible to say that the studies affect awareness in special education and change the effectiveness of mathematics and mathematics education.

Mathematics and mathematics education studies in special education have an important place in the literature. The adoption of the importance of mathematics in special education has enabled the studies to become widespread. In addition, mathematics and mathematics education studies in special education have been effective in shaping educational policies and guiding academic studies. In addition, mathematics and mathematics education studies in special education are effective in shaping educational policies and guiding academic studies. When the studies conducted in this context were analysed, it was seen that the journal in which the most studies were published was "Journal of Special Education", the most influential author was "Bouck Ec" and accordingly, the majority of the influential authors in the field used the keyword "mathematics" the most. Bouck Ec, the most influential author, is a professor and researcher in special education. His research is directed towards investigating the effectiveness of different instructional strategies, interventions and technologies to improve the academic outcomes of students with disabilities, particularly in the area of mathematics. The fact that he has published widely in academic journals and written many books for teachers and educational professionals has made it inevitable that he will be recognised as one of the most influential authors in the study of mathematics and special education.

Social network analysis is applied in bibliometric studies to show the structural and thematic structure of the field (Johnson and Samakovlis, 2019; Mehraliyev et al., 2019). According to the findings of the study, different cluster classifications draw attention when word analysis results are evaluated. Considering the cluster classifications, link thicknesses and the size of the number of links in the clusters, it is noticeable that the most popular words used are "students", "mathematics" and "children". This is likely to be the result since the participants of the majority of the studies are students and children. Looking at the collaboration network map of social networking and partnerships between individuals or organisations such as authors, countries and universities, it can be said that there is a need for stronger collaborations in the field in order to increase the development of the field where there is a lack of collaborative work. The top three authors in terms of co-operation between authors are Nese Jft, Shanley I and Elliott Sn. It can be

said that the fact that Nese Jft, Shanley I and Elliott Sn are in the first three places in the collaboration between authors is due to the fact that they have similar interests and focus on the same study topics. In general, author collaborations between different groups are very few. In order to strengthen these collaborations, ideas can be shared at conferences, symposiums and congresses to contribute to the development of the field. When the co-operation between countries is evaluated, it is seen that the USA and then the United Kingdom are the countries with high and effective co-operation with other countries. Considering that the authors work in the USA, it is an expected result that USA ranks first in inter-author collaboration. It can be said that the main reasons for the concentration of mathematics and mathematics education research in special education, especially in universities in countries such as the USA and the UK, are strong legal regulations, funding sources, public awareness, interdisciplinary collaborations and educational reforms in these countries. Increasing awareness, especially in special education, and technological applications in mathematics are encouraging universities to do more research in these areas and increasing the research intensity of strong cultural traditions and international collaborations in these areas. According to the cooperation of universities or institutions, the University of Florida, Purdue University and Vanderbilt University are among the prominent universities in terms of cooperation. The University of Florida has a prestigious programme offering advanced mathematics education. Purdue University is also one of the leading institutions in the field of special education with a strong academic background and effective research programmes. In addition, Purdue University stands out with its studies on developing innovative approaches in special education and projects aiming to increase the success of students with disabilities in STEM fields such as mathematics and science. When these factors are taken into consideration, the strong positions of the universities in their respective fields and the deep knowledge they possess have led to co-operation as a natural outcome.

Limitations

The study is limited to the data obtained from the Web of Science database. Different data can be obtained by using Scopus database and Web of Science database together. The open source bibliometrix R-Studio programme package and R software were used in the study. Apart from this, different analysing software can be used. In addition, the study was limited to publications covering special education and mathematics, special education and mathematics education studies.

Conclusions and future direction

In the study, the bibliometric analysis process was developed based on a framework. With this framework, the articles were systematically analysed according to the workflow chart. Within the scope of the study, mathematics and mathematics education publications in special education provided important diagnostic data by presenting trends in past, present and future perspectives in the field. For example, the fact that most of the studies on the subject are found in special education journals is a remarkable issue that should be emphasised. In the studies, it is seen that the most popular words are student and child. However, since the teaching method and the planning of the learning process are also very important for children with special needs, the inclusion of teachers as participants in the studies will contribute to the best organisation of the teaching process. In addition, since the role of families in the education process of students with special needs cannot be ignored, studies that take into account the participation of families as well as teachers should be carried out. Technology has become an important supportive element in special education. For this reason, including innovative approaches such as digital tools and artificial intelligence in the teaching process and conducting more research on this subject will provide students with special needs with an individualised learning experience. However, since the teaching method and the planning of the learning process are also very important for children with special needs, the inclusion of teachers as participants in the studies will contribute to the best organisation of the teaching process. In addition, strengthening collaborations in terms of authors, countries and universities in order to increase the development of both special education and mathematics and mathematics education is an important result for future research. In this context, it is thought that researchers who want to work in the field of special education and mathematics, special education and mathematics education should cooperate with different countries and different universities. In addition, mathematics and mathematics education research in special education can include different disciplines such as psychology, educational technologies, linguistics, etc. to examine the mathematics learning processes of students with special needs in more depth.

Data availability Information is available from the author upon request.

Declarations

Conflicts of Interest Conflicts of interest were not disclosed by the author.

References

Abbasi, M., Samadzadeh, M., & Shahbazzadegan, B. (2013). Study of mathematics anxiety in high school students and its relationship with self-esteem and teachers' personality characteristics. *Procedia - Social and Behavioral Sciences, 83*, 672–677. https://doi.org/10.1016/j.sbspro.2013.06.127

Aktekin, S., Öztürk, M., Tepetaş-Cengiz, Ş. G., Köksal, H., & İrez, S. (2017). *Sınıfında yabancı uyruklu öğrenci bulunan öğretmenler için el kitabı* [Handbook for teachers with foreign students in their classrooms]. Ankara: Öğretmen Yetiştirme ve Geliştirme Genel Müdürlüğü [General Directorate of Teacher Training and Development].

Aria, M., & Cuccurullo, C. (2017). Bibliometrix: An R-tool for comprehensive science mapping analysis. *Journal of Informetrics, 11*(4), 959-975. https://doi.org/10.1016/j.joi.2017.08.007

Aria, M., & Cuccurullo, C. (2022). Package 'bibliometrix'. Retrieved from https://cran.r-project.org/web/packages/bibliometrix/bibliometrix.pdf on 5 January 2024.

Austin, M. (1955). Improving comprehension of mathematics. *The High School Journal, 39*, 71–75. Available online: http://www.jstor.org/stable/40363490 (Accessed on 3 February 2024).

Aydın, B., & Doğan, M. (2012). Matematik öğretimi: Geçmişten günümüze matematik öğretimi önündeki engeller [Mathematics teaching: Barriers to mathematics teaching from past to present] *Batman University Journal of Life Sciences, 1*, 89–95.

Balçın, M. D., & Yıldırım, M. (2021). Kaynaştırma öğrencilerinin fen bilimleri dersi STEM çalışmalarının değerlendirilmesi [Evaluation of inclusion students' STEM studies in science course]. *Ankara University Faculty of Education Journal of Special Education, 22*(2), 307-341. https://doi.org/10.21565/ozelegitimdergisi.660695

Baykul, Y. (2011). *İlköğretimde matematik öğretimi (1-5. sınıflar) [Mathematics teaching in primary education (grades 1-5)]*. Ankara: Pegem Publishing.

Cossio-Bolaños, M., Vidal-Espinoza, R., Pezoa-Fuentes, P., Cisterna-More, C., Benavides-Opazo, A., Espinoza-Galdames, F., Urra-Albornoz, C., De la Torre Choque, C., & Gomez-Campos, R. (2022). Bibliometrics of Scientific Productivity on Physical Activity in Children and Adolescents with Autism Spectrum Disorder and Down Syndrome. *International Electronic Journal of Elementary Education*, *15*(1), 43–52. Retrieved from https://www.iejee.com/index.php/IEJEE/article/view/1908

Carmona-Serrano, N., López-Belmonte, J., Cuesta-Gómez, J. L., & Moreno-Guerrero, A. J. (2020a). Documentary analysis of the scientific literature on autism and technology in Web of Science. *Brain Sciences, 10*(12), 985. https://doi.org/10.3390/brainsci10120985

Carmona-Serrano, N., López-Belmonte, J., López-Núñez, J. A., & Moreno-Guerrero, A. J. (2020b). Trends in autism research in the field of education in Web of Science: A bibliometric study. *Brain Sciences, 10*(12), 1018. https://doi.org/10.3390/brainsci10121018

Çelik, R. (2017). Adalet, kapsayıcılık ve eğitimde hakkaniyetli fırsat eşitliği [Justice, inclusion and equitable equal opportunities in education] *Fe Journal, 9*(2), 17–29. https://doi.org/10.1501/Fe0001_0000000185

Fuentes, P. (1988). Reading comprehension in mathematics. *The Clearing House, 72*(2), 81–88. https://www.jstor.org/stable/30189563

Glick, W. H., Huber, G. P., Miller, C. C., Doty, D. H., & Sutcliffe, K. M. (1990). Studying changes in organizational design and effectiveness: Retrospective event histories and periodic assessments. *Organization Science, 1*(3), 293–312. https://doi.org/10.1287/orsc.1.3.293

Grant, M. J. (2010). Key words and their role in information retrieval. *Health Information & Libraries Journal, 27*(3), 173-175. https://doi.org/10.1111/j.1471-1842.2010.00904.x

Hatisaru, V. (2021). School Students' Depictions of Mathematics Teaching and Learning Practices. *International Electronic Journal of Elementary Education*, *13*(2), 199–214. Retrieved from https://www.iejee.com/index.php/IEJEE/article/view/1273

Hatısaru, V., & Erbaş, A. K. (2012). Matematik eğitiminde endüstri meslek liselerinde yaşanan sorunlar ve çözüm önerileri [Problems in mathematics education in industrial vocational high schools and solution suggestions]. In *X. Ulusal Fen Bilimleri ve Matematik Eğitimi Kongresi [X. National Science and Mathematics Education Kongress]*. Niğde University, Niğde, Turkiye.

Hunt, J. H., Martin, K., Patterson, B., & Khounmeuang, A. (2022). Special educators' knowledge of student mathematical thinking. *Journal of Mathematics Teacher Education, 25*, 581-598. http://dx.doi.org/10.1007/s10857-021-09508-1

Johnson, A. G., & Samakovlis, I. (2019). A bibliometric analysis of knowledge development in smart tourism research. *Journal of Hospitality and Tourism Technology, 10*(4), 600-623. https://doi.org/10.1108/JHTT-07-2018-0065

Karabulut, A., & Yıkmış, A. (2010). Zihin engelli bireylere saat söyleme becerisinin öğretiminde eşzamanlı ipucuyla öğretimin etkililiği [The effectiveness of simultaneous prompting in teaching clock telling skills to individuals with intellectual disabilities]. *Abant İzzet Baysal University Journal of Education Faculty, 10*(2), 129-144.

Kennedy, T., & Odell, M. (2014). Engaging students in STEM education. *Science Education International, 25*(3), 246-258.

Mehraliyev, F., Choi, Y., & Köseoğlu, M. A. (2019). Progress on smart tourism research.

Journal of Hospitality and Tourism Technology, 10(4), 522-538. https://doi.org/ 10.1108/JHTT-08-2018-0076

Mercer, C. D., & Pullen, P. C. (2009). *Students with learning disabilities* (7th ed.). Merrill-Prentice Hall.

Miller, S. P., & Mercer, C. (1997). Educational aspects of mathematics disabilities. *Journal of Learning Disabilities, 30*(1), 47–56. https://doi.org/10.1177/0022219497030001

Maldonado, J. E., & De Witte, K. (2020). The effect of school closures on standardised student test outcomes. Department of Economics, KU Leuven. https://lirias.kuleuven.be/retrieve/588087

National Center for Education Statistics. (2018). *National Assessment of Educational Progress*. U.S. Department of Education. IES.

NCTM (2000). *Principles and standards for school mathematics*. Reston, VA: National Council of Teachers of Mathematics.

Özdemir, S., & Kılıç, Y. (2023). Investigating special education teachers' views on mathematics instruction process: Suggestions for sustainable special education in mathematics instruction. *Sustainability, 15*(5), 3584. https://doi.org/10.3390/su15043584

Pritchard, A. (1969). Statistical bibliography or bibliometrics. *Journal of Documentation, 25*(4), 348-349.

Program for International Student Assessment. (2018). Organization for Economic Cooperation and Development. *PISA 2018 results*. Retrieved from https://www.oecd.org/pisa/publications/pisa-2018-results.htm

RAND Corporation. (2012). *Teachers matter: Understanding teachers' impact on student achievement*. RAND Corporation.

Rosas, C., & Campbell, L. (2010). Who's teaching math to our most needy students? A descriptive study. *Teacher Education and Special Education, 33*(2), 102–113. https://doi.org/10.1177/0888406409357537

Schubring, G., & Karp, A. P. (2014). History of mathematics teaching and learning. In S. Lerman (Ed.), *Encyclopedia of mathematics education*. Dordrecht: Springer.

Song, P., & Wang, X. (2020). A bibliometric analysis of worldwide educational artificial intelligence research development in recent twenty years. *Asia Pacific Education Review, 21*(3), 473–486. https://doi.org/ 10.1007/s12564-020-09640-2

Şimşek, H., Dağıstan, A., Şahin, C., Koçyiğit, E., Yalçınkaya, G., Kart, M., & Dağdelen, S. (2019). Kapsayıcı eğitim bağlamında Türkiye'de temel eğitim programlarında çokkültürlülüğün izleri [Traces of multiculturalism in basic education programs in Turkey in the context of inclusive education]. *Ahi Evran University Journal of Institute of Social Sciences, 5*(2), 177-197. https://doi.org/10.31592/aeusbed.563388

Tatar, E., & Dikici, R. (2008). Matematik eğitiminde öğrenme güçlükleri [Learning difficulties in mathematics education]. *Mustafa Kemal Üniversitesi Journal of Institute of Social Sciences, 5*, 184–193.

United Nations Educational, Scientific and Cultural Organization. (2005). *Guidelines for inclusion: Ensuring access to education for all*. Paris: UNESCO.

Yıldırım, B., & Altun, Y. (2015). STEM eğitim ve mühendislik uygulamalarının fen bilgisi laboratuar dersindeki etkilerinin incelenmesi [Investigating the effect of STEM education and engineering applications on science laboratory lectures]. *El-Cezeri Journal of Science and Engineering, 2*(2), 28-40.

Yıldızlar, M. (2012). *Yapılandırmacı öğretimde matematik problemlerini çözebilme yöntemleri* [Methods of solving mathematics problems in constructivist teaching]. Ankara: Pegem Publishing.

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Silencing Children About 'Forbidden' Topics: Discussing Prevention Education in Australian Early Childhood

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Abstract

Over three decades ago the United Nations developed the Convention on the Rights of the Child (UNCRC; United Nations, 1989) which was aimed at ensuring children were positioned as active agents in their lives, capable of having a voice and participating in decision-making on issues that affected them. Australia ratified the UNCRC in 1990, however implementation required changes in relevant laws, policies and practices which is a complex process (Alston & Brennan, 1991). Whilst ratification provided the Australian Federal Government "an historic opportunity" (Cass, 1991, p. 28) time has proven that change remains limited by the "imbalances of power and resources which are deeply embedded in the way we live and are organised" as originally feared by Parker (1991, p. 19). This discussion paper explores barriers limiting the capacity to change and speculates on ways in which progress might still be made to enhance the ways in which Australia as a nation honours the promise made when UNCRC was ratified. This is important for teacher educators to ensure our teachers embed teaching practices that prevent childhood sexual abuse. This will be of interest to those who design teacher education courses and policy makers.

Keywords:

Teacher Education, Early Childhood Education, Children's Voices, Trauma, Sex Education

Introduction

Recent years in Australia have seen a resurgence of right wing ideology similar to that seen around the world (Hart, 2021). Accompanying this swing towards the right is a narrative of protection: in particular, protecting the national culture from outside influences (Flannery et al., 2021). Whilst this is normally exemplified by rejection of multiculturalism and strong support for nationalism, these characteristics are underpinned by a focus on in-group cohesion and rejection of out-groups. In-groups create and maintain social narratives, whilst out-groups are perceived to threaten these narratives; they are seen as likely to change them, a threat to the status quo (Flannery et al., 2021). This impacts the positioning of children in society, and the ways educators interact with them.

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In this discussion paper, we outline the challenges educators face when society deems children powerless, silences their voices, and enforces this silence through policy. We then discuss the ways educators can resist these notions to promote children's agency and protect children from sexual abuse.

Challenges

Power in Society

Traditionally in Australian society (and many other western societies) children are not considered part of the group that holds power, the group that runs society. Rather, in many ways, they are positioned as out-group members until the time they mature, and have been sufficiently educated to maintain the status quo as adult citizens, to maintain the national narrative as it has been. With the authoritarianism that comes with right-wing compliance welfare and weakened human rights based safeguards (Ottmann, 2020), as members of an out-group, children are silenced, and must rely on others, usually parents, to speak for them, to make decisions for them (ostensibly in their bests interests) and to protect them. In this narrative, children are positioned as innocent, in need of protection, justifying placing them as powerless members of an out-group. Indeed, the safety narrative positions children's innocence as at risk should they be exposed to certain kinds of information, thus it is argued to be in their best interests to restrict their access to 'forbidden' knowledge to avoid corrupting them (Shevlin & Gill, 2020). Certain types of knowledge are perceived, rather like a virus, as capable of spreading, corrupting children. Thus particular information can be "deviant, dangerous and potentially catching" (Rawlings & Loveday, 2022, p. 856). Topics such as gender diversity and sexuality fall clearly into the category of controversial; topics that threaten children's innocence, therefore children need to be protected from such knowledge in order to ensure their safety. Whilst great progress has been made by parents, adults, institutions and agencies to support children in ways not perceived decades ago, clearly more needs to be done.

One example of this quarantining of knowledge to protect children is the knowledge associated with sex. Given that appropriate forms of sex education are found to help prevent sexual violence (Wazlawik et al., 2017), it has been argued for many years that one of the best ways to protect children from sexual abuse is to teach them appropriate forms of touch, and ways to behave when they experience inappropriate forms of touch (Lu et al., 2022; Russell et al., 2020). There are now many effective prevention programs that educators should be made aware of in their initial teacher education courses as an effective way to reduce risks and harm. Apart from the inclusion of age-appropriate discussions about appropriate forms of touch and consent, the program emphasises the need for children to tell a trusted adult (Finkelhor, 2009; Rudolph et al., 2018). Additionally, the programs emphasise the need for parent-educator communication to ensure children feel safe sharing information and asking questions. This positions children as active agents in their own lives, as mandated in 1990 when the Australian Government ratified the UNCROC.

Van Der Kolk (2014) describes the hidden prevalence of children and adult survivors of childhood sexual abuse in our societies so it is clear that despite decades of research reporting the importance of providing age-appropriate sex education, the topic remains controversial in Australia (Shannon, 2022) with many students reporting the information they received as inadequate and incomplete (Waling et al., 2020). Whilst all adults could be positioned as responsible for children's safety, some have mandatory responsibilities, such as school teachers and early childhood educators. In addition to training about their mandatory reporting responsibilities, educators and school teachers need to be provided with training in trauma informed support to ensure they are supporting children who have experienced trauma.

It should be noted that apart from age-appropriate information, all children need information about prevention. Conversely, children who have not been exposed to sexual violence do not need the same level of information that children who have been exposed might need. Therefore, care through specialists such as sexual abuse support workers and counsellors is needed and ideally all adults need to provide sufficient information to give children agency over their safety, as well as knowledge to recognise the signals that suggest more in-depth support may be required.

Tailoring the necessary information, and identifying relevant signals to children's levels of understanding is essential. Research with very young children is limited but there are now screening tools being developed that help educators identify concerning signs in infants and toddlers (Bisagno et al., 2023). Forensic interview techniques are now well established with children as young as 2 years of age (Fernandes et al., 2023) although research with parents of children aged one to five years has to date not demonstrated improvements in parental efficacy in sexual communication with their children (Ferguson et al., 2023). Whilst we know that education programmes for children are more successful over the age of 8 years (Lu et al., 2023), it remains important that all children, irrespective of their age, should be able to be heard and encouraged to ask questions. Both educators and school teachers need to understand how children's voices are silenced in society, and how this is enabled through policies.

Silencing Children's Voices

Notwithstanding this, the voices of children who experience sexual violence are often silenced; it is as if they, as survivors, are sharing information that is inappropriate for children when they speak about their experiences (Rogers et al., 2022). In a sense, their voicelessness can be constructed as the tension between their right to speak (freedom of speech) and political correctness. The latter is a space where it is believed that knowledge inappropriate for children should be censored and silenced (Shevlin & Gill, 2020). In this perspective, children who have experienced sexual violence and survived should be silenced and hidden so their experiences do not contaminate the innocence of other children.

Children's experience of sexual violence often starts in the home, or a place where a trusted adult is present (Australian Institute of Health and Welfare, 2022; Gilmore, 2017). This makes hearing their voices more problematic, because in order to survive their childhood, children often block out their experiences (Van Der Kolk, 2014). Trauma can resurface through various behaviours and emotions, often making relationships difficult in both childhood and adulthood. There is evidence that the earlier the maltreatment was experienced, the more frequently the trauma was experienced and exposure to multiple forms of trauma all make it more likely children will to be developmentally vulnerable throughout their early years (Green et al., 2018). This developmental vulnerability creates a foundation upon which later learning and development are based; an idea encapsulated in the pathway model of the impact of stress (Gustafsson et al., 2010). This model proposes that exposure to traumatic life events, such as sexual abuse, creates a wear and tear effect on physiology and neurobiology, creating allostatic load (Fava et al., 2023). Outcomes of chronically heightened allostatic load include a hypervigilant immune system that struggles to differentiate between major and minor threats causing chronic auto-immune diseases and increased risk of cardiovascular illnesses in later life. Exposure to stressful life events has even been demonstrated to impact on the structure of brain white matter, effects that can be traced throughout the lifespan (Poletti et al., 2023).

Children are often silenced by fear of the perpetrator. Often, they report a feeling that they were not heard. One survivor wrote:

> *"... telling [about the abuse] is not an option. I told them who he was [the abuser] and a very general sentence about him touching me. Two days later, I found myself at school as if nothing had happened. The educational staff did not know anything." (Attrash-Najjar & Katz, 2023, p. 5)*

Male survivors feel an additional disadvantage. Given that the majority of child sexual abuse targets are girls, male survivors often report feeling they were not believed and that their voices were eclipsed (Gill & Begum, 2023). As adults, victims find it difficult to expose family members and live with the ramification of divided families. At any age, they fear being disbelieved because perpetrators have often groomed the whole family. They also struggle to know who to trust and if they will be believed (Van Der Kolk, 2014).

The privacy of the family has often been used to avoid society's gaze (Dimopoulos, 2023), making it more difficult for children to speak about sexual violence. Roy (2004) reminds us that "there's really no such thing as the 'voiceless'. There are only the deliberately silenced, or the preferably unheard" (para. 4). When children enter early childhood services and schools their world widens and there are other adults interacting with them who have the opportunity to create a safe space where children can share their experiences, receive appropriate support and education that addresses their safety needs and creates a context where they can learn more about the nature of healthy human relationships. They also need to learn how to communicate (in particular the words to use) when they are exposed to, or part of, unhealthy relationships. Whilst there remain barriers preventing children from disclosing to a trusted adult, (Brennan & McElvaney, 2020; Halvorsen et al., 2020) it is the responsibility of adults to create a space where children feel safe to disclose, and have opportunities to do so. It is adults who have the responsibility to address the multiple ways in which children are silenced.

In the next section we explore an example of silencing of children through policy. It should be noted that this is a separate issue to child sexual abuse and trauma.

Silencing through Policy

Whilst silencing operates in the context of families, communities and society, it also plays out in the public arena through policy as an extension of social control. One such example is the furore that surrounded the Safe Schools initiative offered by the Safe Schools Coalition Australia (SSCA). This initiative, developed at the end of the Rudd-Gillard government in Australia and begun by the Abbott government in June 2014, was the first national programme designed to support LGBTQAI+ school-aged children (Kurti, 2017). "The aim of the Coalition's work was to help create safer school communities for all students, especially those who were gender variant and sexually diverse" (Thompson, 2019, p. 41). The initiative began in the state of Victoria in 2010 and operated for around 5 years with minimal controversy. It was supported by federal funding from June 2014 and began to roll out across the country. In 2015 the Coalition published a teacher's guide (Safe Schools Coalition Australia, 2016) which began

immediately to receive negative publicity. A number of right wing politicians and media commentators claimed that the material "promoted radical and potentially dangerous views about sexuality and gender", promoted homosexuality and was a threat to children's safety (Thompson, 2019, p. 43). A significant swathe of media critiqued the content as grooming children along with encouraging sexual deviance and paedophilia; positioning, "gender diversity as being deviant, dangerous and potentially catching" (Rawlings & Loveday, 2022, p. 856). Family First Senator, Bob Day, called the programme anti-family and Nationals MP George Christensen, in a speech to Parliament "said the program recommended pornographic material, sex clubs and sex shops, among other things. He also said materials included information on chest-binding, penis-tucking and unlocking parental safety controls" (Zaglas, 2019)

Interestingly, opposition to these views became located in an anti-democratic frame, making it difficult to challenge them:

> *... 'civil society' was at risk because of a minority of people who were persecuting those with conservative views – in this case, particularly around the Safe Schools programme. As such, this problem frame represented that the solution to resisting the erosion of Western democracy and society was to reject Safe Schools (Rawlings & Loveday, 2022, p. 858).*

There were a number of children's voices speaking about the benefits of the programme. In a video available online, (https://player.vimeo.com/video/253728005 0:28 - 0:45), Georgie, a student who was part of a Safe Schools programme said:

> *I think Safe Schools coming in has relieved the pressure off me. I ended up coming out to my friends and they felt more educated and more able to support. I feel like, as a trans young person I can be out and proud.*

Other students credit the Safe School programme with the lack of discrimination they experienced when they 'came out' at school (Alcorn, 2016a). Alcorn continues with quotes from a number of students and parents who found the Safe School experience to not only be positive, but also potentially life-saving.

A review of the programme in 2016 (Louden, 2016) recommended a number of changes including removing 3rd-party links to websites such as LGBTQIA+ websites, restricting materials to high school only, restricting some materials (e.g. OMG I'm Queer) to selected individuals only, and requiring parental consent for participation. Victoria and the ACT, at the time, elected to continue the programme in its original form (despite this resulting in withdrawal of federal funding) whilst other states agreed to the modifications identified in the review (Alcorn, 2016b). Amid ongoing calls for scrapping the programme, the NSW government later decided to substitute it for one that had a more general focus on anti-bullying (Haydar, 2017), again silencing the voices of the LGBTQIA+ students the programme was specifically designed to include.

These examples illustrate the moral panic that surrounds the concept of children and issues relating to gender and sexuality, topics that are considered dangerous and a threat to children's safety (Ullman et al., 2023). In this context, moral panic refers to "something or someone that can be defined as a threat to interests or values" (Rawlings & Loveday, 2022, p. 852), with the destruction of children's innocence represented by sharing so-called unsuitable material with them risking the destruction of society (or at least society as constructed by the in-group). Despite the moral panic associated with the Australian "first national initiative for inclusion of gender and sexuality diversity," it is clear that this policy decision "relied on negative testimonies from conservative parents" (Ullman et al., 2023, p. 1), particularly given that the research undertaken by Ullman and colleagues suggested that the majority of parents in Australia are likely to be supportive of education related to gender and sexual diversity. However, the right-wing push back against perceived threats such as this function to continue to silence children and to ensure they remain without information many identify as necessary for their wellbeing. This not only marginalises those children who have the prohibited knowledge (in the examples above children who have experienced sexual violence, children who are LGBTQIA+), but ensures the ignorance of others who do not have this knowledge, risking their future wellbeing and safety. This has major implications for early childhood education.

Discussion and Implications

Given what we know of the importance of the early childhood years in laying the foundations in brain development for future learning, health and wellbeing (Black et al., 2017; Cattan et al., 2022; Heckman & Karapakula, 2019; Spiteri, 2022; Strong Foundations, 2019), and the negative impact of chronic stress on children's outcomes (in particular allostatic load, see Guidi et al., 2021) we argue that it is essential that early childhood educators advocate strongly for the inclusion of such 'forbidden' topics as those above in the early childhood curriculum. Early childhood, we argue, is an appropriate place to begin this education in age-appropriate way. The National Children's Mental Health and Wellbeing Strategy (National Mental Health Commission, 2021, p. 7) reinforces this, claiming that:

> *There is nothing that will have more impact on improved mental health outcomes for all Australians than early intervention. Investing in the wellbeing of children and their families will have radiating benefits throughout our communities as well as through the broader health and education systems.*

The need for early intervention is paramount and this intervention must be child-centred, interdisciplinary, age and culturally appropriate, and universally available (Burgess et al., 2022; Rogers, 2021; Rogers et al., 2021; Rogers et al., 2024). These are all characteristics common in early childhood pedagogy (Sims, 2011). Additionally, early childhood educators need to be trauma informed, because many children are exposed to trauma through the transgenerational transference of trauma and vicarious trauma (Branson, 2019; Tujague & Ryan, 2023). Trauma and its impacts can also be passed on to children generationally via epigenetic mechanisms (Jawaid et al., 2018; Krippner & Barrett, 2019; Ryan et al., 2016). Early childhood educators need to be particularly aware of the signs of stress children exhibit (often these are individualised, requiring extensive knowledge of each child developed through professional observation and ongoing interaction). Tools to assist in identifying signs of trauma as the first step in trauma-informed practice are now being developed (for example, Beehag et al., 2023). As a key element in trauma-informed practice, early childhood educators need a sound understanding of how best to make their services places of sanctuary (Bloom, 1995) for children. This involves recognising behaviours that might otherwise be interpreted as 'bad', as both attempts at communication and as adaptations necessary for them to manage the stresses they face (Guidi et al., 2021). As Bloom (1995, p. 4) wrote nearly 30 years ago:

> *The key in strategizing how to handle "bad" kids is figuring out how not to do what they are cueing us to do. These children are quite comfortable with rejection, abuse, harsh discipline, unrealistic expectations, hostility, and pain. This is normal for them; it is predictable and in this predictability they feel some tenuous form of safety. They invite rejection; they set up situations in which it is extremely difficult for us to resist treating them in kind. They are not comfortable with firm but fair limits, realistic and clear expectations, kindness, understanding, respect and compassion. They will see this behaviour as suspicious, threatening, unpredictable and terribly frightening until they have tested it repeatedly to see if the safety holds.*

More recent research adds to Bloom's ideas, adding the concept of self-regulation as a key factor in supporting children who have experienced trauma, or who are currently experiencing trauma to reduce levels of anxiety and challenging behaviours (Emerson, 2022). Thus understanding how self-regulation develops (Wu et al., 2021), and its links to prerequisite skills such as emotional regulation (Gagne et al., 2021) become important components of early childhood professionals' toolbox of knowledge. Early childhood educators need to develop skills in co-regulating the emotions of very young children, carefully scaffolding their levels of emotional regulation and gradually encouraging children to take responsibility for self-regulation (Thomas, 2021). Many educators and school teachers are now benefiting from trauma informed practice training (e.g. Australian Childhood Foundation https://professionals.childhood.org.au/training-development/).

Whilst focusing on a social-emotional pedagogy is considered a standard element of current early childhood practice (Department of Education Employment and Workplace Relations, 2009), the inclusion of information addressing the underlying causes of children's stress and trauma (such as the 'forbidden topics' of gender and sexuality) is not easy as the right-wing swing is reflected not only in the political arena but in communities of parents who also reject the rights of their children to access certain (prohibited) information. For example, in their study Shevlin and Gill (2020, p. 16) found that for a number of parents:

> *The existence of open homosexuals was viewed as defiant. The implication was that there is an unwarranted challenge to heterosexual power by homosexuals. Furthermore, implicit in their scorn of open homosexuality was a desire for homosexuals to become closeted, ashamed and subordinated. This would allow for heterosexuals to avoid the threat that open homosexuality poses to their ego... Despite implicit acknowledgement of homosexual oppression, these parents expressed the feeling of oppression as heterosexuals.*

However, a focus on strategies that address the consequences of stress and trauma in children without simultaneously focusing on providing information and support addressing the causes of the stress and trauma is rather like worrying without the ability to change anything. As long as children continue to be harmed by the stress and trauma associated with sexual violence and heteronormativity, early childhood educators will always need to manage their challenging coping behaviours. Social emotional early childhood pedagogy must be accompanied by the ability to provide children with the necessary information to understand how to reduce the risks of exposure to sexual violence, and to affirm who they are irrespective of their gender expression.

In the next sections, we discuss the need for further research and summarise the article.

Need For Further Research

This discussion paper has revealed the need for further research. A desk review of ITE course inclusion of these sensitive topics, along with trauma informed support from unit outlines available on the internet might reveal the prevalence and depth of such topics. Additionally, there is a need to find out from educators their level of knowledge, competence and confidence in supporting children and families who experience sexual trauma.

Conclusion

Early childhood educators are immersed in community, societal and policy frameworks that support silencing around forbidden topics for young children. Challenging this silencing is not easy and those who choose to do so can often be aggressively attacked for their attempts. For example Maughan et

al. (2022) write about the institutional transphobia that created multiple barriers for a student attempting to research transgender issues in early childhood. In a similar manner, the early childhood educators in Shevlin and Gill (2020)'s study had to negotiate the negative parental perceptions about the Safe Schools Programme. If early childhood educators are to address these forbidden topics (and we believe they should) they need a supportive community around them; a community that assists them to offer opportunities for all children to address inclusion, to ensure all children feel valued, accepted and supported. They need extensive preparation in their pre-service studies to understand why and how to undertake this important task. This should include access to both preventative education and trauma informed support programs. Parents also need support and early childhood educators have a role in helping all parents understand the impact of prejudice and exclusion on children, and the ways in which they can help to ensure all children feel valued and accepted for who they are. Again, working with parents is an important element of pre-service preparation for early childhood educators, and this preparation needs to include working with parents on difficult and forbidden topics. When we are able to support all children to be who they are we will be able to fulfil Bloom's (1995, pp. 429 - 430) dream:

> *... we need to learn to function as an orchestra, sometimes performing a classical symphony, but more usually improvising jazz. Wonderful music requires many different kinds of instruments, with different ranges, different tones, and different levels of participation. But they all must be properly tuned and able to make the appropriate individual contribution to the whole. The best music happens when each individual musician is a virtuoso who integrates his or her unique creative gift with other gifted performers until the results of their efforts make a melody and a harmony, a sound that is far greater than that of each individual alone.*

Echoing this, Van Der Kolk (2014, p. 356) explains that many of our great innovators of "social change have intimate personal knowledge of trauma... (due to) insights and passions that came from having dealt with devastation". He goes on to say that the "same is true of societies" such as advances due to the Great Depression and wars (Van Der Kolk, 2014, p. 356). He also states,

> *trauma is now our most urgent public health issues and we have the knowledge necessary to respond effectively. The choice is ours to act on what we know (Van Der Kolk, 2014, p. 356).*

Empowering children's voices and training educators in how to prevent abuse, and support children's experiences of trauma and difference is a first and very necessary step. In turn, this will enable children to be active agents in their own lives, as mandated by the UNCROC. Ensuring our pre-service teacher training courses equip educators to ensure they have the knowledge, competence and confidence to support children's voices in this area is essential.

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Reference

Alcorn, G. (2016a). 'She's just a happy little girl now': the Safe Schools effect on students. *The Guardian, Wednesday 14 December*, 11 pages downloaded. https://www.theguardian.com/australia-news/2016/dec/14/shes-just-a-happy-little-girl-now-the-safe-schools-effect-on-students

Alcorn, G. (2016b). What is Safe Schools, what is changing and what are states doing? *The Guardian, 14 December*, 7 pages downloaded. https://www.theguardian.com/australia-news/2016/dec/14/what-is-safe-schools-what-is-changing-and-what-are-states-doing

Alston, P., & Brennan, G. (Eds.). (1991). *The UN Convention and Australia*. Human Rights Commission ANU Centre for International and Public Law and Australian Council of Social Service. https://humanrights.gov.au/sites/default/files/document/publication/Australia_CRC_1991.pdf.

Attrash-Najjar, A., & Katz, C. (2023, 2023/02/01/). "The story of the abuse as the story of my life": Narrative analysis of the stories of survivors of prolonged child sexual abuse. *Children and Youth Services Review, 145*, 106774. https://doi.org/https://doi.org/10.1016/j.childyouth.2022.106774

Australian Institute of Health and Welfare. (2022). *Family, domestic and sexual violence*. Australian Government https://www.aihw.gov.au/reports/domestic-violence/family-domestic-and-sexual-violence

Beehag, N., Dryer, R., McGrath, A., Krägeloh, C., & Medvedev, O. (2023, 2023/10/01/). Design and development of the trauma informed care beliefs scale-brief. *Children and Youth Services Review, 153*, 107087. https://doi.org/https://doi.org/10.1016/j.childyouth.2023.107087

Bisagno, E., Cadamuro, A., Serafine, D., Dima, B. M., Anne, G., Zane, L.-O., Annija, K., Dóra, V.-S., Dorottya, M., Noémi, L., Monika, R., Andrea, G., Giovanna Laura, D. F., & Johanna Maria Catharina, B. (2023). The Development of a Screening Tool for Childcare Professionals to Detect and Refer Infant and Toddler Maltreatment and Trauma: A Tale of Four Countries. *Children, 10*(5), 858 - 873. https://www.mdpi.com/2227-9067/10/5/858

Black, M. M., Walker, S. P., Fernald, L. C. H., Andersen, C. T., DiGirolamo, A. M., Lu, C., McCoy, D. C., Fink, G., Shawar, Y. R., Shiffman, J., Devercelli, A. E., Wodon, Q. T., Vargas-BarÓn, E., Grantham-McGregor, S., & for the Lancet Early Childhood Development Series Steering Committee. (2017). Advancing Early Childhood Development: from Science to Scale 1. Early childhood development coming of age: science through the life course. *The Lancet, 389*, 77 - 90. https://doi.org/http://dx.doi.org/10.1016/S0140-6736(16)31389-7

Bloom, S. L. (1995). Creating Sanctuary in the School. *Journal for a Just and Caring Education, 1*(No. 4), 403-433. http://sanctuaryweb.com/PDFs_new/Bloom%20Sanctuary%20in%20the%20Classroom.pdf

Branson, D. C. (2019). Vicarious trauma, themes in research, and terminology: A review of literature. *Traumatology, 25*(1), 2.

Brennan, E., & McElvaney, R. (2020). What Helps Children Tell? A Qualitative Meta-Analysis of Child Sexual Abuse Disclosure. *Child Abuse Review, 29*(2), 97-113. https://doi.org/https://doi.org/10.1002/car.2617

Burgess, S., Rogers, M., & Jeffries, D. (2022). Empathy and narrative: A discussion of contemporary stories from education and health. *International Electronic Journal of Elementary Education, 14*(5), 631-646. https://www.iejee.com/index.php/IEJEE/article/view/1854/594

Cass, B. (1991). Towards a national agenda for children. In P. Alston & G. Brennan (Eds.), *The UN Convention and Australia.* (pp. 22 - 28). Human Rights and Equal Opportunity Commission ANU Centre for International and Public Law and Australian Council of Social Service. https://humanrights.gov.au/sites/default/files/document/publication/Australia_CRC_1991.pdf

Cattan, S., Fitzsimons, E., Goodman, A., Phimister, A., Ploubidis, G., & Wertz, J. (2022). *Early childhood inequalities. The IFS Deaton Review of Inequalities*. https://ifs.org.uk/sites/default/files/2022-08/Early-childhood-inequalities-IFS-Deaton-Review%20%282%29%20%288%29.pdf

Department of Education Employment and Workplace Relations. (2009). *Belonging, being and becoming. The Early Years Learning Framework for Australia.* [Produced for the Council of Australian Governments]. Commonwealth of Australia. https://www.acecqa.gov.au/sites/default/files/2018-02/belonging_being_and_becoming_the_early_years_learning_framework_for_australia.pdf

Dimopoulos, G. (2023). *Decisional privacy and the rights of the child*. Routledge. https://doi.org/10.4324/9781003224167

Emerson, A. (2022, 2022/07/03). The case for trauma-informed behaviour policies. *Pastoral Care in Education, 40*(3), 352-359. https://doi.org/10.1080/02643944.2022.2093956

Fava, G. A., Sonino, N., Lucente, M., & Guidi, J. (2023). Allostatic Load in Clinical Practice. *Clinical Psychological Science, 11*(2), 345-356. https://doi.org/10.1177/21677026221121601

Ferguson, M. M., Dotterer, A. M., Schwartz, S. E., & Bradford, K. (2023, 2023/01/02). Parental sexual communication self-efficacy with toddlers and young children: an active learning intervention. *Sex Education, 23*(1), 128-146. https://doi.org/10.1080/14681811.2022.2034612

Fernandes, D., Gomes, J. P., Albuquerque, P. B., & Matos, M. (2023). Forensic Interview Techniques in Child Sexual Abuse Cases: A Scoping Review. *Trauma, Violence, & Abuse, 0*(0), 15248380231177317. https://doi.org/10.1177/15248380231177317

Finkelhor, D. (2009). The prevention of childhood sexual abuse. *The future of children*, 169-194.

Flannery, B. J., Watt, S. E., & Schutte, N. S. (2021). Looking out for (White) Australia: Developing the construct and a measure of right-wing protective popular nationalism. *International Perspectives in Psychology: Research, Practice, Consultation, 10*, 74-91. https://doi.org/10.1027/2157-3891/a000008

Gagne, J. R., Liew, J., & Nwadinobi, O. K. (2021, 2021/06/01/). "How does the broader construct of self-regulation relate to emotion regulation in young children?". *Developmental Review, 60*, 100965. https://doi.org/https://doi.org/10.1016/j.dr.2021.100965

Gill, A. K., & Begum, H. (2023). 'They Wouldn't Believe Me': Giving a Voice to British South Asian Male Survivors of Child Sexual Abuse. *The British Journal of Criminology, 63*(5), 1146-1164. https://doi.org/10.1093/bjc/azac097

Gilmore, J. (2017, 5.7.17). Domestic violence half-yearly update: The numbers we need to know. *The Sydney Morning Herald*.

Green, M. J., Tzoumakis, S., McIntyre, B., Kariuki, M., Laurens, K. R., Dean, K., Chilvers, M., Harris, F., Butler, M., Brinkman, S. A., & Carr, V. J. (2018). Childhood Maltreatment and Early Developmental Vulnerabilities at Age 5 Years. *Child Development, 89*(5), 1599-1612. https://doi.org/doi:10.1111/cdev.12928

Guidi, J., Lucente, M., Sonino, N., & Fava, G. A. (2021). Allostatic Load and Its Impact on Health: A Systematic Review. *Psychother Psychosom, 90*(1), 11-27. https://doi.org/10.1159/000510696

Gustafsson, P., Janlert, U., Theorell, T., Westerlund, H., & Hammarström, A. (2010). Socioeconomic status over the life course and allostatic load in adulthood: results from then Northern Swedish Cohort. *Journal of epidemiology and community health* https://doi.org/10.1136/jech.2010.108332

Halvorsen, J. E., Tvedt Solberg, E., & Hjelen Stige, S. (2020, 2020/06/01/). "To say it out loud is to kill your own childhood." – An exploration of the first person perspective of barriers to disclosing child sexual abuse. *Children and Youth Services Review, 113*, 104999. https://doi.org/https://doi.org/10.1016/j.childyouth.2020.104999

Hart, A. (2021). Right-Wing Waves: Applying the Four Waves Theory to Transnational and Transhistorical Right-Wing Threat Trends. *Terrorism and Political Violence*, 1-16. https://doi.org/10.1080/09546553.2020.1856818

Haydar, N. (2017). Safe Schools program ditched in NSW, to be replaced by wider anti-bullying plan. *ABC News, Sunday 16 April*, 3 pages downloaded. https://www.abc.net.au/news/2017-04-16/safe-schools-program-ditched-in-nsw/8446680

Heckman, J., & Karapakula, G. (2019). *Intergenerational benefits of high-quality early childhood education for underprivileged children: Evidence from the iconic Perry Preschool Project* https://voxeu.org/article/intergenerational-benefits-high-quality-early-childhood-education-underprivileged-children

Jawaid, A., Roszkowski, M., & Mansuy, I. M. (2018). Transgenerational epigenetics of traumatic stress. *Progress in molecular biology and translational science, 158*, 273-298.

Krippner, S., & Barrett, D. (2019). Transgenerational Trauma: The Role of Epigenetics. *Journal of Mind & Behavior, 40*(1).

Kurti, P. (2017). Review of Moral Panic 101: Equality, Acceptance and the Safe Schools Scandal By Benjamin Law Quarterly Essay, Issue 67, Melbourne, Black Inc., September 2017. *Policy, 33*(4), 57 - 58.

Louden, B. (2016). *Review of Appropriateness and Efficacy of the Safe Schools Coalition Australia Program Resources*. https://www.education.gov.au/student-resilience-and-wellbeing/resources/review-appropriateness-and-efficacy-safe-schools-coalition-australia-program-resources

Lu, M., Barlow, J., Meinck, F., Walsh, K., & Wu, Y. (2022). School-based Child Sexual Abuse Interventions: A Systematic Review and Meta-analysis. *Research on Social Work Practice, 0*(0), 10497315221111393. https://doi.org/10.1177/10497315221111393

Lu, M., Barlow, J., Meinck, F., Walsh, K., & Wu, Y. (2023). School-based Child Sexual Abuse Interventions: A Systematic Review and Meta-analysis. *Research on Social Work Practice, 33*(4), 390-412. https://doi.org/10.1177/10497315221111393

Maughan, L., Natalier, K., & Mulholland, M. (2022). Institutional transphobia: barriers to transgender research in early years education. *Gender and Education, 34*(6), 721 - 737. https://doi.org/0.1080/09540253.2022.2057930

National Mental Health Commission. (2021). *The National Children's Mental Health and Wellbeing Strategy Report*. Australian Government. https://www.mentalhealthcommission.gov.au/getmedia/9f2d5e51-dfe0-4ac5-b06a-97dbba252e53/National-children-s-Mental-Health-and-Wellbeing-Strategy-FULL

Ottmann, G. (2020). Surveillance, sanctions, and behaviour modification in the name of far-right nationalism. The rise of authoritarian 'welfare' in Australia. In C. Noble & G. Ottmann (Eds.), *The Challenge of Right-wing Nationalist Populism for Social Work* (pp. 16 pages). Routledge. https://doi.org/https://doi.org/10.4324/9780429056536

Parker, S. (1991). How can 'Rights-talk' help children. An academic perspective. In P. Alston & G. Brennan (Eds.), *The UN Convention and Australia.* (pp. 16 - 19). Human Rights and Equal Opportunity Commission ANU Centre for International and Public Law and Australian Council of Social Service. https://humanrights.gov.au/sites/default/files/document/publication/Australia_CRC_1991.pdf

Poletti, S., Carminati, M., & Zanardi, R. (2023). Environment and White Matter: Risk and Resilience Factors. *Biological Psychiatry, 94*(8), 605 - 606. https://doi.org/10.1016/j.biopsych.2023.07.006

Rawlings, V., & Loveday, J. (2022, 2022/11/02). 'A threat to the social order': a 'problem frame' analysis of the Safe Schools Coalition Australia programme within print media. *Discourse: studies in the cultural politics of education, 43*(6), 851-865. https://doi.org/10.1080/01596306.2021.1918060

Rogers, M. (2021). Contextualised, not Neoliberalised Professionalism in Early Childhood Education and Care: Effects of Prescribed Notions of Quality on Educator Confidence in Australia. *International Electronic Journal of Elementary Education, 13*(4), 549-564. https://www.iejee.com/index.php/IEJEE/article/view/1447/532

Rogers, M., Bible, V., Johnson, A., Bird, J., Harrington, I. & Baker, P. (2021). International programs and resources to support children from military families: A review. *International Electronic Journal of Elementary Education, 14*(2), 119-133. doi:10.26822/iejee.2022.23https://www.iejee.com/index.php/IEJEE/article/view/1756

Rogers, M., Sims, M. & Boyd, W. (2022). The bold and the backlash: When marginalised voices are heard in neoliberal land. *International Electronic Journal of Elementary Education, 14*(4), 459-473. https://doi.org/10.26822/iejee.2022.256

Rogers, M., Ul-Haq, A., Dittman, C., Gossner, M., Krishnamoorthy, G., Small, E., Kanard, T., Johnson, A., Coffey, Y., Hébert, M. L., & Thorsteinsson, E. (2024). Interdisciplinary research collaboration in higher education: Improving end-user experience in children's programs. *Issues in Educational Research, 34*(4), 1548-1572. http://www.iier.org.au/iier34/rogers3-abs.html

Roy, A. (2004, 3.11.2004). *Peace and the new corporate liberation theology* Sydney Peace Prize Lecture, University of Sydney. http://sydney.edu.au/news/84.html?newsstoryid=279

Rudolph, J., Zimmer-Gembeck, M. J., Shanley, D. C., & Hawkins, R. (2018). Child sexual abuse prevention opportunities: Parenting, programs, and the reduction of risk. *Child maltreatment, 23*(1), 96-106.

Russell, D., Higgins, D., & Posso, A. (2020, 2020/04/01/). Preventing child sexual abuse: A systematic review of interventions and their efficacy in developing countries. *Child Abuse & Neglect, 102*, 104395. https://doi.org/https://doi.org/10.1016/j.chiabu.2020.104395

Ryan, J., Chaudieu, I., Ancelin, M.-L., & Saffery, R. (2016). Biological underpinnings of trauma and post-traumatic stress disorder: focusing on genetics and epigenetics. *Epigenomics, 8*(11), 1553-1569.

Safe Schools Coalition Australia. (2016). *All of Us*. https://studentwellbeinghub.edu.au/media/9299/all-of-us-online-version-may-2016-v3.pdf accessed 20 December 2022

Shannon, B. (2022). Sex(uality) Education in Australia from Past to Present. In B. Shannon (Ed.), *Sex(uality) Education for Trans and Gender Diverse Youth in Australia* (pp. 29-55). Springer International Publishing. https://doi.org/10.1007/978-3-030-92446-1_3

Shevlin, A., & Gill, P. R. (2020). Parental attitudes to the Australian anti-bullying Safe Schools program: a critical discourse analysis. *Social Psychology of Education, 23*(4), 891-915.

Sims, M. (2011). *Social inclusion and the early years learning framework: A way of working.* Pademelon Press.

Spiteri, J. (2022). The Untapped Potential of Early Childhood Education for Planetary Health: A Narrative Review. In W. Leal Filho (Ed.), *Handbook of Human and Planetary Health* (pp. 297-311). Springer International Publishing. https://doi.org/10.1007/978-3-031-09879-6_17

Strong Foundations. (2019). *The first thousand days: A case for investment*. https://www.aracy.org.au/documents/item/608

Thomas, C. D. (2021). *Preschool and Kindergarten Teachers' Perspectives on Effective Strategies and Practices for Supporting Self-Regulation* Walden University].

Thompson, J. D. (2019, 2019/01/02). Predatory schools and student non-lives: a discourse analysis of the Safe Schools Coalition Australia controversy. *Sex Education, 19*(1), 41-53. https://doi.org/10.1080/14681811.2018.1475284

Tujague, N., & Ryan, K. (2023). Sharing Trauma Knowledge: Types of Trauma. In *Cultural Safety in Trauma-Informed Practice from a First Nations Perspective: Billabongs of Knowledge* (pp. 113-158). Springer International Publishing. https://doi.org/10.1007/978-3-031-13138-7_5

Ullman, J., Hobby, L., & Ferfolja, T. (2023). Revalidating a Measure of Parents' Attitudes Toward Gender and Sexuality Diversity-Inclusive Curricula in an Australian National Sample. *Journal of Homosexuality*, 1-24. https://doi.org/10.1080/00918369.2023.2178355

Van Der Kolk, B. (2014). *The body keeps the score: Mind, brain and body in the transformation of trauma*. Penguin.

Waling, A., Bellamy, R., Ezer, P., Kerr, L., Lucke, J., & Fisher, C. (2020). 'It's kinda bad, honestly': Australian students' experiences of relationships and sexuality education. *Health Education Research, 35*(6), 538-552. https://doi.org/10.1093/her/cyaa032

Wazlawik, M., Christmann, B., & Dekker, A. (2017, Sep). [Sex education and prevention of sexual violence : Contributions to a differential-sensitive prevention of sexualised violence]. *Bundesgesundheitsblatt Gesundheitsforschung Gesundheitsschutz, 60*(9), 1040-1045. https://doi.org/10.1007/s00103-017-2594-x (Sexualpädagogik und Gewaltprävention : Beiträge zu einer differenzsensiblen Prävention von sexualisierter Gewalt.)

Wu, Q., Yan, J., & Cui, M. (2021). A Developmental Hierarchical-Integrative Perspective on the Emergence of Self-Regulation: A Replication and Extension. *Child Development, 92*(5), e997-e1016. https://doi.org/https://doi.org/10.1111/cdev.13559

Zaglas, W. (2019). Looking back at Safe Schools. *Education Review, May 24*, 3 pages downloaded. https://www.educationreview.com.au/2019/05/looking-back-at-safe-schools/

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Professional Development Experiences Designed to Develop Teachers' Empathy and Engagement with Emergent Bilinguals in Mathematics

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Abstract

In this study, we explore the impact of professional development (PD) on teacher empathy and engagement with emergent bilingual (EB) students in mathematics classrooms. Advancing Inquiry in Middle Mathematics for Rural East Texas (AIMM) a two-year A PD project, targeting teachers in rural schools, aimed to shift teaching beliefs from directive to connected approaches and to increase content knowledge. Three activities are described in detail. During the tasks, teachers experienced the perspectives of EB students, fostering empathy and enhancing their instructional strategies. Pre-post data and monthly reflections demonstrated shifts in teaching practices, highlighting increased use of cognitively demanding tasks and improved teacher-student interactions. Teachers reported greater cultural awareness and understanding of EB students, attributing these changes to the empathetic experiences provided by the PD. Our findings highlight the necessity of incorporating empathy in PD to support diverse students' emotional and cognitive needs, ultimately promoting inclusive and effective teaching practices. These findings suggest that empathy-focused PD can mitigate unproductive teaching beliefs and enhance the learning environment for all students.

Keywords:

Teacher Empathy, Professional Development, Emergent Bilingual Students, Mathematics Education

Introduction

In the United States, student demographics continue to evolve and grow rapidly across public schools. Among these fast-growing groups is the emergent bilingual student population. According to the National Center for Education Statistics (NCES, 2023), there were 5.0 million emergent bilingual students (EBs) in the United States in 2020. This demographic shift necessitates the development of strategies within school districts to accommodate the academic needs of this growing population. Texas alone has approximately 1,269,408 EB students, comprising 23.1% of the student population (Texas Education Agency [TEA], 2023a). Unfortunately, school administrators and teachers often lack adequate support or professional development

(PD) training to effectively address EB students' academic, cultural, and linguistic needs.

Using mathematics as a pathway, teachers can enhance teacher-student engagement, incorporate culturally relevant learning opportunities, and better understand EB students' cultural and linguistic backgrounds. This approach may significantly increase academic achievement levels. Professional development for teachers, focusing on increasing content knowledge in mathematics while considering students' cultural backgrounds and incorporating culturally relevant materials, can collectively impact teachers' beliefs about instruction and learning, potentially rectifying previously counterproductive beliefs.

The Advancing Inquiry in Middle Mathematics for Rural East Texas (AIMM) two-year professional development project focused on increasing teachers' content knowledge and shifting beliefs about teaching and learning mathematics from a "teaching as telling" approach to teaching math as a connected set of ideas (Plowman & Lynch-Davis, 2021). The authors acknowledge that beliefs are not directly associated with teacher empathy, but experiences that support teachers in connecting with students through cultural awareness and stepping into students' shoes as problem solvers can foster an empathetic disposition. This empathy can subsequently change unproductive beliefs about teaching and learning mathematics and enhance teachers' understanding of their students.

Professional development tasks build teacher empathy by encouraging thoughtful reflection on students' perspectives and intentional engagement with students in the content (Rieckhoff et al., 2020). Teachers' command of mathematics content supports their understanding of student thinking (Namakshi & Washauer, 2022), and this understanding is linked to how well students learn (Carpenter et al., 1989). Teachers' low self-efficacy in math negatively impacts students' success when teachers assume students are like themselves (Gulistan et al., 2017). Lampert et al. (2021) found that when teachers extend empathy to better understand student engagement in mathematics, they revise deficit thinking about students. The connection between self-efficacy and student success is explained by teachers' ability to empathize with students (Goroshit & Hen, 2016). Empathy allows teachers to align with students' perceptions, feelings, and thinking, leading to adequate support and responses during instruction, which, in turn, leads to student success.

Experiences that support teachers in connecting with EB students through understanding their cultural backgrounds (cultural and linguistic awareness), life experiences, and incorporating culturally relevant materials are fundamental to the student's growth and development (de Araujo et al., 2018; Domínguez, 2011; Moschkovich, 2007). Building these connections allows teachers to step into an EB student's shoes as problem solvers and develop an empathetic disposition, which can change unproductive beliefs about teaching and learning mathematics.

In this study, we address the following research questions: (1) How does professional development focused on cognitively demanding tasks impact teachers' beliefs and practices regarding engagement with emergent bilingual (EB) students? and (2) In what ways does the PD influence teachers' development of empathy and cultural awareness when working with EB students in mathematics instruction? To build the context of this study, we included details of three specific professional development tasks. To address the questions, we analyzed teachers' evolving beliefs and practices as captured through their monthly written reflections during the second year of the project.

Literature Review

Teacher Empathy

Empathy for students is distinct from sympathy for students (Lesley University, n.d.). While important in demonstrating teachers care for students, sympathy involves feeling for the students from one's own perspective. In contrast, empathy involves understanding another person by considering their point of view and experiences. Empathetic teachers of mathematics relate to students both affectively and cognitively. Understanding the emotions associated with content and learning from the student's perspective supports effective, responsive teaching (Jaber et al., 2024). Empathy plays a fundamental role in mathematics education, particularly when teaching culturally diverse students. According to Askew et al. (1997), effective teachers of numeracy are those who demonstrate an understanding of students' individual needs and backgrounds, which is essential for engaging students who might otherwise feel disconnected from the material. This is consistent with the findings of Roberts (2020), who stress the importance of positioning ELLs within mathematics classrooms through strategies that are inclusive and responsive to their cultural identities. Such approaches allow students to see their experiences and cultures reflected in mathematical concepts, which increases engagement and relevance. Moreover, the principles outlined by the Advisory Committee on Mathematics Education (ACME, 2006) suggest that empathy in teaching mathematics promotes not only cognitive understanding but also emotional connections to the material, making it more meaningful for students.

This empathetic and culturally responsive stance aids teachers in identifying and addressing potential

barriers to learning, thus fostering a more inclusive learning environment. This aligns with the findings of McAllister and Irvine (2002), who expressed that empathy enables teachers to connect with students in ways that are both genuine and respectful of their unique cultural backgrounds. In their study, the authors asserted that teachers who approach their students with empathy can foster stronger, more authentic relationships, which is foundational for creating a supportive learning environment. This empathetic approach not only enhances relational bonds but also allows teachers to incorporate culturally responsive teaching methods effectively (McAllister & Irvine, 2002).

Empathy and Student Success

Studies show that connecting with students through understanding their work and thinking leads to positive outcomes (Carpenter et al., 1989; Fast et al., 2010). Understanding how students think and valuing their problem-solving strategies reflects teacher empathy. These empathetic instructional characteristics have been linked to student achievement (Carpenter et al., 1989) and teachers' content knowledge (Copur-Gencturk et al, 2019). Warshauer (2015) claims that students learn concepts deeply when they engage in productive struggle and suggests that students are more willing to take risks if teachers create a caring atmosphere. This skill of responsive teaching is strongly related to teacher empathy. As Jaber (2021) explains, "Attending to both affective and cognitive aspects of teacher learning can help us appreciate how teachers develop epistemic empathy—a capacity for tuning into and valuing students' intellectual and emotional experiences within an epistemic activity—in ways that foster teachers' responsiveness" (p. 434).

Empathy, Beliefs, and Task Implementation

It is imperative that educators believe that every student can engage in meaningful and significant mathematics. Teachers' ability to respond to students when using cognitively demanding tasks (CDTs) depends on their capacity to listen and suspend evaluation (National Council of Teachers of Mathematics [NCTM], 2014). Teachers may avoid offering CDTs or reduce its demands for students perceived as less advanced, including those labeled as having a learning disability or as non-fluent in English (Monarrez & Tchoshanov, 2020). Engaging in CDTs provokes elements of productive struggle. Students engage in productive struggle when they grapple within their zone of proximal development to make sense of high-demand tasks (Dixon et al., 2015; Hiebert & Grouws, 2007; Vygotsky, 1978). Furthermore, when teachers offer cognitively demanding tasks, unproductive beliefs about struggling students often lead them to reduce the demands, thereby undermining productive struggle (Junk, 2005; Campbell et al., 2014; Cengiz et al., 2011). When teachers fail to empathize with students, these unproductive beliefs limit their responses and understanding of students. Empathetic teachers of mathematics relate to students both in affect and knowledge. When teachers understand the emotions related to content and learning together from the student's point of view supporting effective, responsive teaching (Jaber et al., 2024).

Empathy and Cultural Awareness

Teachers who have the opportunity to learn about students from different cultures and their lived experiences can develop empathetic perspectives and leverage student backgrounds to support success in mathematics. Downey and Cobbs (2007) reported on a task that required preservice teachers to conduct a math interview with a child from a different culture. These interviews "provided a window for preservice teachers to view the teaching and learning of mathematics through the eyes of the child as a learner" (p. 399). Cultural awareness deepens teachers' understanding of students from diverse backgrounds and encourages using cultural strengths during lessons. The importance of cultural awareness and addressing unproductive beliefs about students is highlighted in the work of Hunter et al. (2020) in the Developing Mathematical Inquiry Communities (DMIC) project in New Zealand. In this project, professional development activities shifted teachers' expectations of students' mathematical capabilities by exposing them to the cultural traditions and beliefs held by New Zealand Māori and Pacifica students and parents. Domínguez (2011) emphasizes the importance of recognizing diverse students' out-of-school experiences and first languages: "By providing bilingual students with opportunities to use their two languages to think mathematically, along with the everyday experiences that matter in their lives, students can express, share, and negotiate meanings and ideas in ways that more fully demonstrate their mathematical productivity" (p. 325). Moscovitch (2007) further explains that connecting with students through culture supports "bilingual students' engagement in conversations about mathematics, going beyond translating vocabulary and involving students in communicating about mathematical ideas" (p. 20).

Background: The AIMM PD Project

Pre-post data from a pilot PD led by two of the research team in 2017-2018 showed increased content knowledge and changes in beliefs about teaching and learning, indicating that teachers were moving away from a transmission model of teaching-to-teaching math as a connected set of ideas (Plowman, 2020). Additionally, teachers were surveyed to determine how many tasks presented in the PD sessions were used in their lessons. Survey results indicated that over half of the teachers used the tasks fewer than five times, with some not using any of the tasks. Teachers

indicated that fast-paced curricula, testing pressures, and concerns about how the problems might work with students in regular classes were barriers to using the tasks during instruction.

Using what was learned from the pilot, the team gained funding for the project examined in this study. The AIMM professional development (PD) project was a two-year initiative (2018-2020) designed and led by seven professors from four universities. This project targeted teachers of grades 5 through 10 in rural schools across 39 counties. Many of these schools had growing numbers of students who identified as emergent bilingual. An emergent bilingual student is defined as "a student who is in the process of acquiring English and has another language as the primary language" (TEA, 2023b). In Texas, the terms emergent bilingual (EB) and English learner (EL) are used interchangeably, and we also used these terms interchangeably for the purposes of this project. The AIMM project conducted pre-post surveys which indicate that study teachers shifted their beliefs about teaching and learning from a directive approach to a connected approach (e.g., Swan, 2007) and increased their content knowledge (Plowman, 2020). PD leaders realized that the challenges of implementation needed to be addressed more intentionally.

Like the pilot, the two-year AIMM PD consisted of two 7-day summer workshops and two follow-up sessions each year (2018-2020) to develop deeper content knowledge and support teachers in modifying their instruction to include more student-centered, problem-based approaches for all students. Two of the four authors of this paper designed and led key components of the study presented here. One author documented teacher decision-making and beliefs about students in math class, while the second author provided analysis and feedback on the development of tasks to increase teachers' understanding of English language learners (ELLs). The three tasks detailed here were designed to explicitly address decision making and beliefs about learning math in a problem-solving classroom, especially for EB students. To engage teachers closely with the student perspective, the design included play-acting and improvisation as they engaged with the tasks.

PD Tasks: Integrating Empathy and Cultural Responsiveness During Professional Development for Mathematics Instruction

When developing the agenda for the second year, more tasks centered on implementation issues. For example, teachers were asked to bring in student work to document in detail the questions they asked for two lessons. PD tasks deliberately positioned the teachers as students and were specifically targeted to teaching ELLs/Emergent Bilinguals during PD sessions. All three of the PD tasks included here involved some play-acting or improvisation to put the teachers into the student's shoes, with special attention to EB students during debriefing. Essentially, these PD experiences were helping teachers develop empathy for students.

All aspects of the AIMM PD focused on the effective mathematics teaching practices described in Principles to Actions (NCTM, 2014). The three tasks described in this paper specifically target these principles:

- Implement tasks that promote reasoning and problem-solving.
- Facilitate meaningful mathematical discourse.
- Pose purposeful questions.
- Support productive struggle in learning mathematics.

Productive Tasks

The role of well-designed tasks cannot be overstated. Good tasks provide the space and mediation necessary for productive student engagement. We believe that the overall professional development (PD) tasks experienced in the AIMM PD and the tasks teachers learned to implement with their students embody the characteristics of Cognitively Demanding Tasks (CDTs). CDTs involve making connections, analyzing information, and drawing conclusions (Smith & Stein,1998). Research by Desimone et al. (2013), Stein and Lane (1996), and Henningsen and Stein (1997) found that the use of cognitively demanding tasks leads to better student outcomes. Studies support the idea that better content knowledge and positive beliefs about students' capacity to learn predict teachers' frequency of use of CDTs and improve their abilities to maintain cognitive demand when dealing with struggling students.

The TIMSS 1999 video study classified lesson tasks as procedural or connecting and then classified the tasks to determine if they remained as intended. This study showed that while American lessons featured some problems that could be implemented as connected, almost all were taught procedurally, meaning students simply followed the teacher's explicit directions to solve the problem (Heibert et al., 1999). Connecting tasks are stated in such a way that students connect previous learning and understanding to solve the problem rather than being told how to solve it directly. A primary goal in the AIMM PD was to help teachers maintain the connected features of the tasks during implementation.

The three PD tasks helped teachers connect to the student experience by focusing on teacher responses and questioning, linguistic challenges, and cultural awareness. To build teacher empathy for the student's

mathematical experience, each task asked teachers to imagine they were students themselves when problem-solving and to reflect on their feelings about the experience. While many of the tasks during the two-year PD involved challenging mathematics for the teachers, some tasks were designed to frame pedagogical issues in math class and could also serve as tasks they could directly use in lessons with their students. The PD emphasized maintaining the task demand for students for all tasks, even when they may not have been cognitively demanding for teachers.

The Tasks

Make 24, the Division Task, and La Rosca de Reyes each encouraged reflection on student perspectives toward learning and understanding mathematics. Each experience provided a space for discussion of affective components in effective lessons through building empathy for the student perspective. These task sessions concluded by posing questions about how they felt as learners (and pseudo-students) during the lesson, thus highlighting the importance of an empathetic perspective toward the student experience.

Make 24 addressed how students might feel during math class if they sense that teachers may be treating them differently than their peers, particularly in the type of support received when struggling to solve problems. During the Division Task, teachers "wore the shoes" of the ELL learner and experienced a reversal of linguistic roles as well as the impact of task design. In the La Rosca de Reyes, teachers experienced the power of including traditions from other countries, especially those from which their students were associated. In all cases, leaders invited empathic stances as a way to understand students and the impact of using productive tasks as a path forward to support all students.

Make 24 Task

The PD implementation of the Make 24 task involved role play by the PD leaders and teachers. Leaders played the role of teachers, and teachers acted as students. To assign the roles of students, playing cards were used that signified to the leader-teachers the role each teacher-student was to assume. Each teacher received a playing card, with their role determined by the card's number. These roles were designed to reflect teachers' perceptions about their students (often implicit). The teacher-students were unaware of their assigned roles; only the leader-teachers knew the card meanings. A teacher-student holding a card numbered 2, 3, 4, or 5 was to be ignored; those holding cards 6, 7, 8, or 9 were heavily directed or told what to do (representing a reduction of cognitive load), and those with cards 10, Jack, Queen, King, or Ace were supported with assessing and advancing questions (see Smith & Stein, 2018) to simulate maintenance of cognitive load. Teacher-students were asked to solve the task as their students would and to remain in a student's role.

The Make 24 task asks the problem solver to use any of the four operations to make a total of 24 with just four different numbers. There are many versions of this game. Our version used a deck of playing cards in which each numbered card represented its face value; aces were 1, and face cards were 10. Players worked to construct an equation from four randomly selected cards from the deck to total 24. In a problem-solving, student-centered classroom, the task works well because it invites a variety of solutions and clear explanations and justifications. The task also offers opportunities for students to use mathematical notation and conventions, especially order of operation rules.

Teacher-students sat at tables in mixed groups. Each leader-teacher performed all three kinds of response patterns during the mock teaching episode as they worked with their teacher-students at sets of tables. This PD task set-up created mini-classroom settings within our large group (~90 participants), with each leader-teacher leading a lesson for 15-20 teacher-students. During task work time, responses to teacher-students from their "teachers" were dramatized to enact responses of ignoring students, reducing cognitive demand, or maintaining cognitive demand dependent on which card was in front of the student.

Upon completing the lesson, participants were asked how they felt during the lesson as the leaders acted as their teachers to interact with them as students. Responses to being overtly told what to do versus being supported through questioning were as expected. Participants preferred being supported through questioning and probes but disliked being told exactly what to do. One participant who experienced the "directly told" response pattern (reduce cognitive demand) said, "You just told me what to do and then told me the answer." Another remarked that they were asked about the problem but were told what to do before they even had a chance to get started. One reported that the first thing the teacher said was what they did wrong and that they had not used the right strategy, saying, "It's like they were always giving me the answer." A teacher in the assessing and advancing (maintain cognitive demand) group noted, "She [the teacher] was very nice and was listening to me explain, and I was talking a lot, and she was just listening."

Teachers' reactions to the ignoring pattern, however, were surprising. While some teachers felt that ignoring caused resentment or frustration, many ignored participants responded in several ways, sometimes saying they "enjoyed being left alone" and watched

what was happening with other people at their tables. One person felt "offended" and said, "when I asked for help, you just said I'll get back to you, and you never came back." Some teacher-students in the ignored group commented that they were glad they were not "singled out." They reported they felt invisible and safe!

Leaders noted that in classrooms where students may not want to engage, being ignored provided a safe space as they could avoid explaining their thinking. This reaction of liking to be ignored promoted discussion about helping students through questioning without making them feel out of place, and the challenges of addressing mistakes without directly telling students how to solve problems. It also provided an opening to discuss communication alternatives such as gestures, drawing, and pairing with other students in cases where students resist talking and welcome being ignored. Teachers suggested that an EB student might be either ignored or told what to do because the teacher might also avoid conversation with them.

The Division Task

Many teachers do not feel prepared to meet the needs of emergent bilinguals (EB) (Lucas, 2012). For the predominantly English-speaking teachers, the Division Task was designed to help them empathize with how their emergent bilingual students might feel when learning mathematics. This was achieved by conducting the PD session entirely in Spanish. The professional development throughout the year emphasized the importance of cognitively demanding tasks and productive struggle; it became evident that engaging emergent bilinguals in productive struggle could be challenging if teachers did not recognize the issues encountered by students who are faced with learning in a second language.

The task context was cognitively challenging for teachers, requiring them to consider an unfamiliar algorithm for division commonly used in Spain and South America (Ewing, 2017). We want to note that, in general, cognitive demand involved in learning procedures without connections is considered low (see Smith & Stein 2018). However, this task was selected because it illustrated several important points. First, it exposed teachers to the experience of learning even a simple procedure in an unfamiliar language. Next, it promoted discussion about how a word or story problem might facilitate understanding of a concept if the context is elaborated, or conversely, create more challenges if the context is not illustrated or unfamiliar to some students. Additionally, our teachers had the opportunity to see alternate algorithms for division, which many older students from other countries may be familiar with.

To begin the task, teachers were asked to speak only Spanish for the lesson. They were instructed to sit quietly and avoid speaking in English if they could not speak Spanish.

Figure 1.

Teachers were provided with a worksheet with 12 problems to work (4 shown).

Nombre .....

Resuelve los siguientes problemas[1]:

1:	*2:*	*3:*	*4:*
1485 | 45	5525 | 85	4592 | 56	18.936 | 24

Next, one of the authors presented a demonstration of the algorithm in Spanish (an example can be found in Ewing, 2017 to see how this works). Teachers struggled to follow the instructions, and many eventually stopped trying. Having to speak and understand Spanish while using an unfamiliar algorithm that had to be strictly followed made the task very difficult for them.

Some teachers guessed that they were being asked to divide and rewrote the problems to solve using the American algorithm. The leader crossed out their work and told these teachers in Spanish that they had to solve the division problems as demonstrated. They then stopped working on the problem as well. One teacher, who was born in Russia, was able to solve the problems because she was familiar with that algorithm. The leader asked her in Spanish to explain to the others, in Spanish, how she had solved the problems. The teacher shook her head with wide eyes, mouthing "no."

After five minutes, all the teachers stopped working on the problems. They were asked to reflect on the following questions in pairs:

1. How did you feel learning math in Spanish?

2. How could I have taught you better?

As the teachers discussed their experiences, leaders listened to their conversations. The general consensus was that the teachers felt frustrated and "stupid." They expressed that they would have been able to solve the problems if the instructor had spoken more slowly, modeled how to solve the problems, and translated some of the words. One teacher shared with the rest of the group, "Now I know how my English language learners feel in my class. I have been to workshops about ELLs, but now I truly understand how they feel."

After the simulation, teachers were asked if they would like math if it were taught this way. They unanimously said they would not. Teachers noticed that the lesson's emphasis on a specific procedure impeded their engagement to learn content. In addition to considering the experience of learning in Spanish, teachers noticed that the lesson illustrated how a procedurally focused, teacher-directed lesson

limits engagement and provides little connection for students who may be less fluent in the language. The experience challenged the teachers' understanding of mathematics and the common belief that mathematics is language-free. A few teachers initially said the issue was irrelevant to them because they had no bilingual students in their classrooms, as their students were no longer receiving ESL services. This task revealed that teachers could have students struggling with language without being identified by language assessments, as is often the case with emergent bilingual students. The Division Task challenged teachers' beliefs about teaching procedures and set the stage for considering the struggles non-native English speakers might experience.

The Rosca De Reyes Task

Open-ended tasks, while challenging, provide opportunities to engage and support student struggle and success while maintaining cognitive demand. The Rosca De Reyes Task presented an open-ended word problem set in a cultural context, accompanied by dramatic play to illustrate, and practice the kind of productive teacher-student interaction one could have with an emergent bilingual in the midst of a problem-solving lesson. Specifically, the PD task was aimed to build an understanding of open-ended tasks and the opportunities that non-native English speakers could have if word problems included a context from their own culture.

The Rosca De Reyes is part of a pair of holidays celebrated in many Hispanic countries (e.g., Spain, Mexico, and other Latin American countries) as the biggest celebration during Christmas time: Dia de Reyes and Dia de la Candelaria. Rather than celebrating Christmas on December 25th, many Hispanic families celebrate gift-giving on January 6th, known as "El Dia de Reyes" or Three Kings Day. The night before El Dia de Reyes, children leave water out for the camels and go to bed, anticipating that the Three Wise Men will bring presents to be opened the next morning. A significant part of El Dia de Reyes involves Latinx families eating the Rosca de Reyes, a round cake with a plastic figure of the baby Jesus hidden in one of the slices. In Mexico, the tradition is that whoever finds the baby in their slice must host the next party on February 2nd, known as Dia de la Candelaria or Candlemas Day. For more information on these holidays, visit History of Los Tres Reyes (http://www.mexonline.com/history-lostresreyes.htm) and El Dia de la Candelaria (https://www.inside-mexico.com/el-dia-de-la-candelaria-1/).

After sharing the story of these two celebrations, teachers were asked to consider what a student whose family celebrates these holidays might be feeling on these days, given that they will have to go to school on January 6th and February 2nd. "How might students feel if we recognized these holidays?" and "How would most school students feel if they had to go to school on December 25th?" (authors acknowledge that not everyone in the U.S. celebrates Christian holidays). The teachers considered these cultural and emotional implications before reading the Rosca de Reyes task.

Figure 2.
Rosca de Reyes story presented to teachers during introduction of the task.

> *It is Christmas time and Veronica is excited. Now that she lives in the United States she celebrates Christmas, but her favorite part of the holiday is still on January 6th (El Dia de los Reyes.) She loves eating Rosca de Reyes. The cake is delicious, but the best part is guessing who will get the hidden baby in their slice. Last year her uncle got the plastic baby in the cake. Everyone says that whoever gets the baby has to host a party on February 2nd, Dia de la Candelaria—Veronica doesn't think they will make her host a party but she wonders, "Will my slice of cake have the baby?" What is the probability that the plastic baby will be in Veronica's slice of cake?*

To begin, teachers discussed the problem scenario above. They noticed that the task was open-ended and required the problem solver to add details such as the number of people sharing the cake, the sizes of the slices, and even the possibility of more than one baby hidden in the cake (different numbers of plastic babies are a variation in the holiday tradition). In pairs, teachers discussed the task design and how it might engage students. Teachers were asked how they might maintain cognitive demand and support productive struggle. How would they avoid giving too much help or directly suggesting strategies as students work on the problem (e.g., Dixon et al., 2015; Hiebert et al., 2007)?

PD leaders considered having them read transcripts of interactions and propose the next steps by writing a continuation of the scene. Instead, leaders chose to act out the transcript as a skit, with one of them acting as the teacher and the other as the student. Two PD leaders dramatized the task so teachers could think about possible student-teacher interactions and consider ways of supporting student thinking. By watching the scenes acted out, teachers might become more involved than they would if they just read them.

The script featured an extended interaction between a fictional student, Veronica (an emergent bilingual), and her teacher as she began to work on the task. The script was written using our experiences working with children from diverse cultures. It was broken into seven student-teacher interactions to stage decision-making moments where teachers would need to maintain cognitive demand while supporting student engagement (see Appendix A). After each interaction,

teachers were asked to discuss the interaction to consider the teacher's response patterns. Each segment was acted as dramatically as possible and actors broke character between the segments. The first script was just two lines. (The teacher approaches Veronica, an ELL student, who is having difficulty getting started.)

Teacher: Do you like Rosca?

Veronica: (shyly)Yes. I like it.

After each scene was performed, teachers were asked to consider the interaction and its consequences. For example, a simple question like "Do you like Rosca?" invites students to share their feelings and provides an opportunity to understand the story problem context before being asked mathematical questions. All the scenes and the reasons for each are detailed in Appendix A. The scenes included interactions supporting productive struggle, maintaining cognitive load, justifying solutions, and instances in which key vocabulary was translated into Spanish by the teacher.

After all seven scenes were finished, teachers were asked to work in pairs to create additional scenes or scripts that could follow the seventh exchange between the teacher and Veronica. They were asked to justify and analyze the reasoning for the scene and dialogue. The session concluded with a whole group discussion using the following questions:

1. Was this set of interactions an example of productive struggle?
2. How did the teacher maintain cognitive load?
3. How did the assessing and advancing questions in the interactions invite Veronica to continue working on the problem?

Teachers remarked that the student's ability to connect to the problem and to make choices provided meaningful access to the task. They noted the importance of purposeful questioning to support English Language Learners (ELLs) and Emergent Bilinguals (EBs), as well as any student who might struggle with understanding the problem. For example, one teacher mentioned that it would be necessary for Veronica to realize that the probability of finding the plastic baby would be proportional to the size of the cake. Another suggested having Veronica draw the cake so the teacher could assess if she envisioned all the slices as the same size.

One teacher noted the potential challenge of teaching if each student had a different problem. However, she recognized that it could work to take turns, suggesting that on one day, students could solve Veronica's version of the math problem, and the next day, they could use another student's idea. Teachers acknowledged that the problem design could engage all students' ideas and that varying the numbers of people eating the cake could develop concepts of probability and proportional reasoning embedded in the problem (e.g., more people, less chance of getting the baby; larger slices, fewer pieces, and higher chance).

Finally, the cultural context of the problem scenario was addressed, and teachers discussed how other cultural events could be used similarly to enhance student engagement and understanding. This approach emphasized the importance of incorporating cultural relevance in teaching to support all students' learning experiences effectively.

Methodology

Participants

In this study, we initially recruited 97 teachers, of whom 87 provided demographic information. The participating teachers represent various educational levels: 33 teachers (37.93%) from high schools, 21 teachers (24.14%) from middle schools, 10 teachers (11.49%) from intermediate schools, 11 teachers (12.64%) from elementary schools, and 12 teachers (13.79%) from schools without a specified level. These educators have an average of 8.6 years of teaching experience, ranging from 0 to 42 years, and their average age is 39.9, ranging from 23 to 62 years. The gender distribution includes 9 males and 78 females. Among these 87, 80 teachers participated in the "Last Monday Monthly Survey" (see Appendix B).

Data Analysis Procedures: Thematic Analysis

Thematic analysis was conducted to identify, analyze systematically, and report patterns within the data. Following Braun and Clarke's (2006) six-step framework for thematic analysis, we began by familiarizing ourselves with the data and reading through teachers" responses to project evaluation questions and "Last Monday" reflections multiple times to gain a comprehensive understanding of their experiences and insights. Next, we generated initial codes focusing on specific aspects such as cognitive demand, cultural awareness, empathy, and instructional strategies, which emerged as recurring themes across the dataset.

We then collated these codes into potential themes, examining connections and distinctions among them. For example, codes related to teachers' strategies for supporting students without lowering cognitive demand were grouped under the theme "Supporting and Maintaining Cognitive Demand," while those addressing teachers' growing cultural awareness and empathy were categorized into "Teacher Insights on Cultural Awareness and Diverse Learning Needs."

The themes were then reviewed and refined to ensure they accurately reflected the data and captured the breadth and depth of teachers' experiences. This process involved refining the themes to encapsulate meaningful insights, such as "Affect and Empathy," which highlighted teachers' emotional understanding of their students' struggles and growth. Finally, themes were defined and named to convey their essence, followed by illustrative excerpts from teachers' responses that provided rich, authentic examples of each theme. This rigorous approach allowed us to draw meaningful conclusions about the impact of professional development on teachers' instructional practices, cultural awareness, and empathy in the classroom.

Results

In this section, we present the findings on the impact of PD designed to enhance teachers' ability to maintain cognitive demand, foster productive struggle, and deepen cultural responsiveness in mathematics instruction, particularly for EB students. By examining teachers' reflections and responses to PD activities, we explored how targeted training influenced their instructional choices and awareness of diverse learning needs. The results illustrate shifts in teachers' questioning strategies, an increased emphasis on student autonomy, and a broader recognition of cultural and linguistic diversity. We present the results by the main themes identified in the teacher responses.

"Last Monday" Teacher Responses

Our teachers expressed satisfaction with the PD and observed positive outcomes on periodic evaluation surveys during the first year. However, the lack of details in their responses offered little insight into how the PD helped them. During the second year, the leadership team asked teachers to reflect each month on the last Monday to explain how they were incorporating the PD into their practice. Knowing teachers were reluctant writers, the reflection was structured as "fill in the blank" statements. These statements asked about specific components of the PD, such as productive struggle, challenging students, offering problems learned in training, and sharing their "not-so-stellar" moments (Appendix B). This format allowed teachers to report on specific tasks but was open to any pedagogical or conceptual ideas they applied to their instruction.

There were 408 entries reviewed from the "Last Monday" questionnaire collected between September 2019 and March 2020. These reflections from teachers over time support understanding about how and what the teachers made sense of in the context of their teaching and classrooms. Specific comments about English language learners, culture, and diversity indicated that the PD activities positively impacted the intended direction.

Supporting and Maintaining Cognitive Demand

Responses to these questions demonstrated that teachers were learning how to respond to students without reducing the cognitive load through questioning. For example, one teacher stated, "I pay more attention to the questions I ask. I tend to ask assessing questions and not really advancing questions. I am working on my questioning a lot and I think I am getting better at not making the problems easier for them but asking them to think deeper instead."

Additionally, teachers indicated that they could offer all students challenging tasks, including those who typically struggled in math class:

"With lower-level students, I have done less scaffolding and walked away after I asked a question." ["Walking away" was a specific strategy discussed in PD, as supports offered to perceived struggling students often resulted in the teacher staying too long and providing too much help.]

"I have learned to increase wait time; I have also learned to ask questions like 'What do you know?' when a student says to me 'I don't know.' This [teaching move] had the most impact."

Teacher Insights on Cultural Awareness and Diverse Learning Needs

Comments showed an awareness of culture and language, connections to students, the utility of productive struggle, and allowing student autonomy or voice during math class, pointing to teachers' development of empathetic views of the student experience. For example, one teacher noted, "The topic of emergent bilinguals from the summer training was very helpful this past month when my Spanish-only student needed some help on an assignment in class. I have been doing my best to speak to him in Spanish to make him feel just as safe and welcome in my room. I remember feeling super overwhelmed when Dr. Ewing spoke to us in Spanish for what seemed like forever, but it was only a few minutes. I know that is how my EB student feels in class, and I have been able to connect with him because of my awareness" (October 2019). Another teacher said that the PD made her "more cognizant" of her English language learners.

Attention to student backgrounds was also noted: "Learning about ELL and ESL learners and diverse learners in general from the summer training was very helpful this past month when I realized how many of my students come from culturally diverse backgrounds.

I have tried being more mindful in celebrating all of the culturally different learning styles instead of sticking to just one method that I am comfortable with" (November 2019). Some addressed the issue of diversity more broadly, saying, "Talking about the diversity of students from the summer training was very helpful this past month when I had a new student that I was trying to reach in my classroom. I had to take a big step back and try to understand where she was coming from to help her" (October 2019).

Affect and Empathy

Teachers expressed an understanding of how students feel about problem-solving lessons, framing their own learning about a "positive mindset," productive struggle, a "focus on classroom environment," and "giving students their own voice." For example, one teacher said, "Approaching problems from multiple points from the summer training was very helpful this past month when I had to reexamine student thinking and how I was approaching that in my classroom. It really helped me to connect with students who thought they were not 'getting it.' Approaching problems from different points and engaging students in the discussion about this created a community environment in my room" (February 2020).

One teacher took an extra step to promote empathy between students: "I challenged my students with a task from our training that did not have to do with math but with the understanding that I learned from the training. I had a paraprofessional who spoke Spanish come into my room and introduce a lesson over how to feed monkeys. The students who spoke Spanish laughed because the other students understood the numbers she was saying but nothing else. I did this so my students would understand that sometimes the word 'easy' is not always easy and sometimes it is very hurtful to those who struggle. My classroom had a better outlook on word problems after that" (February 2020).

In early 2020, our teachers did not anticipate the upcoming school shutdowns in response to COVID-19. It was heartening to read comments from March 2020 indicating that connections made during math lessons pre-COVID helped teachers support students during this time. For example, one teacher noted, "I think the biggest takeaway from summer training for this month dealt with multiple perspectives. I had to become okay with being a teacher who needed to rearrange my preconceived notions about how things would/should/could work or be done. One of the things that the training doesn't talk about is the amount of professional knowledge we gain from networking with other great minds. These experiences and information that I have gained have enabled me to be more effective during this transition to online learning" (March 2020).

Discussion

The thematic analyses of teachers' monthly responses to the Monday surveys show that, at minimum, teachers were becoming more culturally and linguistically aware of their students. Like Hunter et al (2020) we believe that this increased awareness helped teachers revise their thinking about the capabilities of their students. Notably, teachers were able to transfer this kind of thinking (e.g., multiple perspectives) during the sudden online shift of spring 2020. Second, we observed that teachers' empathetic views likely led to less lowering of cognitive demand during math class because they became more aware of student perspectives and differences. As noted in Campbell et al (2014), and Cengiz et al (2011) limited opinions of students often lead to reducing the tasks demand in ways that are unproductive for student learning. Finally, the themes indicate that providing tasks during professional development that explicitly target building teacher empathy show promise in enhancing teachers' views about students from diverse backgrounds including those identified as emergent bilinguals. This is evident in the example of the teacher inviting the Spanish speaking paraprofessional to talk to the children in Spanish, this creating space for her students to appreciate and value linguistic differences.

Summary and Conclusions

Recognizing the emotional elements of teaching and learning math through cognitively demanding tasks supports teachers' implementation of these practices so all students can benefit. PD experiences emphasizing the importance of affect or feelings about doing math, particularly for students from diverse cultural and linguistic backgrounds, support an aspect of learning to teach through problem-solving rarely addressed directly in math PD. The three tasks are representative of the tone and overall aim of the PD and provide a level of detail to other researchers and teacher educators to use for themselves and to further interpret teachers' reflections

The Last Monday reflections revealed the many ways teachers connected to student perspectives using what they learned from the PD. Teachers' self-reports are limited in nature, and because they reflected on various experiences from both years, the connection between the three tasks reported here and their comments cannot be claimed solely by these tasks. After experiencing struggles themselves, which allowed them to empathize with ELL/EB students, and visualizing these practices through dramatization, the Last Monday comments showed excitement and interest in providing cognitively demanding tasks to all students.

One persistent issue in professional development projects is whether or not the intervention and its results

have residue and if the PD is effective in increasing student achievement. Desimone's (e.g., 2009) seminal work described essential components of effective mathematics professional development. Relying on this work, which predicts student achievement related to professional development features, our professional development design reflects all five features identified: content focus, active learning, coherence, sustained duration, and collective participation. Our PD included nuance to these features: developing empathy and highlighting the Emergent Bilingual. We believe that a focus on feelings about mathematics and engaging in math tasks with as much attention to the student perspective produces teacher changes that are long-lasting and become internalized. Knowing if these successes after the PD is over is a perennial problem in teacher education. Carpenter, et al (2000) found that if teachers were able to develop certain levels of understanding teaching mathematics as measured by their beliefs and knowledge, teachers who maintained the gains were generative. In other words, they were able to use what they learned in new situations and frequently sought to understand their students' thinking. We believe that our approach of including the empathetic perspective, with a focus on Emergent Bilinguals, provided potential for teachers to sustain their knowledge post PD, although we have not directly examined this claim.

Implications: Empathy as a goal

Professional development often challenges teachers to meet all students' needs and offer engaging, meaningful tasks. However, PD leaders must consider the emotional impact of teaching and learning in new ways (Goroshit & Hen, 2016). Empathetic experiences provide teachers the opportunity to consider and practice the necessary instructional strategies to facilitate productive struggle from the student's perspective. Failure to recognize the necessity of empathy during professional development may lead to lackluster implementation during lessons.

The Importance of Including Empathy Experiences

Providing opportunities for teachers to empathize with their students is increasingly recognized as crucial (e.g., Goroshit & Hen, 2016; Meyers et al., 2019; Rieckhoff et al., 2020). A greater understanding of teacher empathy as a catalyst for student success (Meyers et al., 2019) and the factors contributing to empathy in the classroom is needed, as is insight into how empathy can be developed in PD (Goroshit & Hen, 2016). Maloney and Matthews (2020) noted that empathetic care fosters feelings of inclusion and belongingness in the math classroom. Teachers express empathy in three ways: managing frustration, affirming students' identities as math learners, and sharing struggles with them. Similarly, Meyers et al. (2019) recommend that college professors and their students benefit from an "empathy mindset," which encourages professors to consider their students' lives and circumstances when teaching and making connections through content.

Empathy as a Goal for Professional Development

In math classes, empathetic stances may not come naturally to some teachers. Providing specific opportunities to develop an empathetic mindset during professional development can support both teachers and their students. Our description of three PD tasks, along with responses from our teachers, provides a vision of what can happen in professional development settings. Furthermore, we believe that acknowledging the role of empathy in mitigating the emotional struggles students and teachers may experience in math class is key to successfully implementing the problem-solving, student-centered pedagogies espoused in mathematics professional development.

The AIMM tasks supported teachers in developing a perspective for teaching mathematics that respects students' experiences, thereby building teacher empathy. These three PD tasks demonstrate how the PD provided teachers the opportunity to understand, from the student's perspective, what it feels like on the receiving end of instruction and to reframe their ideas about who can or cannot do the mathematics required to solve challenging tasks. Using these tasks also revealed new insights for math educators which increase their empathy for teachers as they take on the challenges of using problem-solving, student-centered lessons.

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References

ACME. (2006). Mathematics in further education colleges (No. ACME PR/08). London: Advisory Committee on Mathematics Education, The Royal Society.

Askew, M., Brown, M., Rhodes, V., Johnson, D., & Wiliam, D. (1997). Effective teachers of numeracy, final report. London: Kings College.

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative research in psychology*, *3*(2), 77-101.

Campbell, P. F., Nishio, M., Smith, T. M., Clark, L. M., Conant, D. L., Rust, A. H., ... & Choi, Y. (2014). The relationship between teachers' mathematical content and pedagogical knowledge, teachers' perceptions, and student achievement. *Journal for Research in Mathematics Education*, *45*(4), 419-459.

Carpenter, T. P., Fennema, E., Peterson, P. L., Chiang, C. P., & Loef, M. (1989). Using knowledge of children's mathematics thinking in classroom teaching: An experimental study. *American Educational Research Journal*, *26*(4), 499-531.

Carpenter, T. P., Fennema, E., Franke, M. L., Levi, L., & Empson, S. B. (2000). Cognitively Guided Instruction: A Research-Based Teacher Professional Development Program for Elementary School Mathematics. Research Report.

Cengiz, N., Kline, K., & Grant, T. J. (2011). Extending students' mathematical thinking during whole-group discussions. *Journal of Mathematics Teacher Education*, *14*(5), 355-374.

de Araujo, Z., Roberts, S. A., Willey, C., & Zahner, W. (2018). English Learners in K-12 Mathematics Education: A Review of the Literature. *Review of Educational Research*, *88*(6), 879–919. http://www.jstor.org/stable/45277268

Copur-Gencturk, Y., Plowman, D., & Bai, H. (2019). Mathematics teachers' learning: Identifying key learning opportunities linked to teachers' knowledge growth. *American Educational Research Journal*, *56*(5), 1590-1628.

Desimone, L. M. (2009). Improving impact studies of teachers' professional development: Toward better conceptualizations and measures. Educational researcher, 38(3), 181-199.

Desimone, L., Smith, T., & Phillips, K. (2013). Linking student achievement growth to professional development participation and changes in instruction: A longitudinal study of elementary students and teachers in Title I schools. *Teachers College Record*, *115*(5), 1-46.

Dixon, J. K., Adams, T. L., & Nolan, E. C. (2015). In Kanold, T. D. (Ed.), Beyond the common core: A handbook for mathematics in a PLC at work. Bloomington, Ind: Solution Tree Press.

Domínguez, H. (2011). Using what matters to students in bilingual mathematics problems. *Educational Studies in Mathematics*, *76*(3), 305-328.

Downey, J. A., & Cobbs, G. A. (2007). "I actually learned a lot from this": A field assignment to prepare future preservice math teachers for culturally diverse classrooms. *School Science and Mathematics*, *107*(1), 391-403.

Ewing, J. (2017). Facilitating pre-service teachers to learn the Mathematical Practices and engage English language learners. *Journal of Multicultural Affairs*, *2*(1), 3.

Fast, L. A., Lewis, J. L., Bryant, M. J., Bocian, K. A., Cardullo, R. A., Rettig, M., & Hammond, K. A. (2010). Does math self-efficacy mediate the effect of the perceived classroom environment on standardized math test performance? *Journal of educational psychology*, *102*(3), 729.

Goroshit, M., & Hen, M. (2016). Teachers' empathy: Can it be predicted by self-efficacy? *Teachers and Teaching*, *22*(7), 805-818.

Gulistan, M., Athar Hussain, M., & Mushtaq, M. (2017). Relationship between Mathematics Teachers' Self Efficacy and Students' Academic Achievement at Secondary Level. *Bulletin of education and research*, *39*(3), 171-182.

Henningsen, M., & Stein, M. K. (1997). Mathematical tasks and student cognition: Classroom-based factors that support and inhibit high-level mathematical thinking and reasoning. Journal for research in mathematics education, 28(5), 524-549.

Hiebert, J., Stigler, J. W., Jacobs, J. K., Givvin, K. B., Garnier, H., Smith, M., ... & Gallimore, R. (2005). Mathematics teaching in the United States today (and tomorrow): Results from the TIMSS 1999 video study. *Educational Evaluation and Policy Analysis*, *27*(2), 111-132.

Hiebert, J., & Grouws, D. A. (2007). The effects of classroom mathematics teaching on students' learning. In F. K. Lester, Jr., (Ed.), Second handbook of research on mathematics teaching and learning (pp. 371-404). Charlotte, NC: Information Age Publishing.

Hunter, J., Hunter, R., & Anthony, G. (2020). Shifting towards equity: challenging teacher views about student capability in mathematics. *Mathematics Education Research Journal*, *32*(1), 37-55.

Jaber, L. Z. (2021). "He got a glimpse of the joys of understanding"–The role of epistemic empathy in teacher learning. *Journal of the Learning Sciences*, *30*(3), 433-465.

Jaber, L. Z., Davidson, S. G., & Metcalf, A. (2024). "I loved seeing how their brains worked!"—Examining the role of epistemic empathy in responsive teaching. *Journal of Teacher Education*, *75*(2), 141-154.

Junk, D. L. (2005). *Teaching mathematics and the problems of practice: Understanding situations and teacher reasoning through teacher perspectives* (Order No. 3184826). Available from ProQuest Dissertations & Theses Global. (305385134). Retrieved from https://manowar.tamucc.edu/login?url=https://www.proquest.com/dissertations-theses/teaching-mathematics-problems-practice/docview/305385134/se-2

Lambert, R., Imm, K., Schuck, R., Choi, S., & McNiff, A. (2021). "UDL Is the What, Design Thinking Is the How:" Designing for Differentiation in Mathematics. *Mathematics Teacher Education and Development*, *23*(3), 54-77.

Lesley University (n.d.) The Psychology of Emotional and Cognitive Empathy

Retrieved January 2023, from https://lesley.edu/article/the-psychology-of-emotional-and-cognitive-empathy

Maloney, T., & Matthews, J. S. (2020). Teacher care and students' sense of connectedness in the urban mathematics classroom. *Journal for Research in Mathematics Education*, *51*(4), 399-432.

McAllister, G., & Irvine, J. J. (2002). The role of empathy in teaching culturally diverse students: A qualitative study of teachers' beliefs. *Journal of teacher education*, *53*(5), 433-443.

Meyers, S., Rowell, K., Wells, M., & Smith, B. C. (2019). Teacher empathy: A model of empathy for teaching for student success. *College Teaching*, *67*(3), 160-168.

Monarrez, A., & Tchoshanov, M. (2020). Unpacking teacher challenges in understanding and implementing cognitively demanding tasks in secondary school mathematics classrooms. *International Journal of Mathematical Education in Science and Technology*, 1-20.

Moschkovich, J. (2007). Bilingual mathematics learners: How views of language, bilingual learners, and mathematical communication impact instruction. *Improving access to mathematics: Diversity and equity in the classroom*, 89-104.

Namakshi, N., Warshauer, H. K., Strickland, S., & McMahon, L. (2022). Investigating preservice teachers' assessment skills: Relating aspects of teacher noticing and content knowledge for assessing student thinking in written work. *School Science and Mathematics*, *122*(3), 142-154.

National Center for Education Statistics. (2023). English Learners in Public Schools. Condition of Education. U.S. Department of Education, Institute of Education Sciences. Retrieved May 29, 2024, from https://nces.ed.gov/programs/coe/indicator/cgf.

National Council of Teachers of Mathematics. (2014). *Principles to actions*. National Council of Teachers of Mathematics.

Namakshi, N., Warshauer, H. K., Strickland, S., & McMahon, L. (2022). Investigating preservice teachers' assessment skills: Relating aspects of teacher noticing and content knowledge for assessing student thinking in written work. *School science and mathematics*, *122*(3), 142-154

Plowman, D. (2020). The Role of Initial Content Knowledge and the Uptake of New Pedagogies. In International Consortium for Research in Science and Mathematics Education XV (pp. 65–74). Columbus, Ohio: ICRSME.

Plowman, D., and Lynch-Davis. (2021). The proof is in the lesson: Investigating links between PD, teacher profiles and math instruction. In J. Herron (Ed.). Proceedings of the 120th annual convention of the School Science and Mathematics Association (Vol. 8). Virtual: SSMA.

Roberts, S. A. (2020). Important for All: Positioning English Language Learners in Mathematics Professional Development. *The Teacher Educator*, *55*(1), 107-128.

Rieckhoff, B. S., Ockerman, M., Proweller, A., & Wolfinger, J. (2020). Building Teacher Empathy and Culturally Responsive Practice Through Professional Development and Self-Reflection. *Journal of Vincentian Social Action*, *5*(2), 8.

Smith, M. & Stein, M. K. (2018). *5 Practices for orchestrating productive mathematics discussion*. National Council of Teachers of Mathematics.

Stein, M. K., & Smith, M. S. (1998). Mathematical tasks as a framework for reflection: From research to practice. Mathematics teaching in the middle school, 3(4), 268-275.

Stein, M. K., & Lane, S. (1996). Instructional tasks and the development of student capacity to think and reason: An analysis of the relationship between teaching and learning in a reform mathematics project. *Educational Research and Evaluation*, *2*(1), 50-80.

Swan, M. (2007). The impact of task-based professional development on teachers' practices and beliefs: A design research study. *Journal of Mathematics Teacher Education*, *10*, 217-237.

Texas Education Agency (2023a). Supporting Emergent Bilingual Students in Texas. Available online at: https://www.txel.org/Educators

Texas Education Agency (2023b). 2022–23 Texas Academic Performance Reports. Available online at: https://rptsvr1.tea.texas.gov/perfreport/tapr/2023/index.html

Vygotsky, L. S. Mind in Society: Development of Higher Psychological Processes. Edited by Michael Cole et al., Harvard University Press, 1978. JSTOR, https://doi.org/10.2307/j.ctvjf9vz4.

Warshauer, H. K. (2015). Productive struggle in middle school mathematics classrooms. *Journal of Mathematics Teacher Education*, *18*(4), 375-400.

Appendix A:

Teacher-student interaction and possible teacher responses to be used with Rosca De Reyes Task.

Interaction	Script	Analysis/Possible Responses
1	(The teacher approaches Veronica, an ELL student, who seems to be having difficulty getting started.) Teacher: Do you like Rosca? Veronica: (shyly)Yes. I like it.	[This question is affective and invites the student's own ideas. Teachers should allow students time to make sense of the problem context on their own before asking mathematical questions.]
2	Teacher: What is the question asking? Veronica: If I will get the baby...?	[This question assesses what the student knows about the problem.]
3	Teacher: How do you say "probability" in Spanish? Veronica: La probabilidad!	[The question assesses the student knowledge of probability using the Spanish vocabulary equivalent. The teacher shows appreciation for Spanish and is able to assess the student's understanding of the concept of probability and vocabulary development.]
4	Teacher: How can we calculate the probability or la probabilidad? Veronica: (smiling) We need to know how many slices there are in the "Rosca."	This draws the students' attention to the open-ended structure of the task and the student recognizes that more information is needed.]
5	Teacher: How would you like to solve the problem? Veronica: Let's say ten slices. It depends, but we usually share the cake with our neighbors. Let's say ten slices of cake.	[The teacher's question invites the student to provide relevant details. Now the math is personal to the student.]
6	Teacher: What is the probability that you get the plastic baby in your slice of cake? Veronica: (she hesitates for a second) If there are ten slices and I have one slice, then the probability is 1 out of 10 that it is in my slice.	[The question supports the student to focus on the mathematics and can be characterized as an assessing question.]
7	Teacher: Awesome! How will you write down your answer? What if there are more than 10 people? What if some of the neighbors don't come? Can you figure out some more ways that Veronica might get a slice with the baby in it? Veronica: I am not sure. I guess I can try 8 people?	[The teacher now knows that Veronica understands the problem context and knows something about probability. This question advances the student to consider more situations and additional probability statements.]

Appendix B: AIMM Last Monday -Monthly Survey

AIMM Teachers are required to provide monthly reflections on the LAST MONDAY of the MONTH.

Our AIMM Team would like for each teacher to reflect on their teaching throughout the grant program. On the Last Monday of the Month, we will require teachers to complete the following sentence stems related to our grant program's main concepts. The stems are designed to help teachers construct their thoughts related to these concepts. Teachers have the freedom to elaborate beyond the designed structure of each sentence stems.

1. Over the last month, I elicited student thinking by _____ and my best example was when _____.

2. Over the last month, my students engaged in productive struggle when _____, and I was very proud of my students when _____.

3. I had some not-so-stellar teaching moments this past month. There was this time when I wish I would have _____ when _____.

4. I challenged my students with the _____ task from our training, and the students _____.

5. I used the iPad in my teaching this past month when I _____.

6. _____ from the summer trainings was very helpful this past month when _____ happened in my classroom.

7. During this program we have explored the concept of _____, and I have been able to _____ in my classroom.

8. During this program we have explored the concept of _____, but I have been unable to _____ in my classroom.

9. Please provide any additional information you desire.

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Multidimensional Holistic Assessment Framework (HAF): A Case Study of Exploring the Discourses from Elementary School Teachers

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Abstract

The paper investigates the experiences and perceptions of the elementary school teachers implementing a self-designed Holistic Assessment Framework (HAF). This is a transformative multidimensional assessment framework focused on transforming the assessment practices in elementary education, making them more diverse as well as holistic, tailored to the unique needs of the learners. The HAF reflects in detail the progress as well as the uniqueness of each learner in the cognitive, affective, and psychomotor domain. It follows a participatory, inclusive, and learner centric approach and includes assessments of dimensions - physical development, socio-emotional and ethical development, cognitive development, language, and literacy development, and, aesthetic and cultural development. The teachers' discourses based on the implementation of this framework on Grade I students presented as a case. Semi-structured interviews were conducted of elementary teachers (n = 17). The applicability of the framework was determined with the help of hybrid approach including deductive and inductive analysis of the data obtained on the predetermined themes. The paper contributes to the ongoing discourse of HAF, presenting valuable insights on application of holistic assessments and practical insights in a real-world context for teachers and parents. The assessment framework guides and empower teachers to conduct effective learner centric assessments to improve learning and confidence in their students. This framework can be adopted by teachers to incorporate holistic assessments for taking the traditional assessment system towards student centricity and completeness.

Keywords:

Assessment Framework, Innovative Multidimensional Assessments, Elementary Education, Holistic Education, Assessment Reforms.

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Introduction

Background

Learning is an active and interactive life-long process. In formal education system assessments provide us information about the learning progression of learners. Assessment and evaluation are integral parts of the teaching

and learning process at each level of education. Essentially, it is crucial for teachers to understand how children learn in the foundational years, even before they talk about how children should be assessed. Children in this age group have a natural sense of curiosity and so they try to make sense of the world around them by wondering and trying out things. First hand experiences are therefore important for them that would involve manipulation, exploration, and experimentation. Thus, if learning is based in a real-world context, assessments too should be based in a similar environment (Simon & Gregg, 1993) where students get ample opportunities to enhance their learning, imagination, creativity, problem solving and other life skills in their unique ways. Traditional assessments with its benefits also have many challenges like its overemphasis on memorization, neglecting holistic learning as well as the huge stress and anxiety that it brings along. These assessments are also heavily teacher dominated with less emphasis on the real-life application of the learning. Thus, if learning is based in a real-world context, assessments too should be based in a similar environment where students get ample opportunities to enhance their learning, imagination, creativity, problem solving and other life skills in their unique ways. It suggests that the assessments and instruction must be integrated (Shepard, 2000).

These challenges highlight the urgency of a more learner-cantered and inclusive assessment practices that would reinforce active participation and faith in the process of assessment. The assessment reforms would cater to overcome the challenges that are currently being posed by the traditional assessments. Along with the regular term end examination as a summative assessment, formative assessments should focus more on how children are progressing over time, minimizing the reliance on standardized testing, and giving more importance to learning experiences (Hargreaves, 2005). This would mean that the documentation and evidence of achievement are also important to be gathered systematically that can map the learning of students over time. For this purpose, formative assessments (Black & Wiliam,1998) such as portfolios, self-assessments, and peer-assessments are a necessary shift we need to undergo. Reforms would also mean focussing on not just the knowledge and comprehension but also on the skills and core competencies that are mapped with the developmental milestones for the relevant age group learners. Every learning outcome should be able to assess learning progression through a holistic assessment system including cognitive, socio-emotional, and physical development, also with the record of learning progressions (Torrance, 2007). This would also imply that our assessments for the foundational years should be more embedded in play-based activities (Ali, et al. 2018), where children get to participate in many activities like role-playing, puzzles, play-based and project-based assessments, so largely performance based (Darling-Hammond, 2014). Such comprehensive assessments would give an opportunity to assess our students using real-world contexts while also developing some valuable life skills.

Literature Review

Several studies highlighted the need and importance of regular, periodic and need based transformation in school curriculum, teaching-learning practices, and assessment formats. Recent studies reviewed in this area, highlighted the key shifts in the assessment practices in education and the emerging trends to be considered for designing better evaluation framework.

Shift from Traditional to Modern Assessments

Due to openness in education and emergence of advanced technology tools, whole education system witnessed a transition, especially after COVID-19 pandemic. If we focus on assessments in elementary education, recent literature shows the shift from traditional ways of rigid and pen-and-paper based assessments to innovative alternatives focusing more on formative, performance based and skill-based assessments. There are major challenges that make the traditional practices outdated, as there are challenges in test-security and fair implementation. The standardized traditional assessments lack in providing opportunities to assess creativity (Greer et al. 2021), and are more inclined to test lower order thinking skills, having no place for higher order thinking (Carroll, 2013). Due to bias in traditional system and limitations in standardized tests, Hardy & Lewis (2020) advocated culturally responsive assessments for the linguistic diversity. Social-emotional assessments are also found to get attention in modern education that measure non-cognitive skills such as collaboration, empathy, and resilience in children for understanding learners holistically (Jones & Kahn, 2017). Several studies emphasized conducting competency-based assessments supporting skill development approach aligning with the skills required for handling real-world situations (Leutner et al., 2017, O'Reilly et al. 2022, Tobin & Tippett, 2021).

Research emphasizes on the importance of integrating the assessments in regular teaching learning. Formative assessment continually improves student learning (Pellegrino, 2017). Studies such as those by Andrade & Heritage (2019) highlight improved engagement due to formative assessments, that will allow students to know about their progressions. Black & William (2020), reiterate the importance of formative assessments to foster learning with the feedback loops to guide student progression. Effective formative assessments not only provide information on learning but also help teachers to get minute-to-minute, day-

to-day feedback to take decisions regarding teaching (William & Leahy, 2024), and can take many forms such as student reflections, student feedback etc. (Kingston & Nash, 2011).

Major shift was observed towards personalized learning and assessments considering the diversity among learners and their individual differences. Thurlow & Lazarus (2021) provided insights for new assessments in the form of alternative assessment models promoting inclusivity and equitable assessments, along with the assessment modifications (Thurlow & Kopriva, 2015) for students having disabilities. Project based assessments are innovated promoting peer learning as well as peer assessments allowing meaningful learning in remote education (Benton & Kleitman, 2021). Research points out the alterations in assessments, providing opportunities for continuous improvement in learning through pedagogical differentiations (Kanellopoulou & Darra, 2022) and allow teachers to get more feedback on achieving their learning objectives (Flaherty & Hackler, 2010). A meta-analysis of 18 studies on portfolio assessment as a tool for primary school students shows a positive impact on their academic achievement. Portfolio assessments demonstrate student progression over time (Doğan et al., 2024). These assessments contribute to 21st century skills assessment. Portfolios are also found effective for self-reflection and promoting learning (Hj. Ebi et al., 2020).

There is a clear indication from this discussion that flexibility is the key factor to improve today's assessments, to provide more opportunities for teachers to adjust depending on the student needs and unusual situations as in pandemic (Looney et al. 2021). The integration of technology in assessment has taken multiple forms as technology integrated assessments and even AI based formative assessments (Shu & Gu, 2023). Several other studies on modern assessments also supported the need to transform assessment practices in elementary as well as other higher levels of education based on the local needs and global trends.

Modern Assessment Methods

With the changing needs and forms of education, reforms in today's school education reflect inclusion of reflective and learner-centred approaches of student assessments. Unlike traditional memory based summative assessments, a key component of the new system of assessment is formative assessments, as an integral part of teaching and learning (Yan & Brown, 2021). Use of this approach contributes to more autonomy and motivation for learning among students (Leenknecht, et al., 2020). It was stated that the characteristics of assessment fosters learning motivation highlighting the significance of assessments for improving learning (Bui & Nguyen, 2024). Recognizing learner needs and diversity the new assessments are inclusive, rigorous, and responsive (Ansorger, 2021). Reforms have brought a shift to consider the learner feedback, their participation in assessment tasks and self-regulation, that plays a mediating role in quality of assessment (Ibarra-Sáiz, et al. 2020). Innovative and comprehensive assessment methods are more integrated with learning as compared to the traditional assessments.

Modern assessments are technology based providing engaging and attractive environments and gives importance to problem and project-based assessments (Meylani, 2023). Instead of focusing solely on academic knowledge, modern assessments include alternatives to assess students' attitude and behaviour (Puad & Ashton, 2020), considering student perception in the teaching learning and assessments (Mathur, et al. 2024), making use of digital portfolios, peer assessments and simulations (Aliah, et al. 2023), using rubrics for self-assessments (Andrade & Du, 2019), use of AI for assessments (González-Calatayud, et al. 2021), and digital assessments on Google classroom providing simple, practical, and flexible assessment opportunities for teachers (Choirunnisa & Mandasari, 2021). Thus, the new assessment methods are evolving in the post-Covid era of educational transformation, bringing in more openness and flexibility in assessment practices and reducing overdependence on examination-oriented assessment (Yan & Brown, 2021). Research confirms that teachers use a wide range of tools and methods of evaluation according to student preferences to complement learner progress (Fuentealba, 2011) and are showing positive attitude towards the modern assessments (Saira, et al., 2023).

Innovative Assessment Frameworks

Assessment framework is a structured approach for guiding educators to conduct assessments with the purpose, following a specific procedure. In the past, many researchers and educationists have presented and implemented assessment frameworks for different purposes, at different educational levels, as well as online and offline modes of instruction, but with the sole purpose of explaining how assessments can be better and how they help teachers to know about learners and their learning (Stiggins & DuFour, 2009, Gibbs, 2010, Abatihun, 2020, Monteiro, et al., 2021). Assessments framework creates opportunities for teachers to provide creative ways of 'what and how' a child runs, as stated by Bourke & Mentis, 2014. They introduced an assessment framework with an integrated approach for inclusive education, with diverse assessment approaches. A process-based assessment framework for technology education was developed by van Niekerk et al. (2010), which includes - outcomes, content, and assessment methods that serves as a roadmap for technology teachers to assist them.

Technology Assessment Framework (TAF) was presented by Compton et al. (2003), as an effective tool for teachers to support and guide the translation of technology in the curriculum at New Zealand, with the purpose of development of understanding of assessments in technology education, based on socio-cultural theory. The Edu-Metaverse model includes multimodal interactions and AI enabled teaching and assessments to achieve learning outcomes for core literacy (Shu & Gu, 2023). In one of the studies conducted by Widayanti et.al. (2021), an assessment framework was designed for the universities using blockchain technology for improving the quality of education. Multimodal assessment frameworks encourage students to demonstrate their learning through various media tools such as videos, interactive content etc. E-assessment framework emphasized the need for organizing assessments relevant digitally based on the needs (Bearman et al. 2022). The assessment model including - Performance, observation, self and peer assessments, and journal of teacher's records found to be effective for assessment of knowledge, skills, and attitudes in elementary education (Maba & Mantra, 2017). A kindergarten assessment framework was developed by integrating contemporary assessment practices for the kindergarten classrooms suggesting significance of ply-based assessments (Pyle et al., 2020). This framework will help teachers to improve student engagement and holistic development (Parker et al., 2020).

Many other relevant studies were found presenting the assessment framework for improving learning, but majorly in higher education. It was observed that they are widespread, including specificity in use regarding various subjects, knowledge domains, mode of learning, etc., and reiterated that developing comprehensive assessment practices is essential to guide teachers to understand, select. and implement appropriate strategies to understand how students are learning and their learning progression. But the recent literature lacks the consistent and comprehensive framework at elementary level, that can be referred by the teachers to modify their assessment practices and improve learning.

Holistic Assessment Framework (HAF)

As was the case across the world, the Covid-19 also had its impact in schools across India, especially the age group from 3 to 8 years. The school drop-out percentage had tripled during those difficult times in this age group for multiple reasons. Moreover, while the higher grades eventually shifted to the online mode of education, the children in this age range were unable to optimise this medium as parents and educators were concerned about the excessive screen timing they would be exposed to. Also, the attention span of this age group is too less to engage them for long hours and as a result the students lose out on some crucial learning.

Designing and Development of Holistic Assessment Framework (HAF)

Theoretical foundation: Both Western and Indian philosophers, psychologists, thinkers, and educators have shared insights into the importance of exploration and play, art, rhythm, rhyme, movement, and active participation during the early years of children. Constructivism as a theory proposes that learners actively construct their knowledge through their experiences instead of passively receiving information (Piaget, 1952). Proponents of this theory emphasize that learners build upon their prior knowledge and interact with their environment to form new understandings. In the context of the present research, it can be said that learners evolve in all domains – cognitively, emotionally as well as physically, through the engagement they have, and so it is also necessary to have a multidimensional assessment so that the learner's progress can be assessed in all domains (Vygotsky, 1978). Learner Centric approaches in education are those that prioritize the needs, strengths, and interests of the students, thus making them the focal point in the educational process (Weimer, 2013). In the present research too, assessments have been tailored in a manner that would align with the unique learning journey of the students. The HAF proposed in this paper caters to diverse learning paths and provides meaningful feedback to each learner.

This way we are transforming assessments from teacher directed to student driven. Tomlimson, (2001) worked on differentiation stressing the importance of adapting teaching and assessment methods to meet the varying needs of students. The framework as designed in the present research is multidimensional and recognises the diverse strengths and improvements needed. This ensures that all students are not just assessed comprehensively but also fairly. Play is recognized as the most essential component in early childhood education. The present framework incorporates a mix of traditional pen-and-paper tests as well as playful assessments such that the naturalistic and interactive environment is created. This framework is based on the work of educators like Friedrich Froebel (Dar, 2020) and Jean Piaget (Piaget, 1952) who had advocated to promote learning through exploration, experimentation, and discovery. Thus, the Holistic Assessment Framework in this research, looks at assessment with a fresh perspective while providing a robust lens to evaluate the framework in the case study involving elementary school teachers.

Policy Recommendations

Promoting holistic and competency-based learning, especially in the foundational stage, has been one of

the aims of the National Education Policy (NEP) 2020 and the National Curriculum Framework (NCF). The NEP has provided with stage – specific competencies that may guide curriculum development and assessment practices. This policy emphasizes the need to track the interim learning outcomes as competencies are the long-term achievements. This will ensure that the needs of the students are continuously met. The NCF which has been derived from the NEP further focuses on having a comprehensive assessment system so that the student development can be supported across multiple domains.

Other frameworks like the Vidya Pravesh and the National Initiative for Proficiency in Reading with Understanding and Numeracy (NIPUN) Bharat Mission, focuses on ensuring foundational literacy and numeracy by Grade 3. While Vidya Pravesh stresses on a play-based approach to address the learning gaps in early education, NIPUN Bharat Mission emphasizes continuous assessment to track the progress of learners. Further the NEP also recommends the Holistic Progress Card (HPC) such that it provides a multidimensional view of every learner's progress across all domains. Thus, all policies direct schools to follow an assessment pattern that would foster holistic development and ensure that assessments not only serve to quantify learning but it provides a wholesome support and guidance for every student to develop.

Nature of HAF

The key features of the new HAF are as follows –

Innovative framework: This innovative assessment framework is a 360-degree, multidimensional framework, that reflects the progress as well as the uniqueness of each learner in the cognitive, affective, and psychomotor domain. The framework includes application of modern theories of learning and assessments, holistic approach, multiple dimensions, play-based education and innovative, alternative, tailor made assessments.

Principles: HAF followed to design the assessment framework mainly based on learner centricity, constructivism, personalized assessments, differentiation, and authentic assessments.

Assessments: Varied assessment methods and techniques are included in the framework such as observation, analysing artefacts, portfolios, storytelling, self and peer assessments.

Learning Dimensions: Knowledge, skills, and attitudes are integrated in the framework. The individual elements of each dimension are mentioned in Figure 1, indicating the focus on holistic approach.

Achievement levels: Th achievement was captured using four levels based on the performance of a child in the assessment such as – A: Advanced, W: Well versed, P: Progressing, and B: Beginner. These levels were used for reporting in a progress card.

Structured approach: This framework is a comprehensive outline of multidimensional holistic assessments process to be followed by teachers of elementary school regarding planning and conducting assignments. Based on – (i) Needs analysis, (ii) Curriculum analysis, (iii) National policy recommendations, (iv) Post COVID scenario of education and (v) School expectations.

Teacher training: The teachers for grade 1 were trained through the structured training programmes on 'HAF: Why, What and How to implement it'. After the training the teachers were guided and monitored throughout the year, during the implementation of HAF in their respective classes. This handholding helped to get their reflections on their assessment practices, problem solving and motivation to continue implementing HAF.

The Holistic Assessment Framework was designed and developed by the school team. The elements of the framework are presented in Figure 1.

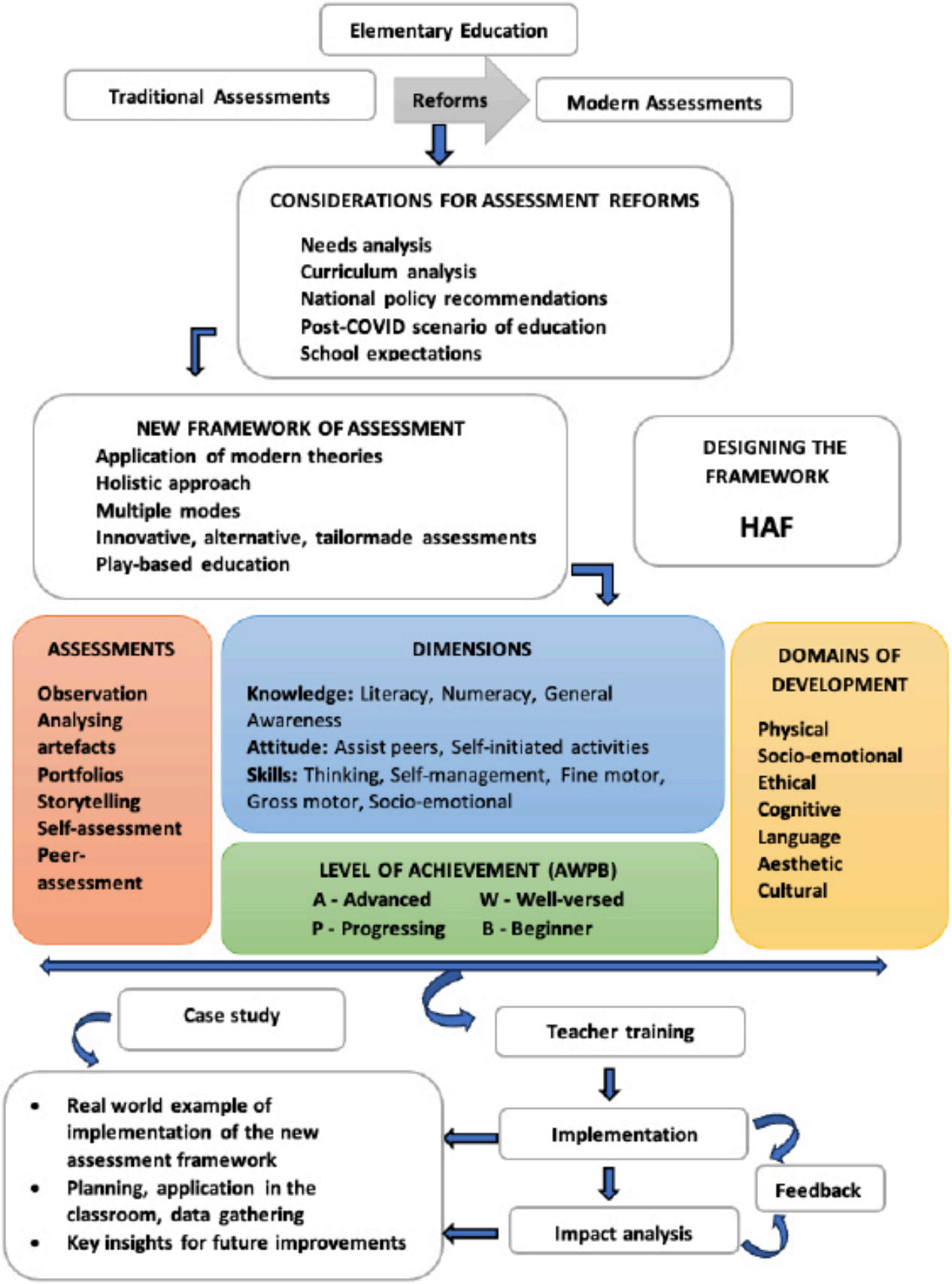
The Context and Research Questions

After the development of the HAF, elementary school teachers were trained by the school director on implementation of HAF in classrooms. The programme was designed to train teachers on –

- What is HAF, why it is needed
- Understanding the components of HAF
- Exploring how to conduct effective formative and summative assessments
- Understanding the principles of learner centred assessment, differentiation, multidimensional and holistic assessment
- Use of activities for assessing knowledge, skills, and attitudes
- Using assessments for giving feedback
- Keeping assessment records

Following the training the teachers implemented the HAF in their respective classrooms, with continuous follow-up, mentoring and problem solving on the issues faced by the teachers in implementation. These reflection sessions were helpful for the teachers to gain confidence and clarity to implement the assessments effectively.

Figure 1:
Holistic Assessment Framework



The primary focus of developing the HAF was to improve the quality of assessments in elementary education providing meaningful evaluation of student learning. After the implementation, it was essential to know the applicability of the HAF to determine whether it effectively serves the intended purpose. The purpose of knowing the applicability of the framework is to address educational outcomes, supporting holistic development and adapting to innovative, alternative, tailor made multidimensional assessments. In this regard the research explores the practical application of implementing the HAF in primary education. The research questions guiding this study are -

RQ1: How do teachers perceive the traditional assessments and the challenges they faced in the traditional assessment framework?

RQ2: What are the teachers' reactions and attitudes towards the HAF?

RQ3: What are the experiences of teachers in implementing the HAF in Grade 1?

RQ4: From a teacher's perspective how has the HAF influenced students and what was the impact of the HAF on learning?

RQ5: What reflections do teachers have on the use of the HAF as transformed assessments?

Methodology

A Case Study: Implementation of the HAF on Grade 1

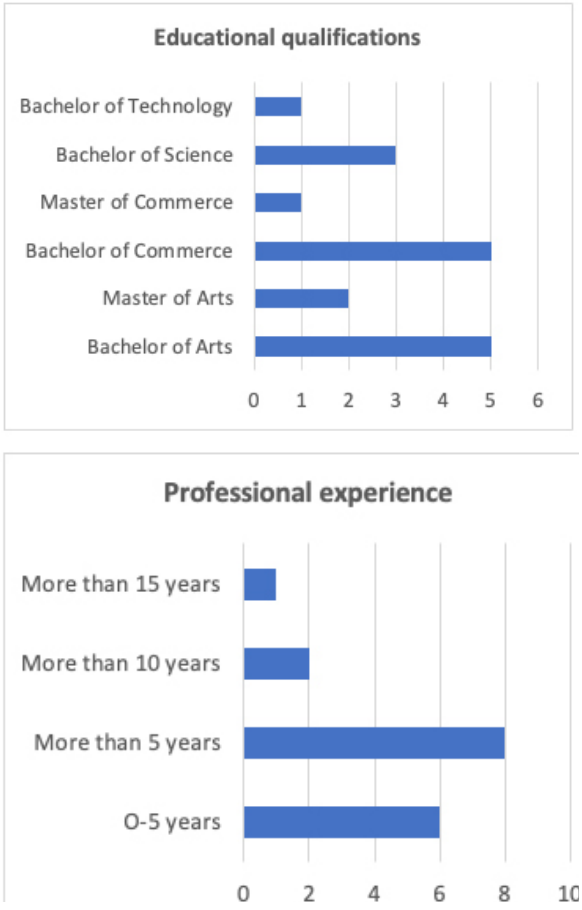
This is an evaluative case study focusing on assessing the applicability of the HCF. Participants were asked to reflect on their experiences using semi-structured interviews, through their feelings, opinions to evaluate the framework applicability.

School Site and Participants

The school where this research was conducted is in the heart of the city of Pune in the State of Maharashtra. This is a private school providing education to students from Grade 1 to Grade 10. This is a private school in which the education was transacted as based on the NEP 2020, since June 2022 in the Foundational years. This school has an approximate strength of 1800 students with approximately 45 students in each division and a teacher student ratio of 1: 22. This school follows the Maharashtra State Board curriculum and in the Foundational years where the focus is on the three developmental goals comprising of - Foundational Literacy and Numeracy, Health and Wellbeing; and, Effective Communicators and Involved Learners. While NEP emphasizes the 5-step pedagogy known as Panchaadi – Aditi, Bodh, Abhyas, Prayog and Prasar, at this school a similar 5 step approach: Provocation (prior knowledge assessment), Concept building, Reinforcement, Assessments and Reflection is implemented. To enhance pedagogy, self-designed workbooks and an integrated curriculum aligned with the United Nations 17 Sustainable Development Goals is considered. The diverse assessment methods used in this school extends beyond what is being used traditionally and incorporates methods like portfolios, presentation, performance-based assessments, anecdotal records, self and peer assessment, accelerated learning programmes and using a Holistic progress card thus making assessments a lot more fun, engaging, and forward-thinking.

The teachers who were trained in conducting assessments using the HAF were selected as participants. Total 17 elementary school teachers teaching Maths, English, Science, Social Science, Hindi (National language), Marathi (Local language of the State), and Music to Grade 1, were willingly participated in the study. The educational and professional profiles are presented in Figure 2. The teachers were coming from all the streams having bachelor's degree in Arts, Commerce and Sciences, and some of them had Masters, along with their Teacher Training degrees. Professionally Most of them have worked for more than 5 years, while some are recently joined the teaching professions (less than 5 years) and others are having 10 plus years of experience of teaching in school.

Figure 2:
Educational and professional profile of participating teachers



Data Collection

Semi-structured interviews (SSI) were conducted with the purpose of understanding the applicability of the HAF with respect to the transformation from traditional assessments to innovative multidimensional, holistic assessment framework. The interviews aimed to capture teachers' insights on using HAF and impact on learning. SSIs were conducted conversationally with one participant at a time (Adams, 2015) by one of the researchers over the period of one month after the completion of implementing the HAF over the full academic year. A systematic process for designing and conducting the interviews was followed to get rich and relevant data. The interview guide was developed, including the open-ended questions to be asked based on the pre-determined themes framed with the purpose of determining the applicability of the new HAF. Informed written consent was taken from all the participants before the actual interview schedule along with the consent to conduct data collection from the school authority. The purpose of the study, role of the teachers, confidentiality and willingness for participation was ensured. Suitable time and location were decided to conduct face-to-face interviews. Audio recorder was used for recording the interviews with the permission from all the teachers. Along with the transcripts, the written notes taken at the time of interviews were also used to capture the data. The data were then analysed in the context of the pre-determined themes.

Data Analysis and Findings

A hybrid approach of Inductive and deductive coding was used to provide meaningful contextualization and clarity about the HCF. Deductive coding was performed using the known predetermined themes and an inductive approach was then used to capture additional themes that emerged during the analysis of the qualitative data. The data captured the perspectives of teachers regarding implementation of HAF and the new assessment activities in their classrooms, through a series of reflective open-ended questions, in the form of semi-structured interviews. In a data analysis process, the deductive coding was performed with the help of - creation of evaluation criteria, data reading, applying the predetermined criteria codes to the data and analysing the coded data. Further the data was analysed using inductive coding through the process of - identifying emergent themes, getting context specific insights by reading through the data. It involved identifying the codes, patterns, and themes as they emerge (Miles et al., 2020). For each predetermined theme the codes were generated and presented in the tables explaining the meaning of the codes and the respective examples. The experiences and views of the teachers are analysed as follows -

Using Traditional Assessments before HAF

Deductive analysis: In deductive coding we applied a predetermined set of themes based on the HAF. The respective codes, definitions and data examples are presented for the predefined theme 'Using traditional assessments before HAF.' The analysis is presented in Table 1 below.

The responses reflect a general dissatisfaction among teachers for the traditional assessment system used at Grade 1 and 2. They highlighted the monotonous nature of the assessments conducted earlier, relying heavily on the standard tests, focusing majorly on the recall based theoretical testing. Teachers stated that the holistic approach was missing and the traditional assessment did not include important skills like creativity, problem solving, and communication.

Table 1:

Deductive analysis for the theme 'Using traditional assessments'

Codes	Definition	Data examples
Monotony	Teachers' perception of repetitive or uninspiring assessment tasks	"The assessment was monotonous for teachers as well as the students"
Limited scope	The focus on theoretical knowledge, recall and standardized testing	"Traditional assessments which we used were primarily focused on evaluating students through standardized tests" "They were limited to theoretical learning, based solely on retention and reproduction of coursework provided"
Major focus on cognitive domain	Emphasis on academic performance, less on other skills	"These were focused more on the academic, subject-wise performance of the student" "These were mostly centred on academic performance, particularly in subjects like mathematics, reading and writing"
Lack of holistic development	Lack of formal assessments on socio-emotional aspects and creative skills	"They lacked a broader view of skills and communication, which are essential for holistic development" "It couldn't grade students on their skills and attitude which is very important aspect of mental development"
Test centric assessments	The reliance on exams in the form of quizzes and tests to assess students	"Recall and demonstrate knowledge through pen and paper tests" "Traditional assessments focused on multiple-choice questions, such as true/false, tests, short answers, FIB"

It resulted in limited scope of capturing students' learning, as the assessments were largely limited to cognitive domain.

Inductive analysis: We derived codes other than the predetermined codes, from the thorough data reading. The codes emerged through the inductive analysis are:

1. Need for holistic assessments: Teachers desire for a more comprehensive system for assessment that includes non-academic skills along with the academic skills and knowledge. They think that the new assessment framework is useful for all students.

2. Benefits of the new assessment system: Teachers commented positively about the holistic assessment framework as compared to their experiences with the traditional assessments.

The data revealed the need for holistic assessments not merely focusing on theoretical knowledge, but demanding more focus on social, emotional, and practical skills. Positive mentions about HAF confirms that the teachers found value in the new assessment framework as compared to the traditional assessments.

Challenges Faced While Using Traditional Assessments

Deductive analysis: The analysis for the predetermined theme as the challenges faced by the teachers while using traditional assessments yielded major codes are presented in Table 2, as below.

The responses indicate that in the traditional assessments teachers faced many challenges as these assessments were based on memorization and not considering student centric approach. The assessments were teacher structured neglecting diverse learning styles, pressurizing students to perform in the assessments. Administrative challenges were also mentioned.

Inductive analysis: The emergent codes obtained through the inductive coding are:

1. Time management difficulties: Teachers responded that they were struggling to manage time for the assessments due to other administrative responsibilities due to their rigidity like conducting each subject paper every day. They felt it was tiring to manage conducting assessments and regular teaching.

2. Lack of engagement and motivation in assessments: The teachers felt difficulty in keeping students engaged and motivated while conducting the assessments due to its fixed nature. It was difficult to make students take interest in completion of the test papers as they get bored sometimes before the exams.

3. One-size-fits-all approach: Assessments that do not consider the diverse learning styles of students are challenging. Teachers felt that the one-size-fits-all approach was followed in traditional assessments with little scope for out-of-the-box thinking.

4. Overemphasis on grades: A few teachers responded that assessments primarily focus on grades and not on holistic learning, highlighting the limitations of traditional exams overemphasizing marks and grading than holistic learning.

This inductive analysis brings out the limited scope of traditional ways of conducting assessments earlier in which teachers face time management difficulties, keeping students engaged and motivated during the assessments. Overemphasis on marks of the students and less importance to assessing broader skills highlight the inaccuracy.

Table 2:
Deductive analysis for the theme 'Challenges faced in traditional assessments'

Codes	Definition	Data examples
Focus on memorization	Focus on rote learning and lack of conceptual understanding	"The traditional assessments have little scope for out of the box thinking" "Teachers do not get to know child's concept clarity due to rote learning system"
Limited assessment scope	Inability to assess practical oriented, no-academic, critical thinking skills	"I found less of real-world application in the assessments" "Incomplete picture of students' growth in all areas"
Teacher centred	Rather than student centred activities, assessments are structured based on teacher's preferred inputs	"Exams were earlier teacher centred" "Traditional assessments do not account for diverse learning styles"
Burden on students	Stress or pressure experienced by students for the exams	"Students were under pressure" "Quite boring for them to learn and study all before exams"
Administrative challenges	Issues of converting marks to grades, adhering to guidelines, and paperwork	"Maintaining records according to State Board guidelines" "Converting the marks into grades"

Highlights of The New HAF

Deductive analysis: Teacher responses were analysed using deductive coding for the predetermined theme 'highlights of the new HAF' as presented in Table 3.

Several key features of HAF were highlighted by teachers. Prominently the holistic nature and scope for skill development was appreciated. They opined that the framework allowed them for broader understanding of students through assessments in skills and attitude along with the academic evaluations. Another standout feature was ongoing continuous assessments focusing on personalized assessments, and practical applications.

Inductive analysis: The inductive coding emerged the following codes:

1. Parent-Teacher communication: Improved scope for communication from teachers with parents on students' progress was recognized by the teachers as a differentiating feature. HAF helped them in better communication with parents of children in Grade 1, to inform them of diverse areas of child's development.

2. Student empowerment: They found that students become active learners, gaining confidence. They can get opportunities to explore more in-depth about the topic.

3. Enjoyable assessments: The new framework changed the perception about assessments, as fun activities, engaging them in assessments and reducing burden.

The assessments were perceived as enjoyable activities for students, empowering them to gain confidence. Similarly, the data revealed that the new system provided more opportunities for reaching out to parents to communicate their child's learning progression.

Implementing HAF in Grade 1

Deductive analysis: We performed deductive coding for the data obtained on the predetermined theme 'Implementing the HAF.' The codes, definitions and examples are presented in the following Table 4:

The teachers' experiences of using HAF reflect a balance of positive aspects and challenges faced by teachers initially. Many teachers appreciated the holistic nature of assessments, providing a complete picture of development in children beyond just academics. The time incentive nature and the need for additional effort were key concerns.

Inductive analysis: The emergent codes obtained through inductive analysis are as follows –

1. Personalized learning: The teachers experienced the opportunities for personalised learning. Teachers stated that the framework helped them to understand the child, their strengths, and weaknesses. The framework allowed easy tracking of each child's progress on an individual basis.

2. Enjoyable Learning: Teachers emphasized that the framework made the learning process fun for students. The HAF makes the assessments enjoyable without causing any burden.

3. Emotional and social development: Teachers focused on non-academic aspects of student progression. The teachers expressed that the HAF helped them in evaluating the social, emotional, physical, and creative development of the students.

4. Adaptation and flexibility: The efforts required to shift from traditional assessments were seen as a hectic task initially. The adaptation was challenging.

Personalised learning emerged as a significant code, with teachers expressing their appreciation for the framework. Another recurring theme was enjoyable learning as the new assessment framework made the process more engaging for the students.

Students' Response to the HAF

Deductive analysis: We applied a predetermined theme 'Students' response to the HAF' to analyse responses using deductive approach. The relevant codes are presented in Table 5.

The analysis highlighted that student responded positively to the new assessment framework, showing high engagement, excitement and they were stress-free. The continuous and integrated nature of assessments help them enjoy assessments conducted in different ways.

Inductive analysis: In inductive coding the codes emerged from the data without the predetermined theme are found as follows –

1. Skill development: Under the new system teachers found development of academic and other critical skills in students. It is found to be in the form of observation skills, listening skills and reading and writing skills, and overall learning skills.

2. Invisible assessments: This code emerged from the responses of teachers implementing the HAF, stating that these ongoing continuous assessments were seamlessly integrated that allowed students to focus on learning without realizing they were being evaluated. Children were not aware about exams and a fixed time table.

3. Confidence building: HAF helped students gain confidence. Teachers expressed that children were very confident while giving answers, they appeared more confident for the new projects, and enjoyed stress-free and more flexible time frames.

Table 3:
Deductive analysis for the theme 'Highlights of the new HAF'

Codes	Definition	Data examples
Practical applications	The use of practical, real-world tasks in assessments	"Gives overall review of how well student has comprehended the topic, skills acquired and where the students can apply the gained knowledge in daily routine" "Use of knowledge in the real world"
Personalized assessments	Scope for customizing assessment activities based on individual students' needs	"It is personalized, catering to considering individual strength based not only on academic skill but also other skills" "It has encouraged continuous growth with individualized feedback"
Holistic nature	Inclusion of cognitive as well as social, emotional skills	"It includes the progress record of the child in every aspect which includes overall development like social, emotional, self-reflection, creativity and communication skills" "It focuses on comprehensive development of students encompassing all domains of learning rather than academic achievement"
Continuous assessments	Ongoing rather than high-stakes nature of assessments	"Students are assessed more on class or peer activities, and daily observations where they are active agents rather than being passive learners" "The assessments didn't burden the students but was ongoing, allowing them to demonstrate their abilities in a playful environment"
Skill development opportunities	Focus is on skill building, and not only on knowledge acquisition	"The unique grade descriptors reporting overall achievements include knowledge, skills and attitude" "It captures the progress of the child where students become confident, creative and develops questioning skills"

Table 4:
Deductive analysis for the theme 'Implementing the HAF'

Codes	Definition	Data examples
Holistic assessment	Inclusion of knowledge, skills, and attitude in assessments	"Helps understand students' progress beyond test score" "Shifting my approach to evaluate students more holistically. For knowledge, I assessed how well students understood the content through different activities. For skills we observed how they applied what they learned in practical tasks, group activities, and projects"
Student engagement	Engagement of students due to new assessment framework	"The entire experience was engaging and enriching for students" "We prepared assessment sheets in such a way that children will enjoy the process rather than feel bored"
Teacher satisfaction	Teachers' feelings about implementing the HAF	"As a teacher I feel satisfied since the new assessment framework brings out the essence of the learning objectives based on learning outcomes" "It's been a quite good experience; students do not feel pressure of examinations"
Time and effort	Time and efforts required for adaptation of the framework	"It is very time-consuming, but I think the assessment framework works well." "Balancing personal attention for students and managing creative assessments with large groups is difficult"
Challenges	The difficulties encountered by teachers during implementation of HAF	"Adapting new system and setting assessments" "Initially it was a hectic task, but later, got to know that the framework is designed meticulously"

Table 5:
Deductive analysis for the theme 'Students' response to the HAF'

Codes	Definition	Data examples
Student Engagement	Levels of interest and participation in new assessments	"Students love the assessment as it allows them to experience new life skills... they love to play and understand the concept through play-based learning" "Students responded positively as assessments reflected their interest and real-world application"
Learning outcomes	Impact of the assessment on knowledge, skills, and attitudes	"Students did well in reading and listening skills but struggled with writing" "They appear more confidently to these assessments" "The continuous assignment process allowed students to focus on learning without realizing they were being evaluated"
Stress of exams	Changes in anxiety due to assessments	"Students were having fun and did not face any stress due to exam fear" "The most rewarding aspect of this continuous assessment approach is that it takes place in a relaxed, stress-free environment"
Different forms of assessments	Student response to different formats in which assessments conducted such as play-based, practical etc.	"Students enjoyed assessments, especially when they were given choices" "Instead of worrying I found them excited and keep forward to new ones"

The inductive codes represented the increase in confidence and stress-free assessments resulting in assessments as an enjoyable activity. The theme of invisible assessments is unique, which contributed to a relaxed positive learning environment in place of rigidly planned formal, knowledge based, traditional assessments. Teachers also observed growth in specific skill sets.

Impact of HAF on Students' Learning

Deductive analysis: The deductive coding applied to data for the predetermined theme 'Impact of HAF on students' learning' as compared to the traditional system for assessments, yielded the following codes, presented in Table 6.

The responses indicate that the HAF has a profound positive impact on several dimensions of student learning. The teachers observed the impact of the new framework in the form of increased engagement, more self-development, holistic development, building conducive stress-free environment and alignment of learning with the real-world.

Inductive analysis: The codes emerged during the inductive analysis are -

1. Parental involvement: Feedback and guidance from parents was observed due to increased opportunities for communication. When communicated with parents regarding the lenient approach towards learning, reading, and writing, they supported their child, and the children did well.

2. Equity in assessment: Few teachers appreciated the flexibility of assessments to include diverse student strengths. If a student is excellent in oratory skills but not in writing, they can still acquire good grades. It is the best way to assess the conceptual clarity of the child.

3. Relevance to the real-world problems: The assessments related to the real-world issues, and children could relate to the practical problems.

From an inductive perspective, the important themes surfaced. HAF is found to be focusing on individual strengths of students providing equity in assessment. The framework provides assessments that are relevant to real-world issues. Support in the form of parental involvement is also observed in the learning process.

Reflections on the Transformed Assessments

Deductive analysis: In the deductive analysis the analysis evolved several codes for the predetermined themes 'Reflections of teachers on the transformed assessments" as suggested in the HAF. The analysis is presented in Table 7, including the codes and respective examples from which they are drawn.

From a deductive analysis the teachers are found to have expressed positively on the meaningful assessment objectives and significance of student centric approach. They recommended some improvements to improve the quality of the framework and stated the challenges they faced during the implementation of the HAF.

Inductive analysis: The emergent codes are presented below –

1. Teacher empowerment: Implementing the framework provided many learnings to the teachers during the process of designing and grading diverse assessments.

2. Long-term impact on students: teachers reflected that the new framework shapes students' future attitudes and life skills. They felt that in the long run these assessments will help students to be better individuals with good social values.

3. Feedback: Regular feedback should be provided to the parents at least once in two months to practice continuous improvement in students.

Both the deductive and inductive analysis of the HAF significantly impacted student learning, engagement, and holistic development. While there are some challenges like time management in large classrooms, writing skills development, faced by teachers, the framework was largely perceived as beneficial by both teachers and their students because of its key features as holistic, learner centric, stress-free, skill based, practical, continuous, and engaging assessments for better learning.

Discussion

The successful development and implementation of the HAF presented in this study highlights the shaft of assessments at elementary level, from traditional to multidimensional, holistic assessment. This framework can be used as a reference framework for designing the assessments based on the modern learning theories, aligned with the national policy and curriculum. Along with the cognitive, knowledge-based assessments this comprehensive framework also includes skills and attitude-based assessment, aligning with the recent research. The HAF is supported by emerging findings from the research that put emphasis on formative skill-based assessment to improve continuous learning. The study conducted by Black & William (2018) support formative assessments like the HAF which include formative assessments of different kinds, to ensure continuous learning and feedback for the teachers about students' progression. Present study also resonates with the global perspective on assessments with respect to social emotional skills and creativity as suggested by OECD's Learning Compass 2030 (Steponavičius et al. 2023).

Table 6:
Deductive analysis for the theme 'Impact of the HAF'

Codes	Definition	Data examples
Practical aspects of learning	The use of learning in real-world, in the practical context	"Children could relate to practical problems and issues" "Students demonstrated a better understanding of concepts through practical tasks and groups"
Stress free environment	The shift from anxiety levels to joyful learning	"Compared to traditional assessments students do not have the fear of exams" "Students did not have fear of exam,
Interest in learning	Students' involvement and motivation in learning	"The backward design model helped students learn better and retain their interest in learning"
Holistic development	Development of both knowledge and skills	"The detailed assessments suggested in the framework helped the teachers and students to understand their performance across academics, skills and attitude" "It helped view a customized learning journey in critical thinking, reflecting, problem solving and social-emotional skills"
Self-development	Confidence, Creativity and Skill building among students	"It gives more confidence to the kids and impress their leadership qualities" "The assessments helped students come up with different ideas and perform creatively"

Table 7:
Deductive analysis for the theme 'Reflections on the transformed assessments'

Codes	Definition	Data examples
Meaningful assessment objectives	The clarity and purposefulness of assessments	"The assessment has meaning; the objectives tell us exactly what we are assessing" "It is a detail analysis of a student"
Student centric assessments	Emphasis on overall development of students	"These assessments are skill based and student centric" "Using the framework offers more comprehensive view of student development"
Student engagement	Positive impact on student participation in assessments and thus in learning	"Play based assessments are ideal for foundational year students" "The assessments are authentic and conducted in a natural environment"
Challenges/ Improvements	Further enhancement in the assessment process is needed, challenges are to be considered.	"Some assessments can be informed to the children in advance to allow them to prepare better" "Streamlining the assessment process and automating parts of it could reduce time spent on grading"

Moreover, HAF is supported by emerging researches on learner centric assessments, that caters to the higher involvement of learners. The study conducted by Zulkifli, A. F. (2019), allow teachers modify learning activities, also conduct alternative assessments, and demonstrated effective learning in students. According the teachers implementing the HAF in their classrooms appreciated the integration of various learning domains and holistic approach of assessment of their students. Similar results were observed by Huda & Mahmudah (2023), confirming that with the use of holistic assessments teachers can assess students' ability in a better manner.

The multidimensional nature of the present framework aligns with the Universal Learning Design-UDL approach that encourages teachers to provide options in the assessments, inclusive assessments, and consideration on strengths (Kusumaningsih, 2021). The research employed by Lam (2024) gathered the insights on current assessment challenges and practices, and highlighted the need for exploration of strategies for improving competency-based assessments. In the context of modern education, the HAF presented the reforms that are required to make assessments more authentic and competency based. In the present study teachers expressed positive approach towards the HAF though they faced challenges like managing time and effort. Similar findings were observed in the study conducted by Demir et al (2019), wherein teachers showed positive attitude towards alternative assessments although some of them do not feel competent to conduct such assessments.

In conclusion the Holistic Assessment Framework mark a significant step forward in assessment at elementary education, with the evolution of holistic, multidimensional, student centric assessments. The framework reinforces the notion that traditional assessments can be reformed in the context of modern world to include holistic aspects and flexibility to bring in academic evolution for the improving learning and development in elementary school students.

Implications

Implications for Practice

The case study presented clearly demonstrates the potential of multidimensional and holistic assessment framework for assessing learning in students at elementary schools encompassing knowledge, skills, and attitudinal aspects. This framework can be adapted to bring in learner centricity in assessments, prioritizing personalized formative assessments. Assessments can be conducted along with teaching-learning activities, making learning fun that will reduce the burden and exam stress usually associated with the traditional exams.

Implications for Policy

The findings could inform reforms in curricula and teacher training initiatives for student centric and holistic multidimensional assessments. Initiatives in organizing holistic assessments and reducing monotonous test-based evaluations can be practiced by incorporating the HAF in policy reforms. Teachers can be motivated, trained, and incentivized to use this assessment framework in elementary schools by providing necessary support.

For implementing HAF a targeted professional developmental program would be recommended for teachers that can help them to focus on the practical strategies for implementing HAF. The programmes can be conducted throughout the academic year followed by a reflection and follow-up one day session every month during the implementation of HAF. Workshops can be organized for teachers which should include role playing scenarios, designing lesson plans and for time management techniques. The HAF can have a broader reach and utility if implemented as a policy in diverse school settings while funds are allocated justifiably in teacher training and resource utilizations.

Study Limitations

While this case study provides valuable insights into implementation of holistic assessment framework for elementary schools, it is limited by its major focus on a single school in an urban area and may not cover the insights from other schools in rural areas, having diverse social and organizational contexts. This study was limited to a selective school and group of teachers who voluntarily participated in implementing the HAF. Thus, the findings of this paper may not fully represent the experiences of teachers in different contexts or school boards. Apart from this, the effectiveness of the framework also depends on the variations in school resources, teacher training and student demographics, thus limiting the generalizability of the results.

Further the study is based on insights and reflections obtained through teachers who were trained and implemented the HAF, while other data sources such as student performance records and classroom observations were not considered. Additionally, the data collection relied on semi-structured interviews, which may suggest the potential researcher bias. The timebound nature of the study captures the short-term outcomes. Long term effects to understand the effectiveness of HAF is out of the scope of this study. Further research may be conducted in future longitudinally. Despite these limitations the study provides a nuanced understanding of the structure, impact of HAF and teacher perceptions of implementing HAF that can be operationalized in practice.

Conclusion

This comprehensive multidimensional assessment framework holds potential for transforming the educational assessment process at elementary level. The principles followed to design the assessment framework mainly based on learner centricity, constructivism, personalized assessments, differentiation, and authentic assessments. The applicability of the framework was determined with the help of hybrid approach including deductive and inductive analysis of the data gathered through the teachers practicing the HAF on the elementary school children. The perceptions, experiences and insights of these teachers are found to be useful in this process.

The teachers perceived traditional examinations monotonous, having limited scope for holistic learning as the assessments are standardized and theory based, largely focusing on cognitive domain and are test centric relying excessively on exams and tests to assess student learning. Traditional assessments focus on memorization and has limited assessment scope to assess practical oriented, real-world applications on the learning. They perceived these as teacher centred and burdensome for students as students take stress of written examination. Teachers faced administrative challenges and issues like adhering to the guidelines, paperwork, and tasks such as conversion of marks into grades, overemphasizing grading. Time management difficulties, one-size-fits-all approach and difficulty in keeping students engaged in learning and assessments due to lack of motivation and fun, especially for elementary school kids. Teachers desire for a more comprehensive assessments and think positively towards new framework as compared to the traditional assessments.

The Holistic Assessment Framework perceived by teachers as holistic framework providing scope for personalized assessments, practical applications, skill development opportunities, and having wide scope for continuous assessments providing multiple

opportunities for teachers to conduct varied formative assessments. The HAF empowered students making them active and providing opportunities for deep learning, eventually improving their confidence. It was stated that the new framework provides improved communication with parents. Teachers experienced improved student engagement, teacher satisfaction while implementing the HAF. Reiterating the holistic nature of the framework, teachers felt that HAF makes learning enjoyable by providing adaptation and flexibility, scope for emotional and social development and personalized learning. While implementing HAF they faced some challenges as management of time and effort in adapting the new framework in large classrooms. Initially they struggled to setting assessments and managing creative assessment tasks. Additionally, teachers would like to have the processes in the HAF to be streamlined to save on time and effort.

Levels of interest and engagement found to be improved as students enjoyed the assessments, and appeared more confidently to these assessments. They found positive changes due to reduced exam related stress among students as students get choices and variety of assessment tasks. They mentioned these assessments as 'Invisible assessments' as the assessments were seamlessly integrated with the classroom teaching-learning activities. Teachers expressed that the HAF helped them to align assessment tasks with the learning outcomes effectively and achieve them. The HAF also found useful for skill development. The clarity and purposefulness in assessments, emphasis on student centricity, empowering teachers to create and conduct innovative assessment are the important highlights of the framework gained from the teacher reflections. Thus, the teachers found the framework impactful and applicable due to practical learning approach, conducive stress-free learning environment, students improved learning engagement, opportunities to develop skills and attitudes along with cognitive skills, and over the above the scope for students for self-development. The teachers find this framework relevant to modern education requirements as well as equity-based education.

Teachers shared an overwhelmingly positive response to the HAF – especially about how they could assess student engagement, creativity, and socio-emotional development. They emphasized that the traditional forms of assessment were centred around the ability of the students to recall information or apply some basic literacy and numeracy skills, mostly focussed on the book-based knowledge. Before HAF there was rarely any real-world connection and even question paper setting meant to restrict it to what is mentioned in the prescribed text books of the grade. The traditional assessment followed a one-size-fits-all approach. Examinations till before the framework, found students under a peer and parental pressure as against the present one where students enjoy the process even while the assessment is going on.

The present form of HAF ensures that the assessments take into consideration a broader view of creativity and communication skills which are essential for a holistic development of the child. It not only considers the cognitive skills but also other domains of learning like emotional and social. Thus, the HAF promotes a multidimensional view and not just on academic performance. While the HAF ensures that teachers can assess the conceptual clarity of the students, it is also a very fun process for the students. Another highlight of the new framework is that the teachers cannot give a descriptive remark and is more personalized such that the teachers can follow up on the individual strengths of each student. Even the unique grade descriptors introduced in the present HAF was a welcome change. This new assessment method has also meant better communication with parents. All teachers implementing this new curriculum felt it to be an interesting and enriching experience while giving better insights into the learning process of each student in their class. However, they also noted the practical challenges they faced like managing the time for continuous assessments due to the large class sizes. Many assessments needed them to procure eco-friendly material for hands-on activities and that too at times were challenging considering the number of students needing them. They also mentioned that they had to balance the traditional curriculum requirements with the newly developed HAF, for which a better institutional support could have made the process seamless.

This research contributes meaningfully to the body of literature by providing insights into how the teachers teaching in early year classrooms can make assessments both relevant and fun while also catering to the diverse needs of a heterogeneous class with many students. Also, in contrast to other papers that talk about diverse assessments, this assessment framework considers this diversity and results in a HAF as evidence of achievement.

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Conflicts of interest/Competing interests

The author reports there are no competing interests to declare.

Data availability

Data can be shared on request.

References

Adams, W. C. (2015). *Conducting semi-structured interviews.* Handbook of practical program evaluation, 492-505. https://doi.org/10.1002/9781119171386.ch19

Ali, E., Constantino, K. M., Hussain, A., & Akhtar, Z. (2018). The effects of play-based learning on early childhood education and development. *Journal of Evolution of Medical and Dental Sciences, 7*(43), 6808-6811.

Aliah, N., Natsir, N., & Zulkhaeriyah, Z. (2023). Development of innovative assessment methods in the context of modern learning. *International Journal of Education, Language, Literature, Arts, Culture, and Social Humanities, 1*(4), 84–93. https://doi.org/10.59024/ijellacush.v1i4.424

Andrade, H., & Du, Y. (2019). Student perspectives on rubric-referenced assessment. *Practical Assessment, Research, and Evaluation, 10*(1), 3.

Andrade, H. L., & Heritage, M. (2017). *Using formative assessment to enhance learning, achievement, and academic self-regulation.* Routledge. https://doi.org/10.4324/9781315623856

Ansorger, J. (2021). An analysis of education reforms and assessment in the core subjects using an adapted Maslow's hierarchy: Pre- and post-COVID-19. *Education Sciences, 11*(8), 376. https://doi.org/10.3390/educsci11080376

Black, P., & Wiliam, D. (1998). Assessment and classroom learning. *Assessment in Education: Principles, Policy & Practice, 5*(1), 7-74.

Black, P., & Wiliam, D. (2010). Inside the black box: Raising standards through classroom assessment. *Phi Delta Kappan, 92*(1), 81-90. https://doi.org/10.1177/003172171009200119

Black, P., & Wiliam, D. (2018). Classroom assessment and pedagogy. *Assessment in Education: Principles, Policy & Practice, 25*(6), 551-575. https://doi.org/10.1080/0969594X.2018.1441807

Benton. A. L. & Kleitman, S. (2021). Digital assessment and remote learning during COVID-19: Opportunities and challenges. *Journal of Learning Analytics, 8*(1), 63-80.

Bearman, M., Nieminen, J. H., & Ajjawi, R. (2022). Designing assessment in a digital world: an organising framework. *Assessment & Evaluation in Higher Education, 48*(3), 291–304. https://doi.org/10.1080/02602938.2022.2069674

Bourke, R., & Mentis, M. (2014). An assessment framework for inclusive education: integrating assessment approaches. *Assessment in Education: Principles, Policy & Practice Benton, 21*(4), 384–397. https://doi.org/10.1080/0969594X.2014.888332

Bui, H. P., & Nguyen, T. T. T. (2024). Classroom assessment and learning motivation: Insights from secondary school EFL classrooms. *International Review of Applied Linguistics in Language Teaching, 62*(2), 275–300.

Carroll, Jamie M. (2013). *The brutal reality of bringing kids up to level: are critical thinking and creativity lost in the world of standardized testing?* University of New Orleans Theses and Dissertations. 1616. https://scholarworks.uno.edu/td/1616

Choirunnisa, M. R., & Mandasari, B. (2021). Secondary students' views towards the use of Google Classroom as an online assessment tool during the COVID-19 pandemic. *Journal of Arts and Education, 1*(1). https://doi.org/10.33365/jae.v1i1.31

Compton, V., Harwood, C. (2003). Enhancing Technological Practice: An Assessment Framework for Technology Education in New Zealand. *International Journal of Technology and Design Education 13*, 1–26. https://doi.org/10.1023/A:1022318118467

Dar, R.A. (2020). Friedrich August Froebel Kindergarten System and His Main Contribution to Education. *International Journal of Advanced Multidisciplinary Scientific Research (IJAMSR), 3*(9), 13 -25.

Darling-Hammond, L. (2014). *Next generation assessment: Moving beyond the bubble test to support 21st century learning.* John Wiley & Sons.

Demir, M., Tananis, C. A., & Trahan, K. W. (2019). Evaluation of alternative assessment methods used in elementary schools. *Egitim ve Bilim, 44*(197). https://doi.org/10.15390/EB.2019.6272

Doğan, Y., Yıldırım, N. T., & Batdı, V. (2024). Effectiveness of portfolio assessment in primary education: A multi-complementary research approach. *Evaluation and Program Planning, 106*, 102461. https://doi.org/10.1016/j.evalprogplan.2024.102461

Flaherty, S., & Hackler, R. (2010). *Exploring the effects of differentiated instruction and cooperative learning on the intrinsic motivational behaviors of elementary reading students* (Master of Arts in Teaching and Leadership, Saint Xavier University Chicago, Illinois).

Fuentealba Greer, C. J., Levin, J., Williams, S., Welton, A., & Koberstein, T. A. (2021). *Re-imagining k-12 schools student assessment.*

Gibbs, G. (2010). *Using assessment to support student learning*. Leeds Met Press. https://eprints.leedsbeckett.ac.uk/id/eprint/2835/

González-Calatayud, V., Prendes-Espinosa, P., & Roig-Vila, R. (2021). Artificial intelligence for student assessment: A systematic review. *Applied Sciences, 11*(12), 5467. https://doi.org/10.3390/app11125467

Hardy, I., & Lewis, S. (2020). Equity and standardized testing in education. *Journal of Educatuin Policy, 35*(4), 538-555.

Hargreaves, E. (2005). Assessment for learning? Thinking outside the (black) box. *Cambridge Journal of Education, 35*(2), 213-224.

Hj. Ebil, S., Salleh, S. M., & Shahrill, M. (2020). The use of E-portfolio for self-reflection to promote learning: A case of TVET students. *Education and Information Technologies, 25*(6), 5797-5814.

Huda, K., & Mahmudah, U. (2023). Implementation of Holistic Assessment in Fun Learning Activities at Mulyorejo Tirto State Elementary School, Pekalongan Regency. In Proceeding of Annual International Conference on Islamic Education and Language (AICIEL), 102-109.

Ibarra-Sáiz, M. S., Rodríguez-Gómez, G., & Boud, D. (2020). The quality of assessment tasks as a determinant of learning. *Assessment & Evaluation in Higher Education, 46*(6), 943–955. https://doi.org/10.1080/02602938.2020.1828268

Jones, S. M., & Kahn, J. (2017). *The evidence base for how we learn: supporting students' social, emotional, and academic development. consensus statements of evidence from the council of distinguished scientists*. Aspen Institute.

Kanellopoulou, E. M., & Darra, M. (2022). Pedagogical differentiation in primary education: Conceptual determinants and definitions. *International Education Studies, 15*(2), 138-148.

Kingston, N. M., & Nash, B. (2011). Formative assessment: A meta-analysis and a call for research. *Educational Measurement: Issues and Practice, 30*(4), 28–37. https://doi.org/10.1111/j.1745-3992.2011.00220.x

Kusumaningsih, S. N. (2021). Incorporating inclusive assessment principles and universal design for learning in assessing multicultural classroom: An autoethnography. *LLT Journal: A Journal on Language and Language Teaching, 24*(2), 337-348.

Lam, T. N. (2024). Enhancing the quality of competency assessment for elementary school students in modern education. I*nternational Research Journal of Management, IT and Social Sciences, 11*(3), 93-101. https://doi.org/10.21744/irjmis.v10n3.2429

Leenknecht, M., Wijnia, L., Köhlen, M., Fryer, L., Rikers, R., & Loyens, S. (2020). Formative assessment as practice: The role of students' motivation. *Assessment & Evaluation in Higher Education, 46*(2), 236–255. https://doi.org/10.1080/02602938.2020.1765228

Leutner, D., Fleischer, J., Grünkorn, J., & Klieme, E. (2017). Competence assessment in education: An introduction. *Competence Assessment in Education: Research, Models, and Instruments,* 1-6.

Maba, W., & Mantra, I. B. N. (2017). An analysis of assessment models employed by the Indonesian elementary school teachers. *International Journal of Social Sciences and Humanities, 1*(1), 39-45. https://doi.org/10.29332/ijssh.v1n1.38

Mathur, G., Nathani, N., Chauhan, A. S., Kushwah, S. V., & Quttainah, M. A. (2024). Students' satisfaction and learning: Assessment of teaching-learning process in knowledge organization. *Indian Journal of Information Sources and Services, 14*(1), 1–8. https://doi.org/10.51983/ijiss-2024.14.1.3798

Meylani, R. (2023). A comparative analysis of traditional and modern approaches to assessment and evaluation in education. *Batı Anadolu Eğitim Bilimleri Dergisi, 15*(1), 520–555. https://doi.org/10.51460/baebd.1386737

Ministry of Education (2022). National Curriculum Framework for Foundational Stage 2022. https://ncert.nic.in/pdf/NCF_for_Foundational_Stage_20_October_2022.pdf

Ministry of Education (2020). National Education Policy 2020. https://www.education.gov.in/sites/upload_files/mhrd/files/NEP_Final_English_0.pdf

Ministry of Education (2021). NIPUN Bharat. National Initiative for Proficiency in Reading with Understanding and Numeracy. https://nipunbharat.education.gov.in/fls/fls.aspx

Ministry of Education (2022). Toy Based Pedagogy - A Handbook on Learning for Fun, Joy and Holistic Development. https://ncert.nic.in/pdf/notice/toy_based_pedagogy.pdf

Miles, M. B., Huberman, M. A., & Saldaña, J. (2020). *Qualitative data analysis: A methods sourcebook*. Sage Publications

O'Reilly, T., Sabatini, J. & Bruce, K. (2022). Competency model in educational assessment: Development and applications. *Educational Psychologist, 57*(2), 109-126.

Parker, R., Thomsen, B. S., & Berry, A. (2022). Learning through play at school – a framework for policy and practice. *Frontiers in Education, 7,* 751801. 10.3389/feduc.2022.751801

Pellegrino, J. (2017). Teaching, learning, and assessing 21st century skills, in Guerriero, S. (ed.), *Pedagogical knowledge and the changing nature of the teaching profession.* OECD Publishing. https://doi.org/10.1787/9789264270695-12-en.

Piaget, J. (1952). *The origins of intelligence in children.* International Universities Press.

Puad, L. M. A. Z., & Ashton, K. (2020). Teachers' views on classroom-based assessment: An exploratory study at an Islamic boarding school in Indonesia. *Asia Pacific Journal of Education, 41*(2), 253–265. https://doi.org/10.1080/02188791.2020.1761775

Pyle, A., DeLuca, C., Danniels, E., & Wickstrom, H. (2020). A model for assessment in play-based kindergarten education. *American Educational Research Journal, 57*(6), 2251-2292. https://doi.org/10.3102/0002831220908800.

Saira, Z., Bakhtyzhamal, A., Mariya, J., & Manara, A. (2023). Modern approaches to assessment in preschool education. *ISL, 12*(1), 203. http://dx.doi.org/10.18576/isl/121203

Shu, X., & Gu, X. (2023). An empirical study of A smart education model enabled by the edu-metaverse to enhance better learning outcomes for students. *Systems, 11*(2), 75. https://doi.org/10.3390/systems11020075

Shepard, L. A. (2000). The Role of Assessment in a Learning Culture. *Educational Researcher, 29*(7), 4-14. https://doi.org/10.3102/0013189X029007004

Simon, K., & Gregg, S. (1993). *Alternative assessment--can real-world skills be tested?* Policy Briefs.

Steponavičius, M., Gress-Wright, C., & Linzarini, A. (2023). *Social and emotional skills: Latest evidence on teachability and impact on life outcomes.* OECD Education Working Papers, No. 304, OECD Publishing, Paris. https://doi.org/10.1787/ba34f086-en.

Stiggins, R., & DuFour, R. (2009). Maximizing the power of formative assessments. *Phi Delta Kappan, 90*(9), 640-644. https://doi.org/10.1177/003172170909000907

Thurlow, M. L., & Kopriva, R. J. (2015). Advancing accessibility and accommodations in content assessments for students with disabilities and english learners. *Review of Research in Education, 39*(1), 331-369. https://doi.org/10.3102/0091732X14556076

Thurlow, M. L., & Lazarus, S. S. (2021). Accessible assessments for students with disabilities: Implications for policy and practice. *Educational Measurement: Issues and Practice, 40*(3), 45-55.

Tobin, R., & Tippett, C. (2021). Competency-based education: Aligning teaching, assessment, and learning. *Journal of Educational Change, 22*(2), 149-171.

Tomlimson, C.A. (2001). *How to differentiate instruction in mixed-ability classrooms.* ASCD.

Torrance, H. (2007). Assessment as learning? How the use of explicit learning objectives, assessment criteria and feedback in post-secondary education and training can come to dominate learning. *Assessment in Education, 14*(3), 281-294.

van Niekerk, E., Ankiewicz, P. & de Swardt, E. A process-based assessment framework for technology education: a case study. *Int J Technol Des Educ, 20,* 191–215 (2010). https://doi.org/10.1007/s10798-008-9070-8

Vygotsky, L.S. (1978). *Mind in society: The development of higher psychological processes.* Harvard University Press.

Weimer, M. (2013). *Learner-centered teaching: Five key changes to practice.* John Wiley & Sons.

Widayanti R., Rahardja, U., Oganda, F. P., Hardini M. & Devana, V. T. (2021). *Students formative assessment framework (faus) using the blockchain.* 2021 3rd International Conference on Cybernetics and Intelligent System (ICORIS), Makasar, Indonesia, pp. 1-6. https://doi.org/10.1109/ICORIS52787.2021.9649582.

Wiliam, D., & Leahy, S. (2024). *Embedding formative assessment: practical techniques for k-12 classrooms.* Solution Tree.

Wood, E. A. (2013). *Play, learning and the early childhood curriculum.* SAGE Publications.

Yan, Z., & Brown, G. T. (2021). Assessment for learning in the Hong Kong assessment reform: A case of policy borrowing. *Studies in Educational Evaluation, 68*, 100985. https://doi.org/10.1016/j.stueduc.2021.100985

Zulkifli, A. F. (2019). Student-centered approach and alternative assessments to improve students' learning domains during health education sessions. *Biomedical Human Kinetics, 11*(1), 80-86.

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Revolutionizing Elementary Mathematics Education Through Virtual Labs

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Abstract

This study aimed to investigate the effectiveness of the virtual lab in teaching mathematics and its impact on the development of mathematical power and tendency towards mathematics among fourth-grade students in the Kingdom of Bahrain. To achieve the study's objectives, a quasi-experimental approach was employed. The sample consisted of 64 randomly selected students, divided into two groups (control=31, experimental=33). The study instruments included a mathematical power test and a scale of tendency towards mathematics. The results indicated a statistically significant difference between the mean scores of the two groups in the post-test for mathematical power in favor of the experimental group. There was also a statistically significant difference between the mean scores of the two groups in the post-application for the scale of tendency towards mathematics, favoring the experimental group. Furthermore, a positive relationship was found between mathematical power and tendency towards mathematics among students in the experimental group who were taught using the virtual lab. The study recommends that the Ministry of Education in the Kingdom of Bahrain consider the importance of establishing a virtual mathematics lab in primary education due to its positive impact on students' learning. Curriculum designers are advised to reconstruct primary school mathematics curriculum to incorporate various and diverse virtual lab activities. Additionally, teacher preparation programs should emphasize equipping educators with the necessary skills to effectively utilize technology, particularly virtual laboratories, in mathematics instruction.

Keywords:

Virtual Lab in Teaching Mathematics, Mathematical Power, Tendency Towards Mathematics, Elementary Stage, Kingdom of Bahrain

Introduction

The primary education stage is considered one of the most crucial educational phases, as it plays a fundamental role in shaping students' intellectual, social, skill, and informational development. Recognizing its significance, the Kingdom of Bahrain has shown keen interest in primary education, providing various support and resources to enable it to effectively fulfill its developmental role (Jebara, 2017).

In the educational system of Bahrain, mathematics is regarded as a subject deserving substantial attention to meet the needs of the Bahraini society and achieve the vision of Bahrain 2030, aiming to produce citizens capable of contributing to the kingdom's development and enhancing its economy through the acquisition of mathematical skills and knowledge (eGovernment of Bahrain, n.d.).

Mathematics holds a distinctive position and importance due to its role as a foundational and diversified subject, encompassing more than isolated concepts, operations, and routine skills (Turgut & Turgut, 2020). At the core of this foundation lies mathematical power, defined as the maximum knowledge in mathematics that can be utilized for thinking and communication (National Council of Teachers of Mathematics [NCTM], 2000). Developing mathematical power involves enhancing students' capacity for reasoning, critical thinking, and problem-solving (Abouassar, 2003). The development of mathematical power improves students' academic achievement, indicating their mastery of the required competencies, leading to increased performance in local and international assessments (Rizk, 2012).

To foster proper development of mathematical power in students, they must be motivated to learn mathematics and reach a stage of enjoyment in the learning process, thereby satisfying their inclinations. Therefore, a positive tendency towards mathematics encourages students to engage in activities requiring mathematical skills, driven by the sense of pleasure and satisfaction during their performance. Hence, students should experience enjoyable activities to consolidate their positive inclinations toward mathematics, enabling them to progress in acquiring new skills and knowledge, especially since some mathematics topics are often perceived as abstract (Rizk, 2012).

Virtual laboratories are technological tools that support active and student-centered learning. They represent artificially created learning environments that simulate reality, allowing students to interact using electronic devices such as computers, mobile phones, tablets, or other electronic devices (Alradi, 2008). Elmaradany and Mokhtar (2011) explained that virtual environments are essential learning systems providing various services and educational tools to meet students' needs for communication and interaction with peers and educators.

In a virtual lab, mathematics lessons are modeled and presented in electronic form, conveying the intended meaning through audio, visual, and motion techniques. The characteristics of virtual laboratories, as mentioned in the study by Albasyouny et al. (2010), Abouassar (2018), and Hassn (2019), motivate their use in the teaching and learning process due to their positive impact on students' cognitive and skill development in mathematics. Therefore, the current study seeks to investigate the effectiveness of the virtual lab in mathematics on the development of mathematical power and tendency towards mathematics among primary school students.

Study problem and questions:

The awareness of the study's problem emerged through one of the researchers' experiences in teaching mathematics at the elementary level. The prevalence of traditional teaching methods and the absence of utilizing virtual lab technology was observed. Additionally, the Ministry of Education provided electronic classrooms with a set of computers sufficient for each class, but these classrooms were not utilized for employing virtual lab technology in mathematics. Furthermore, the researchers had a passion and desire to enhance teaching methods for the elementary level, aligning them with virtual laboratories to develop mathematical power and a tendency towards mathematics.

Therefore, the purpose of this study is to investigate the effectiveness of the virtual lab in teaching mathematics on the development of mathematical power and tendency towards mathematics. The research aimed to answer the following research questions:

1. What is the effectiveness of the virtual lab in teaching mathematics on the development of mathematical power among fourth-grade students in Bahrain?
2. What is the effectiveness of the virtual lab in teaching mathematics on the development of the tendency towards mathematics among fourth-grade students in Bahrain?
3. What is the relationship between mathematical power and the tendency towards mathematics among fourth-grade students in Bahrain?

Theoretical Framework & Literature Review

Virtual Lab:

The virtual lab is considered one of the modern innovations in educational technology, extending from electronic simulation systems. The virtual lab is an artificial learning environment that replaces and simulates the real world. In this virtual environment, students immerse themselves in a fictional setting, interacting with it through their senses using computer devices. The virtual lab is an extension of electronic simulation systems (Alradi, 2008). Bajpai (2012) defined it as computer software that facilitates low-cost laboratory experiments. The virtual lab assists students in conducting safe experiments without exposing them to the risks associated with real labs. It allows

students to build a mental model of the experiment to easily achieve the experiment's goals, aiding in the development and mastery of mathematical and life skills (Abouassar, 2018).

The philosophy of the virtual lab is rooted in making the learning process accessible to all students, to the extent that their abilities enable them to succeed in achieving the principle of equal educational opportunities. It also provides educational opportunities for students with special needs, allowing them to work actively and sustainably. Several studies (e.g., Elsadi, 2011; Epper & Garn, 2004; Yang & Heh, 2007) have indicated that the philosophy of the virtual lab is based on several principles derived from the philosophy of virtual reality and distance education, including (1) entering the imaginary world as if it were a created reality as an alternative to the real world due to the inability to access it or due to its dangers, (2) breaking the barriers of time and place in the old education system, emphasizing the continuity of lifelong learning, (3) enhancing student learning freedom, where each student learns on their own according to their abilities and needs, (4) promoting distance education principles and relying on new educational tools and modern methods, embodying the spirit of the age and its requirements, and (5) innovating interactive scientific topics in simple and interesting ways.

The virtual lab plays a significant role in mathematics education as it helps develop students' practical skills by conducting laboratory experiments. It provides an opportunity for students to understand the principles and concepts related to the subject content accurately and deeply through the interactive environment. The virtual lab supplies students with a clear set of events in which to actively participate in the simulation experience, offering them multiple options that suit their preferences. It allows students to deal with systems that may be challenging to handle under ordinary circumstances due to high costs or concerns about safety and security. It enables each student to expand their scientific imagination and develop their innovative ideas individually. Serious play is integrated into practical practice, attracting students' interest and encouraging their participation in the learning process (Albyaty, 2006; Bajpai, 2012; Jung et al., 2006; Noufal, 2010; Stewart et al., 2006).

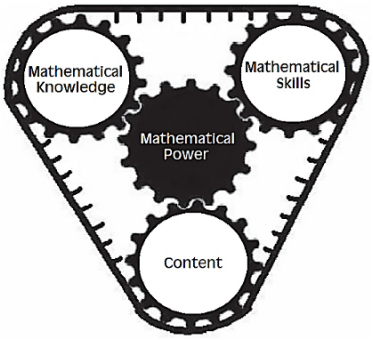
It is evident from the above that the virtual lab serves as a mediator between reality and abstraction. Through it, students can learn mathematics in its true form. The virtual lab helps students remember and learn properties, apply skills, understand concepts, and solve mathematical problems. Additionally, the virtual lab can be used as an introduction to teaching applied mathematics at the elementary level, allowing students to build mathematical models to illustrate abstract concepts and principles, conduct experiments using the scientific method for verification and proof, and ultimately verify laws and theories.

Numerous studies have attempted to test the impact of implementing the virtual lab in teaching and learning mathematics at different educational stages. The virtual lab had a positive effect on teaching the volume unit for sixth-grade students, positively influencing their cognitive and performance aspects, and increasing their academic achievement levels (Albasyouny et al., 2010). In teaching engineering and measurement to secondary school students, it improved the learning experience of various engineering concepts (Guerrero et al., 2016). It contributed to the academic development of secondary school female students by providing fun and excitement and facilitating teamwork (Al Maghamasi, 2016). It enhanced the measurement skills of spatial volumes and aesthetic perception for sixth-grade students (Hassn, 2019). It fostered motivation, independence, and improved the level of secondary school students (Moreno-Guerrero et al., 2020). It also developed the skills of students with learning difficulties (Alghanmi & Alhassani, 2020). Consequently, many studies have confirmed the positive effectiveness of the virtual lab for mathematics on various dependent variables. Thus, the virtual lab will be used as an independent variable in this study.

Mathematical Power:

Mathematical power is considered the primary standard for evaluating the quality of mathematics among students. It encompasses students' abilities in research, estimation, reasoning, creative and critical thinking, as well as the ability to formulate and solve problems (Alhasani & Al-Dulaimi, 2011). According to Qassim and Al-Saydawy (2013), mathematical power is the highest level of mathematical knowledge that a student can use in thinking and communication. It is also defined by Almuqayed (2017) as the student's ability to use mathematical knowledge in discovery, correlation, mathematical reasoning, and solving familiar and unfamiliar mathematical problems.

Figure 1:
The Mathematical Power Dimensions (Sahin & Baki, 2010)



Sahin and Baki (2010) pointed out that mathematical power has three main dimensions: mathematical content, mathematical knowledge, and mathematical skill (see Figure 1). Mathematical content includes the domains and fundamental standards of mathematics, such as numbers, arithmetic operations, algebra, and geometry (Pilten, 2010). Mathematical knowledge is the students' ability to understand and determine the role that mathematics plays in meeting their life needs (BouJaoude, 2009). Mathematical knowledge includes three capacities: conceptual knowledge, procedural knowledge, and problem-solving. Mathematical skills include three areas: mathematical communication, mathematical connection, and mathematical reasoning (Abu-Zaineh, 2017; Al-Kubaisi & Abdullah, 2015). According to Riani (2012), mathematical power is characterized by the ability to identify multiple patterns of mathematical skills (mathematical communication, mathematical connection, mathematical reasoning) and to determine sub-levels of mathematical knowledge (conceptual knowledge, procedural knowledge, problem-solving).

Given the importance of developing mathematical power in students at various stages, educational studies have attempted to find the best ways to nurture it. Many studies (Abdelwahed et al., 2022; Albashiti, 2015; Al-Haddad, 2021) have demonstrated the impact and effectiveness of employing electronic programs in improving and developing mathematical power. Abdelwahed et al. (2022) found the effectiveness of a nanotechnology-based electronic program in developing mathematical power and future thinking skills among secondary school students. Al-Haddad (2021) determined the effectiveness of electronic software for teaching mathematics in developing mathematical power for teacher-students in the College of Education. Albashiti (2015) recognized the effectiveness of a multiple intelligences-based electronic program in developing mathematical power among third-grade female students. From the above, we find that many studies have diligently tried to develop mathematical power as a dependent variable, given its importance in students' learning of mathematics. Therefore, mathematical power will be used as a dependent variable in this study.

Tendency Towards Mathematics:

Tendencies are psychological motivations acquired through the environment and experiences. Tendency can be defined as behavior that arises and manifests as a result of natural psychological needs (Al-Mosawi et al., 2015). Therefore, educators affirm that developing tendencies has become an essential educational requirement due to the significant outcomes it can demonstrate in regulating the course of the educational process and adjusting its direction. There is a correlation between tendencies and learning that gives the educational process a vital and meaningful aspect. Several recent studies have confirmed that students' positive tendencies toward the subject they are learning help them master it (Abdulhadi, 2015; Alraie, 2014; Jouda, 2013).

The definitions of tendency have varied; Alkhouli (2002) defined it as a desire arising from emotions and expressing the student's readiness to express love for a specific task. Al-Dahiri and Al-Kubaisi (2016) described it as feelings accompanying a person's attention and interest in a particular subject. Abu Gado (2020) defined it as a set of cognitive, emotional, and behavioral components related to an individual's response to a problem, topic, or situation, and the acceptance or rejection of these responses. This is the definition adopted in this study.

Teachers play a crucial role in developing students' tendency toward mathematics, transferring experiences, and motivating them. Elholy (2011) identified the teacher's role in developing students' tendencies through: (1) encouraging desired tendencies in students and nurturing them, (2) extinguishing undesirable tendencies and replacing them with desired tendencies through educational methods, (3) instilling new tendencies that were not originally present in students, such as a love for reading or writing, (4) developing human relationships with students built on respecting opinions and self-appreciation, helping reveal students' tendencies and fostering them. Abuhelal (2012) believes that for a teacher to develop a student's tendencies toward mathematics, they must consider (1) the student's needs, (2) creating a comfortable learning environment, (3) diversifying mathematical learning methods to include all learning styles, (4) conveying the idea or concept through appropriate representation, and (5) involving the student in reaching the mathematical concept.

Given the importance of developing a tendency toward mathematics in students' learning of mathematics, various studies have sought the most suitable ways to develop and improve it. Abuhelal (2012) clarified the impact of mathematical representations on acquiring concepts and a tendency toward mathematics for sixth-grade primary school students. Abdulqader (2018) demonstrated the effect of employing the numbered heads together strategy in developing visual thinking skills and a tendency toward mathematics for fourth-grade primary school students. Abuhelal (2018) affirmed the impact of entertainment-based learning on developing some thinking skills and a tendency toward mathematics in students. From the above, we find that many studies have diligently tried to develop a tendency toward mathematics as a dependent variable, given its importance and necessity in students' learning

of mathematics. Therefore, the tendency toward mathematics will be used as a dependent variable in this study.

This study differs from others as it aims to study the effectiveness of the virtual lab in teaching mathematics on developing mathematical power and a tendency toward mathematics for fourth-grade students in primary school in the Kingdom of Bahrain, which has not been studied by previous studies within the researchers' knowledge boundaries.

Methodology

The current study aims to investigate the effectiveness of the virtual lab in teaching mathematics on developing mathematical power and tendency toward mathematics among fourth-grade students in primary schools in the Kingdom of Bahrain. To achieve this, a quasi-experimental design was employed, based on a two-group design. One group, considered the control group, studied the chapter "Identifying and Describing Geometric Shapes" using traditional methods, while the experimental group studied the same unit using the virtual mathematics lab. This design was used to study the impact of the independent variable on the dependent variables, with study instruments applied to both groups before and after treatment.

Research Population:

The study's population includes all individuals who are the subject of the research problem, encompassing people such as students and teachers or a group of things like books (Obeidat et al., 2020). In this study, the population consists of all fourth-grade students in Muharraq Governorate in the Kingdom of Bahrain during the second semester of the academic year 2023-2024.

Research Sample:

The study sample is a subset of the study population with its characteristics and features (Al-Adl, 2014). The sample of this study was selected randomly, facilitated by one of the researchers working as a primary school teacher in Al-Muharraq Governorate. Two groups were randomly chosen from a total of four fourth-grade groups using the random sampling method. One group represented the control group (*N* = 31), studying the chapter "Identifying and Describing Geometric Shapes" using traditional methods. The second group represented the experimental group (*N* = 33) with students studying the same unit using the virtual lab. Thus, the sample size in this study comprises (*N* = 64) fourth-grade students (see Table 1).

Table 1:
Study sample information

Group	Treatment	N
Experimental	Virtual lab	33
Control	Traditional methods	31
Total of the sample size		64

Research Variables:

The research variables were defined as follows:

Independent Variable: Virtual lab usage.

Dependent Variables: Development of mathematical power and tendency towards mathematics.

External Variables:

a. Age: To ensure the homogeneity of the study groups' ages, school records were reviewed, revealing that both groups' ages ranged from 9 to 10 years.

b. Gender: The sample consisted exclusively of male students.

c.Level of Dependent Variables in the participants: Equality in the level of mathematical power and tendency towards mathematics was verified through the pre-application of study instruments to both groups.

d.Teachers: One of the researchers served as the teacher who implemented the study with both groups to ensure educational equality.

Experimental Treatment Materials:

To achieve the study's objectives, experimental treatment materials and the following study tools were designed:

Experimental Treatment Materials: A teacher's guide for teaching according to the proposed virtual lab in the chapter "Identifying and Describing Geometric Shapes," accompanied by various in-class and out-of-class activities for students.

Instrumentation:

The researchers prepared all research instruments, including:

A. Mathematical power test on the chapter "Identifying and Describing Geometric Shapes."

B. Tendency toward mathematics scale.

C. A dedicated website for the virtual mathematics lab.

Mathematical Power Test:

Test objective: This test aims to assess the proficiency level of fourth-grade students in the three dimensions of

mathematical power: communication, connections, and reasoning.

Test items: Drawing upon the literature and previous studies that focused on developing the dimensions of mathematical power, it was found that measuring the three dimensions (communication, connections, and reasoning) could be achieved by preparing a test that assesses students' conceptual, procedural, and problem-solving aspects. The test consists of 19 items, divided into two sections: one for multiple choice (13 items) and the other for essay questions (6 items), distributed across the axes of mathematical power, as illustrated in Table 2. Each multiple-choice question offers four options (a, b, c, d), while the essay questions require a comprehensive response. Correct answers in multiple-choice questions are awarded 1 point each. Essay questions are scored as follows:

0: No response or irrelevant answer.

1: Partially correct answer.

2: Fully correct answer.

Validity of the Test:

i. Face validity: The test, in its initial form, was presented to a group of curriculum and instruction specialists, as well as some mathematics teachers, to gather their opinions on the general framework of the test, test instructions, the number of test items, distribution of scores on items, inclusivity of the test for scientific content, appropriateness of questions to measure mathematical power dimensions, balance in the distribution of mathematical power dimensions among test questions, linguistic formulation of questions, scientific formulation of questions, appropriateness of questions to students' levels, diversity of questions, and clarity of ideas in test questions. Some modifications were made based on the experts' opinions, leading to adjustments in the test specifications, including the number of questions and grades for each dimension of mathematical power (see Table 3).

Pilot Study: The researchers applied the test to an experimental sample consisting of 45 students in the fourth grade (not the study sample) to calculate the psychometric properties of the mathematical power skills test.

ii. Discriminant/divergent validity: Discriminant validity was conducted on the test. The survey participants (n = 45) were ranked in descending order according to the total score each achieved on the mathematical power test. The top 27% of scores (12 students) and the lowest 27% of scores (also 12 students) were selected. A comparison was then made between the scores of the two groups using the Mann-Whitney U test (see Table 4).

Table 4 indicates statistically significant differences at a significance level of 0.01 between the average scores of low and high scorers on the mathematical power test. This confirms the test's validity in discriminant between performance levels in the mathematical power test among participants.

Reliability of the Test:

Test reliability refers to the extent to which the test yields nearly the same results when reapplied to the same students. The tool was applied to a survey sample of 45 students, and the reliability coefficients were calculated using the test-retest method with a time interval of 15 days (see Table 5).

Table 5 shows that all reliability coefficients for dimensions of the mathematical power test, as well as the whole test, are statistically significant at the 0.01 level. The correlation coefficient value between the total score in the two applications of the mathematical power test is 0.962, indicating a strong correlational relationship. This confirms that the test has a high level of reliability.

Difficulty index: The difficulty index is the percentage ratio of the number of students who answered the question incorrectly to the total number of correct and incorrect answers. According to Al-Huwaidi (2015), any item with a difficulty index between 0.1 and 0.9 is considered acceptable and can be included in the test. The difficulty index for the mathematical power test items is presented in Table 6.

Table 6 shows that the difficulty index for mathematical power test items range between 0.16 and 0.29. According to Al-Huwaidi (2015), any item with a difficulty index in this range is acceptable and can be included in the test.

Item discrimination: The discriminatory ability of the mathematical power test items was verified by calculating the Pearson correlation coefficient between the scores of each individual item and the dimension to which it belongs, as well as the correlations between the test dimensions themselves and the whole score of the test to which they belong (refer to Table 7).

Table 7 indicates that all items are statistically significantly correlated with their respective dimensions at significance levels of 0.05 and 0.01. This demonstrates the ability of the test items to discriminate. Correlation coefficients were also computed between the score of each dimension of the test with other dimensions and the overall score of the test (see Table 8).

Table 2:

Items of mathematical power test

Dimensions	Number of items
Mathematical communication	8 items (5 multiple choices, 3 essay)
Mathematical connection	5 items (4 multiple choices, 1 essay)
Mathematical reasoning	6 items (4 multiple choices, 2 essay)
Total	19 items

Table 3:

Specifications of the mathematical power test in the final form

Chapter	Lessons	Mathematical communication		Mathematical connection		Mathematical reasoning		# Items	# Scores
		Items	Scores	Items	Scores	Items	Scores		
Identifying and describing geometric shapes	3D shapes	2	2	2	2	1	2	5	6
	2D shapes	3	5	-	-	2	2	5	7
	Angles	1	1	2	2	-	-	3	3
	Triangles	-	-	-	-	3	4	3	4
	Quadrilaterals	2	3	1	2	-	-	3	5
Total		8	11	5	6	6	8	19 items	25 scores

Table 4:

Results of discriminant validity (Mann-Whitney U test) for mathematical power test

Mathematical power test	*n* = 12	Mean Rank	Sum of Ranks	Z	p-value
Mathematical communication	high scores	18.20	218.47	4.050	0.000
	low scores	6.70	81.00		
Mathematical connection	high scores	18.51	222.00	4.487	0 .000
	low scores	6.50	78.00		
Mathematical reasoning	high scores	18.33	219.30	4.473	0 .000
	low scores	6.79	88.00		
Total	high scores	18.50	222.00	4.452	0.000
	low scores	6.50	78.00		

Table 5:

Reliability coefficients for the mathematical power test

Dimensions	Correlation coefficients
Mathematical communication	0.913**
Mathematical connection	0.947**
Mathematical reasoning	0.851**
Total	0.962**

Note: ** Correlation is significant at 0.01 level.

Table 6:

Difficulty index for mathematical power test

Mathematical communication		Mathematical connection		Mathematical reasoning	
Item	Difficulty index	Item	Difficulty index	Item	Difficulty index
1	0.24	2	0.18	5	0.24
3	0.27	7	0.27	6	0.27
4	0.20	11	0.22	9	0.20
8	0.24	12	0.22	13	0.13
10	0.29	Essay 5	0.16	Essay 2	0.18
Essay 1	0.16			Essay 4	0.13
Essay 3	0.18				
Essay 6	0.24				

Table 7:

Pearson correlation coefficients for items of mathematical power

Mathematical communication		Mathematical connection		Mathematical reasoning	
Item	Correlation coefficient	Item	Correlation coefficient	Item	Correlation coefficient
1	0.413**	2	0.517**	5	0.450**
3	0.503**	7	0.448**	6	0.614**
4	0.482**	11	0.515**	9	0.300*
8	0.597**	12	0.358*	13	0.300*
10	0.569**	Essay 5	0.810**	Essay 2	0.679**
Essay 1	0.571**			Essay 4	0.787**
Essay 3	0.636**				
Essay 6	0.476**				

Note: * Correlation is significant at 0.05 level, and ** correlation is significant at 0.01 level.

Table 8 reveals that all dimensions of the mathematical power test are correlated with each other and with the whole test score at a statistically significant level of 0.01. This affirms that the test possesses a high ability of its items to discriminate.

Discrimination Index: The discrimination index measures the test's ability to differentiate between high-achieving and low-achieving students in the characteristic assessed by the test (Abu Nahiah, 1994). The discrimination index for each item of the test was calculated using the following equation:

$$DX = \left(\frac{H - L}{\frac{1}{2}N} \right) \times 100$$

where:
DX = Discrimination Index.
H = number of correct answers in the upper group.
L = number of correct answers in the lower group.
N = total number of individuals who attempted to answer the question in both groups.

To obtain the discrimination index for each item of the test, the researchers divided the students into two groups: an upper group consisting of the top 27% of students who scored the highest on the test and a lower group consisting of the lowest 27% of students who scored the lowest on the test. Each group contained 12 students.

Some experts suggest that the discrimination index should not be less than 25%, and the higher the percentage of the discrimination index, the better, as it enhances the item's ability to discriminate (Abu Nahiah, 1994). Table 9 illustrates the discrimination indices for each item of the test.

Table 9 shows that the discrimination indices for the test items were not less than 25%. Therefore, all items have acceptable discrimination indices, and accordingly, all items in the mathematical power test were accepted.

Tendency toward Mathematics Scale:

Scale objective: The purpose of this scale is to identify the tendency of fourth-grade students towards learning mathematics and to reveal the impact of using the virtual lab in teaching mathematics on developing the tendency towards it.

Scale items: Based on the literature and previous studies focusing on developing the tendency towards mathematics, the scale was formulated to encompass four dimensions: (tendency towards the nature of mathematics, tendency towards learning mathematics, tendency towards enjoying mathematics, tendency towards the mathematics teacher). The scale consists of 26 items distributed across the dimensions of the tendency towards mathematics, as illustrated in Table 10.

Validity of the Scale:

i. Face validity: After preparing the initial version of the scale, it was presented to a group of experts specialized in curriculum and instruction and some mathematics teachers to gather their opinions regarding adding, deleting, or modifying scale statements. The goal was to ensure the relevance of the statements to each dimension, the clarity and linguistic appropriateness of the statements for fourth-grade students, and the sufficiency and clarity of the scale instructions. Some adjustments were made to the scale statements based on the reviewers' feedback. The final scale comprised 26 statements distributed on a three points Likert scale, where the responses were Agree = 3, I don't know = 2, and Disagree = 1.

Pilot Study: The researchers applied the test to a pilot sample of 45 fourth-grade students (not part of the study sample) to calculate the psychometric properties of the scale of tendency towards mathematics.

ii. Discriminant/Divergent Validity:

Discriminative validity was assessed by ranking the survey sample individuals (n = 45) in descending order based on the scores achieved in the scale of tendency towards mathematics. The top 27% of scores (12 students) and the lowest 27% of scores (also 12 students) were selected. Finally, a comparison was made between the scores of the two groups using the Mann-Whitney U test (see Table 11).

Table 11 indicates statistically significant differences at a significance level of 0.01 between the average scores of low and high scorers on the scale of tendency towards mathematics, confirming the scale's validity in distinguishing performance levels among participants.

Reliability of the Scale:

To verify the scale's reliability, the Cronbach's alpha coefficient was calculated. The Cronbach's alpha test results were 0.784 for the scale as a whole, indicating an appropriate level of reliability for the scale.

Item discrimination: The ability of the statements of the scale to discriminate was verified by calculating the Pearson correlation coefficient between the scores of each statement of the scale and the dimension to which it belongs, as well as the correlations between the scale dimensions themselves and the whole score of the scale to which they belong (refer to Table 12).

Table 8:

Pearson correlation coefficients for dimension of mathematical power

Dimensions	Mathematical communication	Mathematical connection	Mathematical reasoning	Whole
Mathematical communication	-	0.664**	0.736**	0.938**
Mathematical connection	-	-	0.606**	0.817**
Mathematical reasoning	-	-	-	0.882**

Note: ** Correlation is significant at 0.01 level.

Table 9:

Discrimination Indices for Each Item of the Mathematical Power Test

Mathematical communication		Mathematical connection		Mathematical reasoning	
Item	DX	Item	DX	Item	DX
1	42%	2	58%	5	50%
3	58%	7	33%	6	75%
4	50%	11	33%	9	33%
8	42%	12	25%	13	25%
10	58%	Essay 5	50%	Essay 2	42%
Essay 1	50%			Essay 4	33%
Essay 3	42%				
Essay 6	33%				

Table 10:

Items of tendency towards mathematics scale

Dimensions	Items	Number of items
Nature of mathematics	1-2-3-4-5-6	6
Learning mathematics	7-8-9-10-11-12-13	7
Enjoying mathematics	14-15-16-17-18-19-20	7
Mathematics teacher	21-22-23-24-25-26	6
Total		26

Table 11:

Results of discriminant validity (Mann-Whitney U test) for the scale

Scale of tendency towards mathematics	*n* = 12	Mean Rank	Sum of Ranks	Z	p-value
Nature of mathematics	high scores	18.21	218.50	4.052	0.000
	low scores	6.79	81.50		
Learning mathematics	high scores	18.51	222.00	4.450	0.000
	low scores	6.50	78.00		
Enjoying mathematics	high scores	18.50	222.22	4.433	0.000
	low scores	6.50	78.00		
Mathematics teacher	high scores	15.92	191.00	2.413	0.007
	low scores	9.08	109.00		
Total	high scores	18.50	222.00	4.184	0.000
	low scores	6.50	78.00		

Table 12:

Pearson correlation coefficients for items the scale

Nature of mathematics		Learning mathematics		Enjoying mathematics		Mathematics teacher	
Item	Correlation coefficient	Item	Correlation coefficient	Item	Correlation coefficient	Item	Correlation coefficient
1	0.678**	7	0.599**	14	0.528**	21	0.398**
2	0.667**	8	0.684**	15	0.441**	22	0.469**
3	0.657**	9	0.418**	16	0.409**	23	0.490**
4	0.345*	10	0.648**	17	0.512**	24	0.649**
5	0.315*	11	0.631**	18	0.331*	25	0.606**
6	0.590**	12	0.685**	19	0.512**	26	0.468**
		13	0.349*	20	0.308*		

Note: * Correlation is significant at 0.05 level, and ** correlation is significant at 0.01 level.

Table 12 shows that all scale items are statistically significantly correlated with the dimensions of the scale of tendency towards mathematics to which they belong at significance levels of 0.05 and 0.01. Correlation coefficients were also calculated between the score of each dimension of the mathematics inclination scale with other dimensions and the whole score of the scale (see Table 13).

Table 13:
Pearson correlation coefficients for dimension of the scale

Dimensions	Learning mathematics	Enjoying mathematics	Mathematics teacher	Whole
Nature of mathematics	0.556**	0.615**	0.315*	0.788**
Learning mathematics	-	0.670**	0.343*	0.878**
Enjoying mathematics	-	-	0.317*	0.796**
Mathematics teacher	-	-	-	0.515**

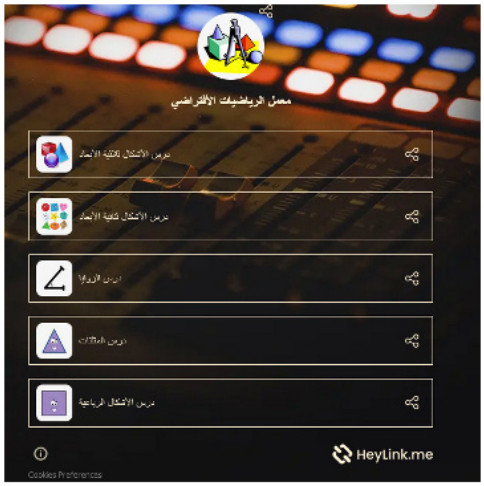
Note: * Correlation is significant at 0.05 level, and ** correlation is significant at 0.01 level.

Table 13 reveals that all dimensions of the scale are correlated with each other and with the whole score of the scale at a statistically significant level of 0.05 and 0.01. This confirms that the scale possesses a high degree of ability of its statements to discriminate.

Virtual Mathematics Lab

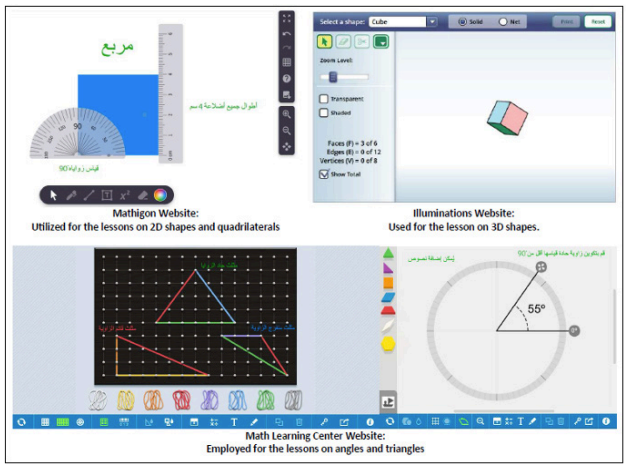
The virtual mathematics lab was developed to suit the selected instructional chapter "Identifying and Describing Geometric Shapes," which comprises five lessons: (Lesson on 3D shapes, Lesson on 2D shapes, Lesson on angles, Lesson on triangles, and Lesson on quadrilaterals). The Heylink software was utilized for designing the virtual lab due to its user-friendly interface and ease of organizing materials and tools in one place. Figure 2 displays the Home page of the virtual lab.

Figure 2:
Home Page of the Virtual Mathematics Lab



Three websites were chosen for inclusion in the virtual lab, and these sites are tailored to the age group of the participants. They are characterized by user-friendliness and their ability to achieve the chapter's objectives. Figure 3 illustrates the content and tools of the virtual mathematics lab and the website.

Figure 3:
Example of virtual lab contents and tools



The actual implementation of teaching the chapter "Identifying and Describing Geometric Shapes" was carried out by one of the researchers for both groups, as she is a mathematics teacher at the same school. The experimental group was taught using the virtual mathematics lab, while the control group was taught using traditional method. Teaching for both groups took 11 class sessions, with each session lasting 45 minutes.

Pre-Application of Study Instruments

Mathematics power test:

The mathematics power test was administered to both the experimental and control groups two weeks before commencing the teaching process of the "Identifying and Describing Geometric Shapes" chapter. This was done to ensure the equivalence of the two groups. Table 14 presents the results of t-test to identify differences between the experimental and control groups in the mathematics power test.

Table 14 indicates that all p-values are not statistically significant differences at a 0.05 level ($p>0.05$), suggesting no significant differences in the pre-application of the mathematical power test between the students in both groups. This confirms the equivalence of the research groups in the mathematical power test.

Scale of tendency towards mathematics:

The scale of tendency towards mathematics was distributed to both the experimental and control

groups preliminarily to verify the equivalence of the two groups. Table 15 displays the results of the t-test to identify differences between the experimental and control groups in the scale of tendency towards mathematics.

Table 15 reveals that all p-values are not statistically significant differences at a 0.05 level (p>0.05), indicating no statistically significant differences in the pre-application of the scale of tendency towards mathematics between the students of both groups. This affirms the equivalence of the research groups on the scale of tendency towards mathematics.

Results and Discussion:

To answer the first question, which examines the effectiveness of the virtual lab in teaching mathematics in developing mathematical power in fourth-grade students in the Kingdom of Bahrain, the validity of the following hypothesis was tested: there is no statistically significant difference at a (0.05) level between the mean scores of students in the experimental group and the control group in the post-application of the mathematics power test. Table 16 indicates the results of the independent samples t-test to examine the differences between the two groups in the post-application of the mathematical power test.

Results from Table 16 indicate statistically significant differences at a (0.05) level between the scores of students in the experimental and control groups in the mathematics power test overall and its various dimensions, favoring students in the experimental group. Therefore, the null hypothesis is rejected, and the alternative hypothesis is accepted, which states that there is a statistically significant difference at a (0.05) level between the mean scores of students in the experimental group and the control group in the post-application of the mathematical power test.

Table 17 illustrates the effect size of the independent variable (using the virtual mathematics lab) by calculating eta squared (η^2) and the effect size *(d)* (Cohen, 1988).

Table 17 shows that the effect size of using the virtual lab in developing mathematical power overall and in the mathematical communication dimension was large (d = 0.81). However, the effect of using the virtual lab was moderate in the mathematical connection dimension (d = 0.61) and the mathematical reasoning dimension (d = 0.70) for fourth-grade students. This may be attributed to the fact that the virtual lab, in general, enhances students' practical skills through hands-on experiments and interactive environments, making students more engaged in the learning process. This, in turn, provides them with opportunities to understand the principles and concepts related to the scientific content accurately and deeply. Additionally, simulation programs in the virtual lab contributed to providing students in the experimental group with a clear set of events to actively participate in the simulation experience, offering them multiple options that suit their preferences and allowing them to deal with systems that may be difficult to handle under conditions that are hard to meet in regular classrooms. The virtual lab covered all course ideas through interactive practical experiments, enabling each student to expand their scientific imagination and develop their innovative ideas. It helped bridge the gap between abstract mathematical concepts and make them more tangible and understandable (Albyaty, 2006; Bajpai, 2012; Jung et al., 2006; Noufal, 2010; Stewart et al., 2006).

This result aligns with previous studies suggesting that mathematical power can be developed through the virtual lab (Abouassar, 2003; Almuqayed, 2017; Ismail, 2001). They also support the findings of O'Brien and Levy (2008), who noted that the virtual mathematics lab is characterized by an engaging interactive environment, providing easy ways to display algebraic, numeric, and equation applications. The virtual mathematics lab allows drawing curves, solids, and diagrams and presenting them in three dimensions, offering an attractive, colorful, and easy-to-use interface. It presents many options in the displayed tools, providing students and teachers with everything they need to understand and teach mathematical ideas, knowledge, skills, and theories and make them more realistic. These are important elements in enhancing processes related to mathematical communication, mathematical connection, and mathematical reasoning.

To answer the second question, which focuses on the effectiveness of the virtual lab in teaching mathematics in developing the tendency towards mathematics among fourth-grade students in the Kingdom of Bahrain, the validity of the following hypothesis was tested: there is no statistically significant difference at (0.05) level between the mean scores of students in the experimental group and the control group in the post-application of the scale of tendency towards mathematics. Table 18 indicates the results of the independent samples t-test to examine the differences between the two groups in the post-application of the scale of tendency towards mathematics.

Results from Table 18 indicate statistically significant differences at (0.05) level between the scores of students in the experimental and control groups in the scale of tendency towards mathematics overall and its various dimensions, favoring students in the experimental group. Therefore, the null hypothesis is rejected, and the alternative hypothesis is accepted, which states that there is a statistically significant

Table 14:

Result of pre-application of the mathematical power test

Dimensions	Group	N	Mean	SD	df	t	p-value
Mathematical communication	Experimental	33	6.42	1.92	62	0.568	0.572
	Control	31	6.71	2.10			
Mathematical connection	Experimental	33	3.91	1.04	62	0.471	0.639
	Control	31	4.03	1.05			
Mathematical reasoning	Experimental	33	4.24	1.32	62	0.461	0.646
	Control	31	4.39	1.117			
Whole test	Experimental	33	14.58	3.31	62	0.687	0.495
	Control	31	15.16	3.51			

Table 15:

Result of pre-application of the scale of tendency towards mathematics

Dimensions	Group	N	Mean	SD	df	t	p-value
Nature of mathematics	Experimental	33	14.85	2.69	62	0.446	0.657
	Control	31	15.16	2.91			
Learning mathematics	Experimental	33	17.06	2.69	62	0.620	0.538
	Control	31	17.48	2.77			
Enjoying mathematics	Experimental	33	17.12	2.76	62	0.835	0.407
	Control	31	17.71	2.88			
Mathematics teacher	Experimental	33	14.55	2.76	62	0.417	0.678
	Control	31	14.84	2.86			
Whole test	Experimental	33	63.58	10.17	62	0.617	0.539
	Control	31	65.19	10.82			

Table 16:

Results of t-test for mathematical power test

Dimensions	Group	N	Mean	SD	df	t	p-value
Mathematical communication	Experimental	33	10.33	0.98	62	2.92	0.0048**
	Control	31	9.32	1.76			
Mathematical connection	Experimental	33	5.58	0.71	62	2.39	0.0199*
	Control	31	5.03	1.08			
Mathematical reasoning	Experimental	33	7.30	1.02	62	2.76	0.0075**
	Control	31	6.45	1.43			
Whole test	Experimental	33	23.27	2.14	62	3.77	0.0003**
	Control	31	20.84	2.98			

Note: * p-value is significant at 0.05 level, and ** p-value is significant at 0.01 level.

Table 17:

Effect size of the virtual lab in the mathematical power test

Independent variable	Dimensions	t	df	η^2	d
virtual lab	mathematical communication	2.92	62	0.140	0.81*
	mathematical connection	2.39	62	0.085	0.61
	mathematical reasoning	2.76	62	0.109	0.70
	whole test	3.77	62	0.187	0.96*

Note: * is greater than (0.8).

Table 18:

Results of t-test for scale of tendency towards mathematics

Dimensions	Group	N	Mean	SD	df	t	p-value
Nature of mathematics	Experimental	33	17.24	1.28	62	2.64	0.0104*
	Control	31	16.06	2.21			
Learning mathematics	Experimental	33	20.00	1.22	62	3.60	0.0006**
	Control	31	18.26	2.48			
Enjoying mathematics	Experimental	33	20.12	1.24	62	3.82	0.0003**
	Control	31	18.26	2.49			
Mathematics teacher	Experimental	33	17.42	0.75	62	3.94	0.0002**
	Control	31	16.06	1.82			
Whole test	Experimental	33	74.79	3.81	62	3.79	0.0003**
	Control	31	68.65	8.45			

Note: * p-value is significant at 0.05 level, and ** p-value is significant at 0.01 level.

difference at (0.05) level between the mean scores of students in the experimental group (those who studied using the virtual lab) and the control group (those who studied using the traditional method) in the post-application of the scale of tendency towards mathematics.

Table 19 illustrates the effect size of the independent variable (using the virtual mathematics lab) by calculating eta squared (η^2) and the effect size *(d)* (Cohen, 1988).

Table 19:
Effect size of the virtual lab in the scale of tendency towards mathematics

Independent variable	Dimensions	*t*	*df*	η^2	*d*
Virtual lab	Nature of mathematics	2.64	62	0.101	0.70
	Learning mathematics	3.60	62	0.173	0.91*
	Enjoying mathematics	3.82	62	0.191	0.97*
	Mathematics teacher	3.94	62	0.200	1.00*
	Whole test	3.79	62	0.188	0.96*

Note: * is greater than (0.8).

Table 19 demonstrates that the effect size of using the virtual lab in developing the tendency towards mathematics overall (*d* = 0.96) and in its various dimensions is large, except for the tendency towards the nature of mathematics, which was moderate (*d* = 0.70), indicating the effectiveness of the virtual lab in developing the tendency towards mathematics among fourth-grade students. This may be attributed to the fact that using the virtual lab enhances students' engagement in mathematics activities, provides them with opportunities for imagination and expression of their thoughts, highlights the importance of mathematics in students' daily practical lives, simplifies mathematics, and presents it in an easy and exciting way to capture their attention. Additionally, the virtual lab stimulates students towards learning, generating positive attitudes towards mathematics, diversifying stimuli to help them acquire new inclinations, and integrating serious play into practical learning processes to engage and encourage them in the learning process (Albyaty, 2006; Bajpai, 2012; Jung et al., 2006; Noufal, 2010; Stewart et al., 2006).

This result aligns with studies that have addressed the development of the emotional aspect of learners when studying mathematics. Albasyouny et al. (2010) pointed out the effectiveness of the virtual lab in giving learners complete freedom to access information. Hassn (2019) affirmed the effectiveness of designing a virtual lab using different feedback patterns in developing aesthetic sensibilities in mathematics among elementary students. A study by Alhowaity and Albalawi (2019) indicated that the attitudes of mathematics teachers towards using augmented reality technology in teaching were positive and highly rated. Moreno-Guerrero et al.'s study (2020) found that e-learning has a positive impact on students' motivation and independence when learning mathematics.

This result is also in line with what Elnablsia (2018) mentioned, that the mathematics lab contributes to developing a tendency towards mathematics by removing boredom from students, making mathematics a fun, entertaining, and exciting subject to learn, and providing students with the necessary skills to use mathematics in their daily lives outside the school.

In answer to the third question, which queries the connection between mathematical power and the tendency towards mathematics among fourth-grade elementary students in the Kingdom of Bahrain, the validity of the following hypothesis was examined: There is no linear correlation between mathematical power and the tendency towards mathematics among fourth-grade students. To test this hypothesis, the Pearson correlation coefficient was computed between the scores of students in the experimental and control groups on the scale of tendency towards mathematics and their scores in the mathematical power test (see Table 20).

Table 20:
Correlation coefficients between the test scores and the scale scores

Variables	Groups	N	Correlation coefficients
correlation between the two variables	experimental	33	0.45*
	control	31	0.24

Note: * is significant at 0.05 level.

Table 20 reveals a positive linear correlation between the development of mathematical power and the tendency towards mathematics among students in the experimental group who were taught using the virtual lab. Conversely, no statistically significant correlation was found between these variables among students in the control group, who were taught using the traditional teaching method. This result for the experimental group students can be attributed to what Abuhelal (2012) pointed out regarding the correlation between tendency and learning. As a learner's tendency increases, so does their learning, coupled with an enhanced desire to comprehend the subject matter. All of this is reflected in the development of various dimensions of mathematical power among learners, encompassing mathematical communication (mathematical representation, mathematical listening, mathematical discussion, mathematical reading, and mathematical writing),

mathematical connection (structural, contextual, and integrative connections), and mathematical reasoning (deduction, induction, prediction, and evaluation).

Table 20 showed that there is a statistically significant relationship (0.45) between the dependent variables (tendency towards mathematics - mathematical power) among students in the experimental group which can be attributed to the effectiveness of the independent variable (virtual lab). This variable provided a suitable educational environment tailored to the students' learning styles, reinforcing the teacher's role in motivating learners to study mathematics. It granted learners the opportunity to express their thoughts mathematically, engaged them in various activities, and emphasized the importance of the mathematical knowledge and skills they were acquiring by linking them to tangible aspects and real-life examples (Abuhelal, 2012). The virtual lab made mathematics an enjoyable, entertaining, and stimulating subject for learning, filling learners with positive expectations and enthusiasm for the math class. It also fostered an atmosphere of cooperation and respect among peers, as well as between teachers and students, equipping learners with the necessary skills to apply mathematics in daily life outside school. Furthermore, it encouraged collaboration, interaction, and competition among students, leading to increased motivation and enthusiasm for learning, which manifested in students' inclination towards mathematics (Elnablsia, 2018). On the contrary, the correlation coefficient in the control group (0.24) affirmed there is not a statistically significant relationship between the dependent variables (tendency towards mathematics - mathematical power). The reason behind this might be attributed to the use of the conventional teaching method, which renders mathematics a less engaging subject for learning, fails to motivate learners to participate in various activities during mathematics classes, and does not enhance their motivation while acquiring mathematical knowledge. Consequently, it does not contribute to the development of the various dimensions of mathematical power.

Conclusion:

This study aimed to assess the effectiveness of the virtual lab in teaching mathematics and its impact on the development of mathematical power and tendency towards mathematics among primary school students in the Kingdom of Bahrain. The results indicated statistically significant differences in the post-application scores for physical strength and the inclination towards mathematics between the experimental group (taught using the virtual mathematics lab) and the control group (taught using the traditional method). Additionally, a positive relationship was found between the development of mathematical power and the tendency towards mathematics among students in the experimental group who were taught using the virtual lab. This underscores the positive impact of the virtual lab on teaching and learning in primary education. The study recommends that the Ministry of Education in the Kingdom of Bahrain utilize the study results by establishing a virtual mathematics lab for primary education, recognizing its positive impact on enhancing effectiveness and engagement in various activities connecting mathematical concepts to students' daily lives. Curriculum designers are urged to develop and update mathematics curriculum to align with the integration of the virtual lab in both teaching and learning processes. Lastly, the current study recommends teacher preparation programs in Bahrain to design initiatives that help educators acquire the necessary skills to leverage technology, especially the virtual lab, in the teaching process for its positive impact on student learning.

Ethics Approval and Consent to Participate:

The research was approved by the Ethics Committee of the Imam Abdulrahman Bin Faisal University (IRB Number: IRB-2023-15-616). The research was conducted in accordance with the Declaration of Helsinki.

References

Abdelwahed, A., Eskander, A., & Kamel, W. (2022). The effectiveness of a program based on nano technology mathematical application in developing the mathematical power skills of the secondary stage students. *Journal of Mathematics Education, 25*(2), 193-245. https://doi.org/10.21608/armin.2022.233954

Abdulhadi, A., Shoke, M., & Ibrahim, B. (2015). The effectiveness of a program based on active learning to develop a solution to geometric problems and a tendency towards the subject among preparatory stage students. *Journal of Mathematics Education, 18*(7), 186–196. https://doi.org/10.21608/armin.2015.81928

Abdulqader, M. (2018). *The impact of using numbered heads strategy on developing visual thinking skills in mathematics and attitudes toward it among fourth graders in gaza* (Order No. 1010732) [Master's thesis, Islamic University of Gaza]. Almandumah Database.

Abouassar, R. (2003, October 8-9). *Mathematical power: A modern approach to developing mathematics learning assessment in general education stages* [Paper presentation]. 3rd Scientific Conference: Teaching and learning mathematics and developing creativity, Egyptian Society for Mathematics Education, Ain Shams University, Egypt.

Abouassar, R. (2018). Tablet: A Virtual Math Lab for Teaching Practical Skills and Life Applications of Math. *Journal of Mathematics Education, 21*(4), 6-39. http://dx.doi.org/10.21608/ARMIN.2018.81235

Abugado, S. (2020). *Psychology socialization*. Dar Massira.

Abuhelal, F. (2017). *The impact of entertainment-based learning on developing thinking skills in mathematics among third graders and their attitude towards it in gaza* (Order No. 1010602) [Master's thesis, Islamic University of Gaza]. Almandumah Database.

Abuhelal, M. (2012). *The effect of using mathematical representations to acquire concepts and a tendency towards mathematics among students in sixth primary grade* (Order No. 15960) [Master's thesis, Islamic University of Gaza]. Shamaa Database.

Abu Nahiah, S. (1994). *Educational measurement*. Anglo-Egyptian Bookshop.

Abu-Zaineh, F. (2017). *School mathematics curricula and teaching*. Dar Alfalah.

Al-Adl, A. (2014). *Research methods in the human sciences*. Dar Shorok.

Albashiti, H. (2015). *The effectiveness of a computerized program based on multiple intelligences in developing mathematical power among third-grade female students in gaza* (Order No. 737470) [Master's thesis, Islamic University of Gaza]. Almandumah Database.

Albasyouny, M., Abujalala, R., & Amasha, M. (2010). Designing an educational software based on virtual laboratories and its impact on teaching mathematics to students in the primary education stage. *Egyptian Society for Educational Technology*, *20*(1), 77-112.

Albyaty, M. (2006). *Practical and applied dimensions in e-learning*. Arab Network for Open and Distance Education.

Al-Dahiri, S., & Al-Kubaisi, W. (2016). *General psychology*. Yazori Group For Publishing and Distribution.

Al-Haddad, S. (2021). Effectiveness of e-software based on auto play program for teaching mathematics on the developing achieving and mathematical power with the teacher-students of basic education maths at faculty of education ibb university. *International Journal of Information and Education Technology, 129*(129), 309- 336. https://doi.org/10.21608/SAEP.2021.134552

Alhasani, G., & Al-Dulaimi, B. (2011). Mathematical power and its relationship to the metacognitive skills of second-year students. *Journal of the University of Anbar for Humanities,* (2), 170-182.

Alhowaity, H., & Albalawi, A. (2019). Attitudes of mathematics teachers of the middle stag towards the augmented reality technology and obstacles to its use in teaching mathematics in tabuk. *Arab studies in education and psychology,* (112), 119–238. https://doi.org/10.21608/SAEP.2019.54111

Al-Huwaidi, Z. (2015). *Basics of educational measurement and evaluation*. University Book House.

Alghanmi, D., & Alhassani, S. (2020). The effectiveness of an educational program using virtual hands on tablet devices to develop arithmetic skills among students with learning difficulties in mathematics in jeddah governorate. *Journal of Human Sciences,* (5), 8-24.

Alkhouli, H. (2002). *Cognitive methods and their controls in psychology.* Modern Book Dar.

Al-Kubaisi, A., & Abdullah, M. (2015). *Mental abilities and mathematics*. Al-Mujtamaa Al-Arabi Bookstore.

Al-Mosawi, F., Shnean, M., & Hassan, M. (2015). The effect of using tragist model in the acquisition of the female students of the second intermediate class in physics. *Basic Education College Magazine for Educational and Humanities Sciences,* (24), 178–194. https://www.iasj.net/iasj/download/5c813c7fd6bd985b

Al-Mughamisi, F. (2016). Effect of using the technical mathematics lab on the level of achievement of mathematics in the 37 high school female students in jeddah, saudi arabia. *Arab Journal of Sciences and Research Publishing, 2*(6), 109-117. https://doi.org/10.12816/0028583

Almuqayed, S. (2017). *The effectiveness of a suggested program based on habits of mind in developing mathematical power among fourth graders in gaza* (Order No. 875170) [Master's thesis, Islamic University of Gaza]. Almandumah Database.

Alradi, A. (2008, May 23-25). *Virtual laboratories are a model of e-learning* [Paper presentation]. E-Learning in Public Education Conference, General Administration of Education in Riyadh, Saudi Arabia.

Alraie, A. (2014). *The effectiveness of the differentiated instruction strategy in teaching mathematics on the acquisition of mathematical concepts and inclination toward mathematics among seventh grade students* (Order No. 695760) [Master's thesis, Islamic University of Gaza]. Almandumah Database.

Bajpai, M. (2012). Effectiveness of developing concepts in photo electric effect through virtual lab experiment. *International Journal of Engineering and Advanced Technology (IJEAT), 1*(6), 296-299. https://www.ijeat.org/wp-content/uploads/papers/v1i6/F0687081612.pdf

BouJaoude, S. (2009, March 16-18). The role of curricula and teachers in taking the path to twenty-first century skills. *Curricula: Future visions* [Symposium]. Sultan Qaboos University, Muscat, Oman.

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2nd ed.). Lawrence Erlbaum Associates.

eGovernment of Bahrain. (n.d.). Bahrain Economic Vision 2030. https://www.mofne.gov.bh/media/rgkdztkg/visionplus2030plusenglishplus-lowplusresolution.pdf

Elholy, A. (2011). *Educational foundations*. Aafaq Bookstore.

Elmaradany, M., & Mokhtar, N. (2011). The effect of the interaction between the style of providing feedback within virtual classrooms and the level of mental capacity in developing self-regulation skills and learning efficiency among educational technology students. *Journal of Education, 6*(146), 775-876.

Elnablsia, M. (2018). *The impact of employing mathematics' lab in developing geometric skills and the tendency towards mathematics among the fourth grade students in gaza* (Order No. 1010783) [Master's thesis, Islamic University of Gaza]. Almandumah Database.

Elsadi, E. (2011). The effectiveness of the three-dimensional virtual science laboratory in acquiring abstract physical concepts and developing the tendency towards conducting experiments virtually among secondary school students. *Journal of Faculty of Education, 27*(2), 448-497.

Epper, R., & Garn, M. (2004). Virtual universities: Real possibilities. *EDUCAUSE Review, 39*(2), 28-39. https://er.educause.edu/-/media/files/article-downloads/erm0422.pdf

Guerrero, G., Ayala, A., Mateu, J., Casades, L., & Alamán, X. (2016). Integrating virtual worlds with tangible user interfaces for teaching mathematics: A pilot study. *Sensors, 16*(11), 1775. https://doi.org/10.3390/s16111775

Hassn, S. (2019). Designing a Virtual Lab Using Patterns of Feedback in Developing Stereometry Skills and Math's Aesthetic Sense for Primary Stage Pupils. *Journal of Mathematics Education, 22*(12), 6-66. http://dx.doi.org/10.21608/ARMIN.2019.81273

Ismail, A. (2001). *Information technology and modernization of education*. Alam Alkutub Dar.

Jebara, A. (2017, August 28). Bahrain Vision 2030-Education. *Alwatan news*. https://alwatannews.net/Opinion/article/731118

Jouda, M. (2013). *The effectiveness of a proposed program based on the role-playing strategy to develop geometric thinking among fifth-grade students in gaza in mathematics and their attitudes toward it* (Publication No. 128202) [Doctoral dissertation, Jinan University]. Shamaa Database.

Jung, K., Lee, H., Lee, Y., Cheong, S., Choi, M., Suh, D., Suh, D., Oah, S., Lee, S., & Lee, J. (2006). The application of a sensory integration treatment based on virtual reality-tangible interaction for children with autistic spectrum disorder. *PsychNology Journal, 4*(2), 145-159.

Moreno-Guerrero, A., Aznar-Díaz, I., Cáceres-Reche, P., & Alonso-García, S. (2020). E-learning in the teaching of mathematics: An educational experience in adult high school. *Mathematics, 8*(5), 840. https://doi.org/10.3390/math8050840

National Council of Teachers of Mathematics. (2000). *Principles and standards for school mathematics*. Reston, VA: NCTM.

Noufal, K. (2010). *Virtual reality and its educational uses*. Dar Al Manahej.

Obeidat, D., Abdul Haq, K., & Adas, A. (2020). *Scientific research: Its concept, tools and methods* (19th ed.). Dar Alfiker.

O'Brien, M., & Levy, R. (2008). Exploration through virtual reality: Encounters with the target culture. *Canadian Modern Language Review, 64*(4), 663-691. https://doi.org/10.3138/cmlr.64.4.663

Pilten, P. (2010). Evaluation of mathematical powers of 5th grade primary school students. *Procedia - Social and Behavioral Sciences, 2*(2), 2975-2979. https://doi.org/10.1016/j.sbspro.2010.03.450

Qassim, B., & Al-Saydawy, G. (2013). The effect of a training program to develop mathematical power among applied students on mathematical power among second-year intermediate students. *Alustath Journal for Human and Social Sciences,* (206), 355-384.

Riani, A. (2012). *The effect of an enrichment program based on habits of mind on creative thinking and mathematical ability among first-year intermediate students in mecca* (Publication No. 532418) [Doctoral dissertation, Umm Al-Qura University]. Almandumah Database.

Rizk, H. (2012). The effect of using the mathematical power approach for female student teachers in developing the achievement and attitude towards mathematics for their students in the middle school. *Journal Educational Sciences, 20*(3), 178-202.

Sahin, S., & Baki, A. (2010). A new model to assess mathematical power. *Procedia - Social and Behavioral Sciences, 9*, 1368-1372. https://doi.org/10.1016/j.sbspro.2010.12.336

Stewart, B., Ezell, S., DeMartino, D., Rifai, R., & Gatterson, B. (2006). Virtual technology and education: A collaborative pilot case. *Quarterly Review of Distance Education, 7*(4), 377–385.

Turgut, S., & Turgut, İ. (2020). Me while I am learning mathematics: Reflections to elementary school students' drawings. *International Electronic Journal of Elementary Education, 13*(1), 139–154. https://www.iejee.com/index.php/IEJEE/article/view/1246

Yang, K. & Heh, J. (2007). The impact of internet virtual physics laboratory instruction on the achievement in physics, science process skills and computer attitudes of 10th-grade students. *Journal of Science Education and Technology, 16*(5), 451–461. https://doi.org/10.1007/s10956-007-9062-6

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Effects of Dyscalculia on Personal, Social, Academic, Professional and Daily Life: A Case Study

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Abstract

Dyscalculia is a learning difficulty that negatively affects individuals' abilities to understand, apply, and learn mathematical operations. This study aims to explore the wide-ranging impacts of dyscalculia on individuals' lives. The experiences of Nur, an English teacher, are used to examine the effects of dyscalculia on personal, social, academic, professional, and daily life.

This study is designed as a qualitative case study. Nine significant stories from Nur's life were obtained through in-depth interviews and analyzed in detail using content analysis methods, focusing on themes, categories, and codes.

The findings reveal that dyscalculia significantly affects not only Nur's academic development but also her psychological well-being and overall quality of life. The difficulties in her mathematical skills have led to issues such as lack of self-confidence, social isolation, and challenges in professional skills.

The study highlights the importance of early individualized psychoeducational interventions and effective support systems to improve the lives of individuals with dyscalculia. It also emphasizes the critical role of increasing public awareness to create a supportive and inclusive environment for those with math learning difficulties.

This study highlights the significant impact of dyscalculia on individuals' lives and emphasizes the critical need for further research in this area. Developing and implementing effective intervention and support strategies is essential to enhance the quality of life and overall well-being of those affected by dyscalculia. Future research should prioritize longitudinal studies to assess the sustainability and adaptability of early interventions. Such studies should explore how tailored support strategies not only improve immediate outcomes but also contribute to long-term academic, social, and emotional development, thereby providing a comprehensive understanding of their lasting impact on individuals with dyscalculia.

Keywords:

Dyscalculia, Mathematics Learning Difficulties, Effects Of Dyscalculia, Adults With Dyscalculia

Introduction

Dyscalculia is a specific learning difficulties that affects an individual's ability to acquire arithmetic skills, with a prevalence ranging from 3% to 6.5% (Shalev, 2004; Price & Ansari, 2013). This condition manifests as significant difficulties in numerical operations, mathematical logic and problem solving skills in the individual's life (Monei & Pedro, 2017). The main features of dyscalculia are inadequacies in mathematical skills that usually begin in preschool period and negatively affect the individual's academic performance or daily life (Lewis, 2016; Kaufmann et al., 2003). Dyscalculia is a learning difficulties characterized by persistent and specific difficulties in basic mathematical skills. Individuals with dyscalculia have significant difficulties in understanding and using basic concepts related to numbers and operations. This can be observed as difficulties in processing numerical information, remembering and applying mathematical operations, and understanding mathematical concepts (Yoong, 2023).

Although the symptoms of dyscalculia can be seen differently in each individual (Gifford & Rockliffe, 2012), it is possible to mention common symptoms. In individuals with dyscalculia, understanding, sorting and comparing numbers and number sequences (Deruaz et al, 2020), understanding and performing simple addition, subtraction, multiplication and division operations (Lewis, 2016), remembering the rules of mathematical operations and formulas (Williams, 2013), reading analog clocks, understanding time concepts (Mutlu & Korkmaz, 2020), and performing money operations (Zhang, 2018), in identifying and applying the necessary steps to solve problems (Wilkey, Pollack, & Price, 2020), in remembering numerical information, especially long sequences of numbers (Geary, 2013), and in mathematical thinking and processing processes (Deruaz et al., 2020) and increased anxiety, stress and lack of motivation in mathematics lessons and mathematics-related activities (Mutlu, 2019; Williams, 2013).

The causes of dyscalculia, like its symptoms, are complex and multifactorial. In general, the underlying causes of dyscalculia include genetic factors, problems with brain development, and educational experiences in early childhood (Kaufmann et al., 2013). Dyscalculia may differ between individuals and is usually caused by a combination of multiple factors. Dyscalculia can be inherited in families. Research shows that the risk of dyscalculia is associated with genetic factors (Shalev et al., 2001). In addition, differences in brain structure and functioning have been observed in individuals with dyscalculia (Kroesbergen et al., 2023). Abnormal brain development in early childhood may increase the risk of dyscalculia. This may affect the development of brain areas critical for numerical and mathematical operations (Hughes et al., 2023). In addition, weaknesses in an individual's basic cognitive functions, such as working memory and attention deficits, can lead to the development of dyscalculia (Geary, 2004; Szucs et.al., 2013).

Although environmental factors are not directly involved in the causes of dyscalculia, inadequate or inappropriate mathematics education can make it difficult for students to understand mathematical concepts and develop mathematical skills (Witzel et al., 2023). Environmental factors such as socioeconomic status, family educational environment, and teacher expectations may also affect the risk of dyscalculia (Kaufmann et al., 2003; Lewis, 2017). In addition, insufficient interaction with mathematical concepts in early childhood may trigger the development of dyscalculia (Hughes et al., 2023). Possible delays in language and communication skills in early childhood may cause difficulties in understanding mathematical terms and concepts (Gersten et al., 2005). In addition, mathematics-related anxiety and stress can negatively affect students' mathematics learning and achievement (Rubinsten & Tannock, 2010; Mutlu, 2019). Such negative learning experiences can lead to a lack of motivation to learn mathematics, which can further deepen learning difficulties (Sella & Cohen Kadosh, 2018).

Dyscalculia (developmental dyscalculia) is diagnosed using various assessment tools and tests (Mutlu& Akgün, 2017a). These assessments help to determine educational and intervention strategies by examining the individual's mathematical abilities and difficulties in detail. However, heterogeneity among individuals with dyscalculia significantly affects the processes of diagnosis and intervention of this learning difficulties. A study by Skagerlund and Träff (2014) revealed the heterogeneity of individuals with dyscalculia and the different cognitive profiles and deficits that need to be considered in the diagnosis of this condition. The main reason why researchers use different diagnostic tools and methods is that individuals with dyscalculia have heterogeneous characteristics. For example, in a study conducted by Bugden et al. (2020), the effectiveness of the Numeracy Screener, a tool used in the diagnosis of dyscalculia, was examined. This tool is used to determine symbolic (Arabic numerals) and non-symbolic (dot arrays) numerical magnitude processing abilities and dyscalculia risk in children and can be administered in about 2 minutes. On the other hand, Kaufmann et al. (2003) state that according to the International Classification of Diseases and Health Problems (ICD-10) criteria published by the World Health Organization, dyscalculia can be diagnosed when there is a significant difference between the average intelligence level of the individual and the sub-average performance in mathematics achievement tests. This diagnostic method evaluates the relationship between specific difficulties in mathematical skills and general intelligence level. A test battery developed by

Skagerlund and Träff (2014) is used to identify students' number processing skills and dyscalculia subtypes. This test battery assesses children's numerical abilities and mathematical processing difficulties in detail. Dinkel et al. (2013) investigated the benefits and limitations of using single case functional brain imaging (fMRI) methods in the diagnosis of dyscalculia. This study shows how brain imaging technologies can be used in the diagnosis of dyscalculia. In each of these studies, almost a different diagnostic method and approach was employed. Although the debate on the variety of methods used continues, it is clear that assessments are critical in the identification and intervention of mathematical learning disabilities. This suggests that special attention and appropriate methods should be paid to the education of individuals with dyscalculia and the development of their mathematical skills.

It is important for teachers to be trained in dyscalculia and intervention techniques for dyscalculia in order to provide more accurate support to students. In this context, teachers should be made aware of the symptoms of dyscalculia observed in students and strategies that can help these students (Sousa, Dias, & Cadime, 2017). Research on dyscalculia reports that interventions contribute to the development of mathematical skills and success in the educational process. In this process, early diagnosis and intervention are critical for students' academic and social development (Ganor-Stern, 2017). Educators and therapists can use various strategies and interventions to support individuals with dyscalculia in learning mathematics. Some of these interventions and approaches can be briefly mentioned. Children with dyscalculia often have difficulty understanding abstract mathematical concepts. Therefore, using concrete materials and visual aids to visualize numbers and mathematical relationships can be effective. For example, number lines, blocks, and shapes can be used for this purpose (Monei, & Pedro, 2017). Breaking mathematical concepts into small steps and presenting each step in a clear and structured way can facilitate the learning process of dyscalculic children. It is important to give clear instructions at each step and allow children to understand the concepts at their own pace (Lewis, 2016). Each dyscalculic child has different challenges and needs. Therefore, it is important to develop individualized education plans taking into account individual differences. It is necessary to identify strategies that support the student's strengths and improve their weaknesses (Zhang et al., 2020). It can be effective to utilize technological tools and educational applications to improve calculation and problem solving skills (Mutlu& Akgün, 2017b; Mutlu& Akgün, 2019). These tools can make mathematical concepts more understandable by providing students with an interactive and fun learning experience (Deruaz et al., 2020). Providing continuous feedback to dyscalculic children supports their learning process and increases their motivation. It is important to appreciate their achievements and adopt a constructive approach to correct their mistakes (William, 2013).

Recent research has demonstrated that dyscalculia persists into adulthood and leads to significant challenges in daily quantitative tasks essential for independent living beyond academic settings (Vigna et al., 2022). Vigna et al. (2022) examined the impact of dyscalculia on adults' daily living activities and found that they face considerable difficulties with practical tasks such as managing finances, time, and measurements, which are fundamental for functional independence and quality of life. Their research utilized a standardized battery to assess numeracy skills in both formal and informal contexts, revealing poor numeracy abilities among adults with dyscalculia in all settings.

Furthermore, Mejias et al. (2012) investigated the approximate number system (ANS) deficit in adults with a history of dyscalculia. Their findings indicate ongoing difficulties with numerical estimation and magnitude representation, affecting areas ranging from academic performance to everyday numerical demands. This suggests that interventions aimed at improving numerical estimation skills in adults with dyscalculia could enhance their practical numerical abilities.

In addition to cognitive challenges, Burgio et al. (2022) reported that adults with dyscalculia often experience emotional distress and low self-esteem, negatively impacting their job choices and overall well-being. This underscores the importance of holistic approaches that address both the psychological and cognitive aspects of dyscalculia. Hosseini's (2020) research delved into the dyscalculia-related experiences of adults working in the music field—a domain requiring mathematical thinking and numerical comprehension. The study highlighted how musicians with dyscalculia cope with these challenges and how their condition affects their careers.

While these studies contribute valuable insights, there remains a significant gap in the literature concerning in-depth qualitative explorations of adults living with dyscalculia, particularly regarding how it affects various aspects of their lives over time. Most existing research focuses on children or adolescents, leaving a lack of understanding about the long-term effects and personal narratives of adults coping with this condition. Additionally, there is limited examination of how dyscalculia influences professional life outside of fields directly related to mathematics.

The main purpose of this study is to address these gaps by providing an in-depth understanding of the challenges faced by individuals with dyscalculia

through the life experiences of Nur, a primary school English teacher. Through this qualitative case study, we seek to provide insights that can inform the development of targeted interventions and support mechanisms for adults with dyscalculia. By highlighting Nur's experiences, this study contributes to a more comprehensive understanding of dyscalculia across different age groups and professional fields, emphasizing the necessity for support systems that extend beyond childhood to address the lifelong challenges associated with this condition.

Method

This study was conducted using the holistic single case design of the case study method based on the qualitative research paradigm. Case study is a research approach in which the researcher collects in-depth information about real life, a current situation with defined boundaries, or situations in a certain time period through observation, interviews, audiovisual materials or documents, and then makes a description of a situation (Creswell, 2013). By designing the study as a qualitative case study, we were able to closely relate our research method to our purpose. This design provided the flexibility and depth required to explore the intricate effects of dyscalculia on an individual's life, thereby contributing valuable insights to the existing body of knowledge on learning difficulties.

Participant

This study focuses on Nur, a primary school teacher with four years of teaching experience who, although not officially diagnosed, exhibits clear symptoms of dyscalculia based on the researcher's observations and interviews. The findings section enumerates her dyscalculia symptoms, revealing specific difficulties with mathematics despite her success in other academic areas.

Selected through purposive sampling, Nur serves as the principal participant to examine in detail her mathematical challenges at different stages of her educational life and the effects of these challenges on her personal, social, academic, and professional life. Raised in a well-off family with no history of mathematical difficulties, she is known for being friendly and sociable; However, she experiences anxiety when confronted with mathematics.

Data Collection

The data of the study were collected through a semi-structured interview with a participant named Nur, in which open-ended questions were asked. Audio recordings of the interviews with Nur were taken. During the interview, stories that were considered to be particularly striking and important were identified. Since these stories (Annex 1) were considered important for in-depth analysis and evaluation, Nur was asked to describe them in detail and in writing. In response to this request, Nur submitted detailed texts containing these stories to the researcher in the days following the interview. This process aimed to reflect the participant's experiences and perspectives in more detail and allowed the researcher to conduct a more comprehensive analysis of these experiences.

Data Analysis

The data collected in the study were carefully analyzed through content analysis methodology and evaluated using Generative Pre-trained Transformer (GPT-4) technology. This process aimed to identify Nur's math-related difficulties, emotional reactions and coping strategies in depth. The analysis allowed for a systematic categorization of the data into categories and codes (Table 2), providing an opportunity to consider Nur's experiences from a broader perspective. This approach broadened the scope of the research and contributed to a more detailed understanding of the findings.

In Table 1, the stories from the life of Nur, who struggles with dyscalculia, are organized thematically. Each theme reflects the specific situations Nur faced and their impact, ranging from mathematical struggles to practical difficulties in daily life.

Table 1

Nur's Dyscalculia Stories

No	Theme	Description of Story
1	Fighting Math	Failure and emotional impact in secondary school.
2	Tutoring days	Placement test and challenges.
3	University Journey	Transition from high school to university and math avoidance.
4	Daily Accounts	Computational challenges in everyday life.
5	Mental Calculation Race	Computational difficulties with students in professional life.
6	Percent Confusion	Percentage calculations in professional life.
7	Disoriented Teacher	Wayfinding and left-right confusion.
8	Market Showdown	Calculating change in shopping.
9	Disappearing Directions	Difficulties finding paths and directions.

Credibility and Transferability

To ensure the credibility of the study, the participant selection, data collection and analysis processes were conducted with great care. Nur, who was selected as a participant, is an English teacher with dyscalculia and her experiences constitute the focus of the study. In the data collection process, semi-structured interview technique was used and open-ended questions were asked during the interviews. This approach allowed

Table 2

Thematic analysis of the challenges faced by Nur who struggles with dyscalculia

Main Theme	Category	Codes
Personal Impacts	Personal Challenges and Coping Methods	Lack of self-confidence, Sense of inadequacy, Personal coping strategies
Social Impacts	Social Interaction and Reactions	Social isolation, Friendship relations, Family interaction
Academic Impacts	Academic Performance and Learning Processes	Classroom performance, Learning difficulties, Adaptation to learning preferences
Professional Impacts	Job and Career Guidance	Vocational skills, Workplace challenges, Occupation choice
Impacts on Everyday Life	Daily Routines and Activities	Shopping, Household chores, Daily planning

Nur to freely express her experiences from her own perspective. The interviews were designed and conducted in a way that made the participant feel at ease. Recording and later transcribing the interviews increased the accuracy of the data and transparency of the analysis process. In addition, stories from the interviews are shared with the reader in the appendix of the article.

The stories obtained from the interviews were processed through content analysis and the findings obtained from Nur's stories were grouped under broad themes. The researcher avoided subjective interpretations during the analysis process and took care to interpret the data as objectively as possible.

The transferability of the research is aimed at assessing whether the findings are valid for other situations or other individuals with similar characteristics. In this study, the findings obtained through Nur's experiences can shed light on the life experiences of other individuals with dyscalculia. However, it is left to the reader's interpretation to determine to what extent these findings are transferable to other situations or individuals.

Role of the Researcher

The researcher, who has conducted numerous academic studies on dyscalculia, examined the effects of dyscalculia on Nur's life. The researcher prioritized ethical norms and took care to collect reliable data by providing a comfortable environment for the participant. By effectively using her expertise in data collection and analysis, she strengthened both the accuracy and validity of the study. The researcher's experience in this field has contributed significantly to the wider theoretical and practical evaluation of the findings of the study.

Ethics

The ethical dimensions of the research were handled with great importance especially to the confidentiality and privacy of the participant. In this context, the name 'Nur' was used instead of the participant's real name. This was done both to protect the anonymity of the participant and to ensure the accuracy of the research. During the research process, Nur's personal information and interview data were protected and used with her explicit consent and full knowledge. This approach is critical in ensuring a data collection and analysis process that complies with ethical standards. The participant was informed about the purpose and process of the study and a voluntary consent form was signed by the participant. In addition, the ethics committee certificate for the study was obtained.

Findings

In the first part of this section, Nur's dyscalculia symptoms are presented. In the second part, the effects of dyscalculia are discussed in detail through themes, categories and codes.

Symptoms of Dyscalculia

Nur's dyscalculia symptoms and real life examples of these symptoms are given in Table 3. Each symptom is detailed in relation to Nur's own experiences. The table exemplifies Nur's difficulties with mathematical concepts and operations, practical problems she encountered in daily life, and the emotional effects of these situations.

Table 3

Nur's dyscalculia symptoms and excerpts from her life

	Symptoms Of Dyscalculia	Excerpt About Nur's Experience
1	Failure to Comprehend Mathematics Subjects	"In the classroom... I couldn't make sense of the math topics."
2	Avoiding Mathematics Lessons	"In high school... avoiding math, gravitating towards English."
3	Difficulty in Basic Mathematics	"Difficulty in percentage calculations, especially in calculating exam grades."
4	Directional Confusion and Difficulty Finding Addresses	"Difficulty distinguishing between left and right, confusion in directions in the classroom."
5	Difficulty Making Calculations with Cash	"Calculation difficulties when paying with cash."
6	Inability to Cope with Simple Mathematical Situations in Daily Life	"Inability to cope with simple mathematical situations in daily life."
7	Failure in Mathematics while Successful in Other Subjects	"Unexpected failure in math while succeeding in other subjects."
8	Difficulty performing mental operations in the classroom	"I used a calculator to add up the results of the quiz."

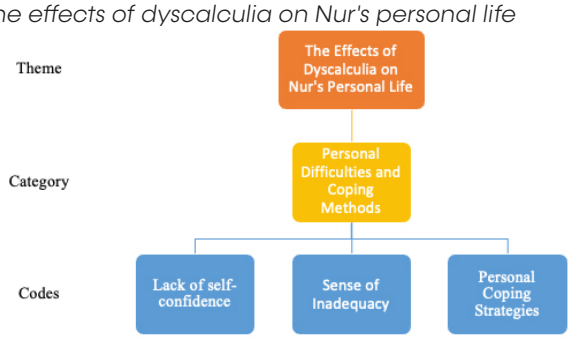
Effects of Dyscalculia

In this section, Nur's experiences of struggling with dyscalculia are analyzed under five main themes. Each theme explores in depth the effects of dyscalculia on personal, social, academic, occupational and daily life, and is classified using specific categories and codes to more clearly capture these effects. This classification illuminates the broad domain of dyscalculia and the various aspects of this condition in an individual's life.

The effects of dyscalculia on personal life

Under the theme of the effects of dyscalculia on personal life, the codes of lack of self-confidence, self-evaluation and personal coping strategies belonging to the category of "Personal Difficulties and Coping Methods" are presented in Figure 1. These codes represent Nur's processes of coping with personal difficulties and the effects of these processes on her psychological structure. Lack of self-confidence refers to individuals' perceptions of their own abilities and achievements; sense of inadequacy refer to the tendency to underestimate one's own worth and abilities; and personal coping strategies refers to the methods and approaches used to cope with difficulties. This figure illustrates the various effects of dyscalculia on Nur's life and the consequences of these effects on Nur's personal development and coping methods.

Figure 1.
The effects of dyscalculia on Nur's personal life



Lack of Self-Confidence: When Nur failed in math, it caused a serious drop in her self-confidence. Although she was successful in other subjects, this failure in math shook her self-confidence.

"It was quite upsetting and challenging as a child to go through this experience just because of math, even though I was good at other subjects." (Struggling with Math)

Sense of Inadequacy: Nur felt inadequate by evaluating her failure in mathematics in terms of her general academic ability. This was especially evident when compared to her older relatives.

"If there was more awareness, maybe these situations would not have happened." (Tutoring days)

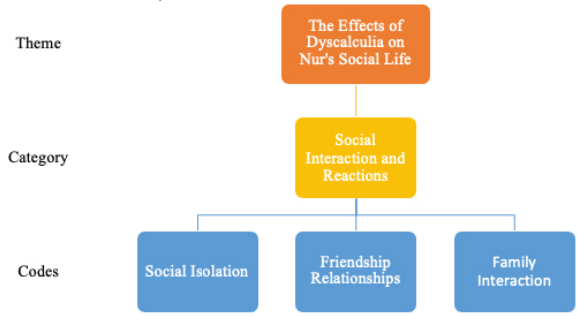
Personal Coping Strategies: Nur tried different ways to overcome her difficulties with mathematics. For example, her focus on English in high school can be seen as a coping strategy by avoiding mathematics. She also found practical solutions such as using a calculator.

"Then I looked for a solution in English, I was good with words and there was no math." (University Journey)

The effects of dyscalculia on social life

Under the theme of the effects of dyscalculia on social life, the codes of social isolation, friendship relations and family interaction belonging to the category of "Social Interaction and Reactions" are presented in Figure 2. These codes represent the difficulties Nur encountered in her social interactions and relationships and the processes of coping with these difficulties. Social isolation refers to the tendency of individuals to withdraw from their social environment; friendship relations refers to the quality of friendship ties within the social environment; and family interaction refers to the quality of communication and interaction between family members. This figure illustrates the various effects of dyscalculia on Nur's social life and the consequences of these effects on Nur's social relationships.

Figure 2.
The effects of dyscalculia on Nur's social life



Social Isolation: Nur has difficulty interacting with her friends and teachers because of her difficulties in math. Her sense of failure, especially in math classes, isolates her socially.

"Learning that day that I would not get a certificate of achievement because of one subject affected me deeply" (Struggling with Mathematics)

Friendship Relationships: Nur's relationship with her childhood friend is strained because of her friend's success in math and Nur's failure in this subject. This situation affects Nur's friendship relations.

"I was almost like an invisible student next to him. This situation pushed me to gradually withdraw into myself." (Tutoring days)

Family Interaction: Nur's family is unsympathetic to her difficulties in mathematics, which negatively

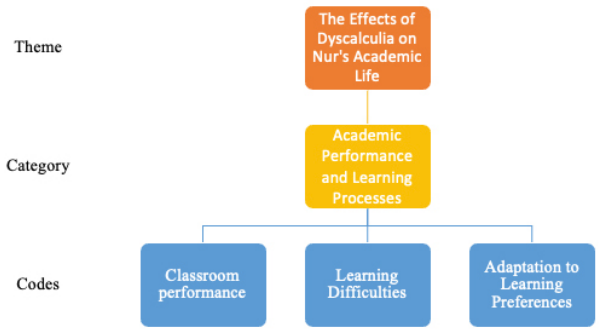
affects communication within the family. Her family's insensitivity, especially when she is upset about her report card, causes problems in family interaction.

"My family did not react when they saw my tears" (Fighting Math)

The effects of dyscalculia on academic life

Under the theme of the effects of dyscalculia on academic life, the codes of classroom performance, learning difficulties and educational support belonging to the category of "Academic Performance and Learning Processes" are presented in Figure 3. These codes represent the difficulties Nur encountered in academic environments and learning processes and the methods of coping with these difficulties. Classroom performance refers to students' activities and achievements in lessons; learning difficulties refers to the obstacles encountered in the learning process; and adaptation to learning preferences refers to the tailored approaches and methods used to align educational practices with individual student needs.This figure illustrates the various effects of dyscalculia on Nur's academic performance and the consequences of these effects on Nur's educational processes.

Figure 3.
The effects of dyscalculia on Nur's academic life



Classroom Performance: Nur was unsuccessful in mathematics compared to other subjects, which affected her academic self-confidence. Although she was successful in other subjects, this failure in mathematics had a negative impact on her overall academic performance.

"Thinking that I had been wronged, I hid my report card and returned home in tears. My family did not react when they saw my tears. I hid the truth by telling those who were curious about my report card that I received a certificate of appreciation and I did not show my report card to anyone. Although years have passed, this incident remains fresh in my memory." (Struggle with Mathematics)

Learning Difficulties: Nur had difficulty in understanding mathematics subjects during her days at the classroom. Her inability to grasp the logic of the subjects and her failure in the exams created significant obstacles in the learning process.

"I can't say that I didn't study; I really made an effort, but I couldn't get the logic of the math subjects in my mind." (Tutoring days)

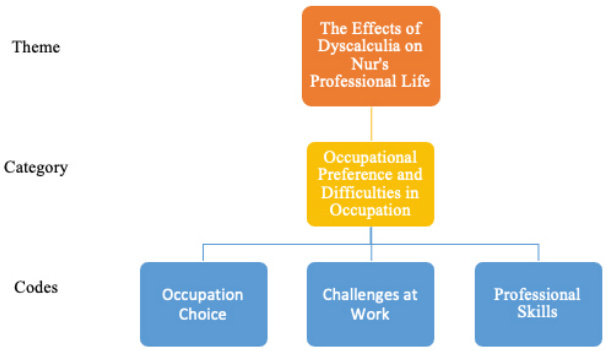
Adaptation to Learning Preferences: During high school, he tended to avoid math and gravitated towards English. This indicates changes in educational preferences and a search for alternative ways of learning.

"I had somehow survived math in high school... then I looked for a solution in English... It was accepted by my family that I could do English, but relatives - especially my cousins who were good at math - were always criticizing me." (University Journey)

Effects of dyscalculia on professional life

Under the theme of the effects of dyscalculia on professional life, the codes of professional skills, difficulties in the workplace and career planning belonging to the category of "Occupational Preference and Difficulties in Occupation" are presented in Figure 4. These codes represent the difficulties Nur encountered in the fields of work and career and the processes of coping with these difficulties. Professional skills refer to individuals' skills and knowledge levels in business life; workplace challenges refer to the obstacles encountered in the professional environment and the methods to overcome them; and occupation choice refers to the decision-making process involved in selecting a profession based on personal interests. This figure illustrates the various effects of dyscalculia on Nur's professional life and the consequences of these effects on her work and career development.

Figure 4.
The effects of dyscalculia on Nur's professional life



Occupation Choice: Nur's difficulties with math influence her career choice and progression. Her choice of English may have been a decision to avoid mathematical operations and this determines the direction of her professional development.

"I chose English teaching because of these difficulties with mathematics. I chose this path to avoid mathematical operations." (University Journey)

Challenges at Work: Nur needs to refer to the percentage calculator website when doing mathematical calculations in class.

"But I was having a hard time understanding how to calculate, how to get 25 percent, etc. I asked a math teacher a lot of questions about this. The teacher tried to explain it to me, but I still couldn't understand it and we laugh about it now. Finally, I found a percentage calculation website on the internet and did the calculations from there." (Percentage Confusion)

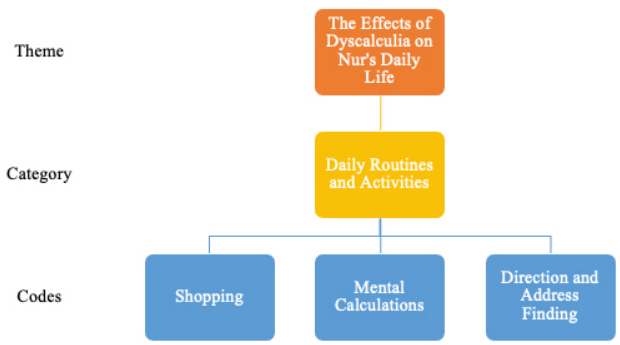
Professional Skills: As a teacher, Nur struggles with calculations in the classroom due to difficulties with mathematical operations. This affects her professional skills and causes difficulties in her teaching practices.

"When I was doing the calculation, the students gathered around me and started laughing when a student passed me and reached the result faster. It was a bit embarrassing to be honest." (Mental Calculation Race)

The effects of dyscalculia on everyday life

Under the theme of the effects of dyscalculia on daily life, the codes for shopping, mental calculations, and finding directions and addresses belonging to the category of "Daily Routines and Activities" are presented in Figure 5. These codes represent the difficulties Nur encountered in her daily life activities and the processes of coping with these difficulties. These three codes represent Nur's daily life challenges and coping strategies. The code "Shopping" refers to difficulties with financial transactions, "Mental Calculations" refers to difficulties with daily mathematical operations, and the code "Direction and Address Finding" emphasizes potential difficulties in spatial perception and orientation skills.

Figure 5.
The effects of dyscalculia on Nur's daily life



Shopping: Nur has calculation difficulties when paying with cash at the supermarket. She finds it difficult to make calculations, especially when paying large amounts with small bills. This leads to stress and difficulties when paying at the supermarket.

"While it is more convenient to pay especially with high denomination banknotes such as 100 tl, I have trouble with the calculation when I pay large amounts with small banknotes such as 20, 10, 5 ." (Market Account)

Mental Calculations: Nur is affected by the inability to cope with simple mathematical situations in everyday life.

"It can also be sad that older people who do not go to school can do mental addition better than me, sometimes I am surprised, sometimes there is a money issue at work or shopping, they add very quickly by adding immediately in their heads, and when I am in such a situation, the calculator comes to my aid immediately (Daily Accounts)

Direction and Address Finding: Difficulties in spatial perception and orientation skills create obstacles in daily life, such as finding an address.

"Finding an address is always a difficult experience for me. Sometimes, even though I've been through the same place many times, when I'm there I can't remember which way I should turn or where I came from and I get a feeling of being lost." (Disappearing Directions)

Discussion, Conclusion and Recommendations

This study focuses on Nur, an English teacher with dyscalculia, and her difficulties in learning mathematical concepts and applying mathematical operations. The findings showed how dyscalculia affected many different aspects of Nur's life. These effects reveal that her learning difficulties negatively affects not only her academic achievement, but also her daily life, social relationships and professional performance.

Nur exhibits typical symptoms associated with dyscalculia. These symptoms include difficulties with simple mathematical operations such as addition and subtraction, confusion in finding directions and addresses, difficulty in calculating with cash, and problems with mental math in the classroom (Shalev et al., 2001; Ansari & Karmiloff-Smith, 2002; Jordan, Hanich, & Kaplan, 2003; Geary, 2004; Hannell, 2005; Sharma, 2015). Mejias et al. (2012) showed that adults with dyscalculia were less successful than control groups in numerical estimation tasks with non-symbolic materials. This points to ongoing difficulties in representing and processing numerical quantities even in non-symbolic tasks. These mathematical

deficits can lead to more pronounced problems, such as the individual's avoidance of mathematics lessons and inability to cope with simple mathematical situations in daily life.

As seen in Nur's life, dyscalculia creates significant difficulties in situations requiring basic mathematical skills that individuals encounter in daily life. Studies by Muñez (2023) and Zhang et al. (2018) have documented the difficulties individuals with dyscalculia face in activities such as shopping, budget planning, and daily calculations. These difficulties highlight how dyscalculia can affect an individual's independence and quality of life (De Visscher et al., 2017).

The effects of dyscalculia on Nur go beyond academic achievement and have a profound impact on personal self-esteem and self-evaluation. Difficulties in mathematics can lead to feelings of inadequacy and contribute to a negative self-image. Burgio et al. (2022) reported that adults with dyscalculia often experience emotional distress and low self-esteem, which negatively affects their job choices and general well-being. The research highlights the need for holistic approaches that address not only the cognitive aspects of dyscalculia but also its psychological effects (Burgio et al., 2022). Furthermore, the importance society places on mathematical skills is a critical factor in how individuals perceive themselves. Studies by Landerl et al. (2004), Dowker (2005), and Mutlu, Çam, and Çalışkan (2021) have shown that the stigmatization and discrimination that individuals with dyscalculia experience due to mathematical difficulties can further undermine their self-confidence and self-belief. These studies reveal the profound effects of dyscalculia on an individual's perception of self-worth and the role of societal expectations on these effects.

The negative effects of dyscalculia on Nur's teaching career seem to be consistent with the findings in the literature. Hosseini's (2020) thesis analyzes the main challenges faced by adult musicians with dyscalculia and reveals how these challenges negatively affect not only their educational process, but also their daily lives and professional careers. As a consequence, there are serious impacts on these individuals in professional fields where math-based skills are required. On the other hand, the study by Vigna et al. (2022) examined in depth the effects of dyscalculia on daily life in adults and found that these individuals had difficulty in estimating time and measurement, as well as in handling money. The study showed that these adults were aware of the difficulties associated with dyscalculia and that this could have negative effects on their academic and professional decisions (Vigna et al., 2022; Mutlu et.al., 2024).

Dyscalculia is a complex learning difficulty that extends beyond challenges in learning mathematics; it can affect many different aspects of an individual's life. Nur's experiences illustrate how dyscalculia impacts a wide range of academic, social, occupational, and daily life dimensions. Therefore, developing effective intervention and support strategies for individuals with dyscalculia is critical for improving their quality of life and overall well-being.

This study sheds light on the difficulties experienced by individuals with dyscalculia and emphasizes the importance of further research in this area. To strengthen our understanding and address the lifelong challenges associated with dyscalculia, future research should explore several key areas. Longitudinal studies are needed to track the long-term impact of early interventions, providing insights into how support strategies influence outcomes over time. Comparative studies on the effectiveness of different educational and psychological interventions can identify the most beneficial approaches for adults with dyscalculia. Additionally, cross-cultural analyses would help understand how dyscalculia affects individuals in various educational contexts, informing culturally sensitive support mechanisms.

By focusing on these areas, future research can guide the development of comprehensive strategies to address the challenges faced by individuals with dyscalculia across different stages of life and settings. Such efforts will contribute to a more inclusive understanding and support system, ultimately enhancing the functional independence and psychological well-being of those affected by dyscalculia.

While this study offers valuable in-depth insights into the experiences of individuals with dyscalculia through the case of Nur, it is important to acknowledge its limitations. One significant limitation is the single-case study design, which may affect the generalizability of the findings to a broader population. Additionally, Nur has not received an official diagnosis of dyscalculia; her symptoms were identified based on observations and interviews conducted by the researcher.

References

Ansari, D., & Karmiloff-Smith, A. (2002). Atypical trajectories of number development: A neuroconstructivist perspective. *Trends in Cognitive Sciences*, *6*(12), 511–516.

Bugden, S., Peters, L., Nosworthy, N., Archibald, L., & Ansari, D. (2021). Identifying children with persistent developmental dyscalculia from a 2-min test of symbolic and nonsymbolic numerical magnitude processing. *Mind, Brain, and Education*, *15*(1), 88–102.

Burgio, F., Danesin, L., Angelini, D., Benavides-Varela, S., & Semenza, C. (2022). Dyscalculia in early adulthood: Implications for numerical activities of daily living. *Brain Sciences*, *12*(3), Article 373. https://doi.org/10.3390/brainsci12030373

Deruaz, M., Dias, T., Gardes, M. L., Gregorio, F., Ouvrier-Buffet, C., Peeters, F., & Robotti, E. (2020). Exploring MLD in mathematics education: Ten years of research. *The Journal of Mathematical Behavior*, *60*, Article 100807.

De Visscher, A., Noël, M.-P., Szmalec, A., & Majerus, S. (2017). Developmental dyscalculia in adults: Beyond numerical magnitude impairment. *Journal of Learning Disabilities*, *50*(6), 644–654.

Dinkel, P. J., Willmes, K., Krinzinger, H., Konrad, K., & Koten, J. W., Jr. (2013). Diagnosing developmental dyscalculia on the basis of reliable single-case fMRI methods: Promises and limitations. *PLoS ONE*, *8*(12), e83722. https://doi.org/10.1371/journal.pone.0083722

Ganor-Stern, D. (2017). Can dyscalculics estimate the results of arithmetic problems? *Journal of Learning Disabilities*, *50*(1), 23–33. https://doi.org/10.1177/0022219415588851

Gersten, R., Jordan, N. C., & Flojo, J. R. (2005). Early identification and interventions for students with mathematics difficulties. *Journal of Learning Disabilities*, *38*(4), 293–304.

Geary, D. C. (2004). Mathematics and learning disabilities. *Journal of Learning Disabilities*, *37*(1), 4–15.

Geary, D. C. (2013). Early foundations for mathematics learning and their relations to learning disabilities. *Current Directions in Psychological Science*, *22*(1), 23–27.

Gifford, S., & Rockliffe, F. (2012). Mathematics difficulties: Does one approach fit all? *Research in Mathematics Education*, *14*(1), 1–15.

Creswell, J. W. (2013). *Qualitative inquiry and research design: Choosing among five approaches* (S. B. Demir, Trans.). Siyasal Kitabevi. (Original work published 2007)

Hand, C. J. (2023). Neurodiverse undergraduate psychology students' experiences of presentations in education and employment. *Journal of Applied Research in Higher Education*, *15*(5), 1600–1617.

Hosseini, S. (2020). *The lived experiences of adult musicians with dyscalculia: A heuristic inquiry* [Doctoral dissertation, University of Miami].

Hughes, E. M., Witzel, B. S., Myers, J., & Lin, T.-H. (2023). Unpacking and understanding specific learning disabilities in mathematics. *Teaching Exceptional Children*. Advance online publication. https://doi.org/10.1177/00400599231175509

Jordan, N. C., Hanich, L. B., & Kaplan, D. (2003). Arithmetic fact mastery in young children: A longitudinal investigation. *Journal of Experimental Child Psychology*, *85*(2), 103–119.

Kaufmann, L., Handl, P., & Thöny, B. (2003). Evaluation of a numeracy intervention program focusing on basic numerical and conceptual knowledge: A pilot study. *Journal of Learning Disabilities*, *36*(6), 564–573.

Kaufmann, L., Mazzocco, M. M. M., Dowker, A., von Aster, M., Göbel, S. M., Grabner, R. H., ... & Nuerk, H.-C. (2013). Dyscalculia from a developmental and differential perspective. *Frontiers in Psychology*, *4*, Article 516. https://doi.org/10.3389/fpsyg.2013.00516

Kroesbergen, E. H., Huijsmans, M. D., & Friso-van den Bos, I. (2023). A meta-analysis on the differences in mathematical and cognitive skills between individuals with and without mathematical learning disabilities. *Review of Educational Research*, *93*(5), 718–755.

Lewis, K. E. (2016). Difference not deficit: Reconceptualizing mathematical learning disabilities. *Journal of Learning Disabilities*, *49*(4), 416–428.

Mejias, S., Grégoire, J., & Noël, M.-P. (2012). Numerical estimation in adults with and without developmental dyscalculia. *Learning and Individual Differences*, *22*(1), 164–170. https://doi.org/10.1016/j.lindif.2011.09.013

Monei, T., & Pedro, A. (2017). A systematic review of interventions for children presenting with dyscalculia in primary schools. *Educational Psychology in Practice*, *33*(3), 277–293.

Muñez, D., Bull, R., Lee, K., & Ruiz, C. (2023). Heterogeneity in children at risk of math learning difficulties. *Child Development*, *94*(3), 1033–1048. https://doi.org/10.1111/cdev.13918

Mutlu, Y., & Akgün, L. (2017a). A new model proposal for diagnosing mathematics learning disabilities: Multiple filter model. *İlköğretim Online*, *16*(3), 1153–1173.

Mutlu, Y., & Akgün, L. (2017b). The effects of computer-assisted instruction materials on approximate number skills of students with dyscalculia. *Turkish Online Journal of Educational Technology*, *16*(2), 119–136.

Mutlu, Y., & Akgün, L. (2019). Using computers for developing arithmetical skills of students with mathematics learning difficulties. *International Journal of Research in Education and Science*, *5*(1), 237–251.

Mutlu, Y. (2019). Math anxiety in students with and without math learning difficulties. *International Electronic Journal of Elementary Education*, *11*(5), 471–475.

Mutlu, Y., & Korkmaz, E. (2020). Investigating clock reading skills of third graders with and without dyscalculia risk. *International Online Journal of Primary Education*, *9*(1), 97–110.

Mutlu, Y., Çam, Z., & Çalışkan, E. F. (2021). *Problems experienced by dyscalculic children and solution suggestions*. Vizetek Publishing.

Mutlu, Y., Çam, Z., & Uçar, S. (2024). *Rakamların ötesindeki hikayeler: Diskalkuli ile yaşayanlar* [Beyond the numbers: Stories of living with dyscalculia]. Vizetek Yayıncılık.

Price, G., & Ansari, D. (2013). Dyscalculia: Characteristics, causes, and treatments. *Numeracy*, *6*(1), Article 2. https://doi.org/10.5038/1936-4660.6.1.2

Rubinsten, O., & Tannock, R. (2010). Mathematics anxiety in children with developmental dyscalculia. *Behavioral and Brain Functions*, *6*, Article 46. https://doi.org/10.1186/1744-9081-6-46

Sharma, M. C. (2015). A window into dyscalculia and other mathematics difficulties. In S. Chinn (Ed.), *The Routledge International Handbook of Dyscalculia and Mathematical Learning Difficulties* (pp. 277–290). Routledge.

Shalev, R. S., Manor, O., Kerem, B., Ayali, M., Badichi, N., Friedlander, Y., & Gross-Tsur, V. (2001). Developmental dyscalculia is a familial learning disability. *Journal of Learning Disabilities*, *34*(1), 59–65.

Shalev, R. S. (2004). Developmental dyscalculia. *Journal of Child Neurology*, *19*(10), 765–771. https://doi.org/10.1177/08830738040190100601

Skagerlund, K., & Träff, U. (2016). Number processing and heterogeneity of developmental dyscalculia: Subtypes with different cognitive profiles and deficits. *Journal of Learning Disabilities*, *49*(1), 36–50.

Sella, F., & Cohen Kadosh, R. (2018). What expertise can tell about mathematical learning and cognition. *Mind, Brain, and Education*, *12*(4), 186–192.

Sousa, P., Dias, P. C., & Cadime, I. (2017). Predictors of primary school teachers' knowledge about developmental dyscalculia. *European Journal of Special Needs Education*, *32*(2), 204–220.

Vigna, G., Ghidoni, E., Burgio, F., Danesin, L., Angelini, D., Benavides-Varela, S., & Semenza, C. (2022). Dyscalculia in early adulthood: Implications for numerical activities of daily living. *Brain Sciences*, *12*(3), Article 373. https://doi.org/10.3390/brainsci12030373

Yoong, M. (2023). The design and development of a dyscalculia checklist based on a focus group. *British Journal of Special Education*, *50*(1), 50–75.

Wilkey, E. D., Pollack, C., & Price, G. R. (2020). Dyscalculia and typical math achievement are associated with individual differences in number-specific executive function. *Child Development*, *91*(2), 596–619.

Williams, A. (2013). A teacher's perspective of dyscalculia: Who counts? An interdisciplinary overview. *Australian Journal of Learning Difficulties*, *18*(1), 1–16.

Witzel, B., Myers, J., Root, J., Freeman-Green, S., Riccomini, P., & Mims, P. (2023). Research should focus on improving mathematics proficiency for students with disabilities. *The Journal of Special Education*. Advance online publication. https://doi.org/10.1177/00224669231168373

Zhang, X., Räsänen, P., Koponen, T., Aunola, K., Lerkkanen, M.-K., & Nurmi, J.-E. (2020). Early cognitive precursors of children's mathematics learning difficulties and persistent low achievement: A 5-year longitudinal study. *Child Development*, *91*(1), 7–27.

Annex 1. Nur's Stories

1.Fighting math

At the time, I was a student in the 7th grade of secondary school. I had progressed well in other subjects, but I unexpectedly failed in mathematics. While trying to understand this situation, I had the opportunity to talk to my mathematics teacher. On the day of the report card, I learned that my average was actually good, but the teacher could not intervene in this situation. On that day, I was deeply affected to learn that I would not receive a certificate of achievement just because of one subject. Thinking that I had been wronged, I hid my report card and returned home in tears. My family did not react when they saw my tears. I hid the truth by telling those who were curious about my report card that I had received a certificate of appreciation and did not show it to anyone.

Years later, this incident remains fresh in my memory. Even though I was good at other subjects, having this experience just because of math was quite upsetting and challenging as a child.

2.Tutoring days

At that time, we took an important exam called the Placement Examination (SBS). I remember I was having difficulty in math again. My parents sent me to a tutoring center to help me overcome this problem, but unfortunately I didn't see much benefit from these efforts. I can't say that I didn't study; I really made an effort, but I couldn't get the logic of the math topics in my mind. The questions I faced seemed completely different from each other. I had some talent for memorization, but it didn't work in math. In the exams, I was able to do most of the questions in other subjects, but in math I could only mark a few questions, which meant that I didn't get the expected score.

He was my childhood friend and also my neighbor, we used to go to the same school, and he was a student who was both well-known and well-liked by the teachers. He was very active in math classes and would often chat with the teachers and attend classes. I, on the other hand, was almost like an invisible student next to him. This situation pushed me to gradually withdraw into myself.

My friend's success in exams led to comparisons between families. Not only my own family but also my friend's family was constantly praising their children in front of my family. This was very demotivating for me. If there was more awareness, maybe these situations would not have happened. Every individual is different, but this fact is often ignored by both parents and teachers. In such cases, instead of investigating the cause of the problem, blames are often made, such as 'she doesn't work'.

3.University journey

I somehow got rid of mathematics in high school, I only saw it in the 9th grade, I failed at that time, but I passed the class with an average, then I looked for the solution in English, both I was good with words and there was no math :) otherwise I knew that if I chose equal weight, for example, I would not be able to do math again. I won the Anatolian high school and my friend was one of the best high schools at that time, we were separated there, I didn't see what he was doing anymore, in fact, this was good because there was no comparison in my family because my family accepted that I could do English, but this time, relatives, especially my cousins who were good at mathematics, were constantly criticizing me, saying that you could not win the exam by not doing mathematics, which I won in the first year, which was surprising for them, and my childhood friend was an English teacher. It was strange in this case because he did well on the numerical side and went to a better university by doing less English, such as mathematics, in this case it is quite common I have witnessed many people who have become English teachers by doing less English and doing numerical courses, this situation makes me think that I have been wronged because I think my English is better equipped, but because of such injustice, maybe we have to go to the university where our score is enough, not the university we want.

4.Daily accounts

It can also be sad that older people who do not go to school can do mental addition better than me, sometimes I am surprised, sometimes there is a money issue at work or shopping, they add very quickly by adding immediately from their heads, and when I am in such a situation, the calculator comes to my aid again I can say that in fact, this situation puts you in a difficult situation as a teacher in such environments, frankly, I am ashamed, I always feel a lack.

I am sometimes surprised and saddened by the fact that older people with no schooling can do some things that I cannot do, especially quick mental addition. For example, when they are calculating money or shopping, they do quick addition in their heads. When I encounter similar situations, I usually immediately resort to a calculator, which puts me in a difficult situation, especially as a teacher, and makes me feel incomplete. In such moments, I have to admit that I feel embarrassed and a sense of inadequacy.

5.Mental calculation race

Recently I gave a quiz to my students and afterwards we checked their correct and incorrect answers. I asked them to calculate the sum of their quiz results, back to front. Some students brought the sum immediately. I, as usual, immediately resorted to the

calculator, because it is difficult for me to do quick mental addition. My attempts are usually either wrong or take too long. While I was doing the calculation, students gathered around me and started laughing when one of them beat me and got the result faster. It was a bit embarrassing, to be honest.

On another occasion, a fourth grader recently asked me what the word 'times' means in English. I answered, but then when the student asked me for numbers from the multiplication table in English, I couldn't answer because I have never been able to memorize the multiplication table completely. I quickly changed the subject so that my student wouldn't notice this.

6.Percent confusion

I cannot grasp the concept of percentage. Especially expressions such as 'what percentage of a hundred' confuse me and I find it difficult to understand how it is calculated. When I encounter such calculations, I usually ask someone. For example, the calculation of discounted prices on discount labels in stores; in the past, sometimes we could only find out the discounted price at the checkout. In my profession, percentage calculations are also used to calculate exam grades. I took three exams and it was easy to calculate 50 percent of one of them, because that's half. But I was having a hard time understanding how to calculate the 25 percent and so on. I asked a math teacher a lot of questions about this. The teacher tried to explain it to me, but I still couldn't understand it and we laugh about it now. Finally, I found a website for calculating percentages on the internet and did the calculations there. Mathematics is really everywhere and no matter how much I try to avoid it, I always feel its importance.

7.Disoriented teacher

I constantly confuse my right and my left; it has been like this since I was a child. Every time I have to stop and think for a moment: which side is my right, which side is my left? Sometimes I try to help myself by wearing my wristwatch on my left arm, but that doesn't always work either.

This is especially evident in second grade lessons. Recently, when I was teaching the 'wool topic', I got quite confused while giving instructions like 'turn right, turn left'. I found myself in confusion while trying to show the students the right direction. Then, I started explaining by turning to the blackboard like the students. Fortunately, the situation didn't become too ridiculous because the children were small, but it was still a bit of a challenge for me.

Another example is when I am driving. When someone gives me directions and says 'turn right', I often find it difficult to understand which way is right. Then I think a little bit and say 'Oh, yes, this way is right', but it usually takes a while.

8.Market showdown

One day I went to the grocery store and there was an old lady at the checkout. This grocer only dealt in cash. I usually don't like to use cash because I find it difficult to count money. I find it easier to pay with high denomination banknotes such as 100 □, but when I pay large amounts with small denomination banknotes such as 20, 10, 5 □, I have trouble with the calculation. I usually either miscalculate or have to wait for a long time due to someone else's intervention.

That day I did my shopping and went to the checkout to pay. I gave 100 □ and the total amount was 37 □. Both I and Auntie had a hard time calculating the change, and I didn't have my phone with me that day, otherwise the calculator app would have saved me from this situation immediately. I don't remember ever feeling so nervous in my life, I felt as if I had found myself in a big test.

9.Disappearing directions

Finding an address is always a difficult experience for me. Sometimes, even though I have been there many times, I cannot remember which way I should turn or where I came from, and I get a feeling of being lost. For example, there is a road that I often use by car; I think about which way I should turn right now, but I cannot think of it. This happens more often on main roads, even if I know the road.

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The Role of Interactive Methods in Preparing Preschool Children for Studying at the New Ukrainian School

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Abstract

Early childhood education plays a pivotal role in shaping an individual's personality and serves as a preparatory stage for primary education. The curiosity sparked during this phase of life influences one's lifelong learning journey, character formation, worldview, adoption of universal values and acquisition of important life skills. This study aims to explore the significance of interactive teaching methods in preparing preschoolers for school while harnessing the advantages offered by digital infrastructure to enhance learning outcomes. A diagnostic evaluation conducted as part of an educational experiment revealed that students who were exposed to interactive teaching techniques demonstrated superior readiness levels compared to their peers. The use of digital tools such as virtual and augmented reality, educational applications and games positively impacted knowledge acquisition, skill development and overall cognitive abilities among the learners. Future research can focus on developing teacher training programs geared towards implementing interactive teaching methodologies using modern software platforms and digital tools in early childhood education settings.

Keywords:

Interactive Teaching Methods, School Readiness, New Ukrainian School, Digital Technologies, Competencies Of The 21st Century

Introduction

Significant transformations in virtually every aspect of human existence, prompted by global challenges, the process of globalization and technological advancements, have triggered revolutionary changes in the entire educational system as well as pedagogical methods and approaches. The preschool education system is no exception in this phenomenon. Presently, there is a demand for effective pedagogical tools, updated teaching methods and new approaches to enhance the quality of preparation given to children for further studies in secondary school.

Currently, educational landscape in Ukraine is being successfully integrated into the European one, the reform of the New Ukrainian School (NUS) is at the stage of active implementation, and monitoring studies of the effectiveness of its practical implementation are being carried out (Khyzhniak & Viktorenko, 2021). One of the primary aims

of the reform is to create a contemporary, versatile, and adaptable educational environment that fosters children's imaginative growth and enthusiasm for learning. The overhaul entails not only updating curricula and textbooks but also expanding the proportion of project-based, collaborative, and collective activities during instructional sessions while diversifying options for configuring learning spaces. To facilitate this transformation in educational settings requires extensive employment of novel information technology (IT) tools, multimedia teaching aids as well as modernizing educational equipment.

The new Ukrainian school is based on the paradigm of a student-centered model of education (Kravchenko et al., 2022). According to the NUS reform, one of the fundamental principles of modern innovative education is the education individualization, i.e. the implementation of individual educational opportunities in the educational environment in accordance with each student's needs (Sas et al., 2023). Moreover, a competence approach is being introduced, which raises the importance and need to rethink the tasks of teaching and adapt pedagogical programs to new requirements (Bondar et al., 2021; Filatova et al., 2023). Furthermore, the change in teacher's and student's functional roles is emphasized. The vectors governing the organization of the educational process are aimed at encouraging students to become proactive seekers of new knowledge. In this regard, educators play a multifaceted role as coaches, collaborators, team coordinators, advisors, monitoring and evaluation experts; occasionally even taking on the role of a student themselves (Byhar et al., 2022).

Enhancing the preparedness of young learners for formal education stands as a paramount objective within the realm of quality high-caliber early childhood instruction (Lumaurridlo et al., 2021). School readiness includes a comprehensive set of core abilities, including cognitive skills, receptive and expressive language proficiency, executive functions, and socio-emotional and behavioral competencies (Józsa et al., 2023). School readiness pertains to the competencies and proficiencies indispensable for a child to facilitate their learning process in school. These encompass not only cognitive abilities, but also social, emotional, and behavioral facets of their development.

Literature Review

The preschool education system is the primary, most important link in continuing education (Kholova, 2022). Preschool education is the initial stage of the education system and forms its basis, therefore it occupies a key place in the long-term design of the effectiveness of the student's future education at school (Hamidova, 2020). In the current conditions of changing the education paradigm, the pivotal element of education lies in the notion of interactivity, which entails dynamic engagement between the participants involved in the educational process as well as the need to mobilize resources, create optimal conditions, introduce advanced pedagogical methods and approaches for its effective implementation within the educational process is increasing (Yuldasheva, 2021). In the realm of early childhood education, the fundamental objective of pedagogical methodology is to cultivate children's cognitive faculties and equip them with the necessary skills to navigate social life conditions (Rakhimov, 2022).

Currently, interactive approaches to learning are of interest to researchers and practicing educators, whose efforts are aimed at finding opportunities to create an effective learning environment and development with the implementation of advanced teaching methods. Interactive teaching methods are ways of purposeful interaction of all participants in the educational process, which activate cognitive and communication activities and ensure students' utmost engagement in the educational process. Interactive gaming techniques have become a fundamental aspect of educational reforms worldwide, serving as efficacious instruments that enhance the overall effectiveness of education (Otajonov & kizi Akhmadjonova, 2022). In contrast to active methods, interactive teaching methods are focused on wider interaction between students both with the teacher and with each other. All interactive techniques are founded on interaction principles and center around the collective group involvement, with mandatory feedback (Orshanskyi et al., 2020).

Indonesian scholars believe that one of the outcomes of early childhood education is quality preparation for school, which should be divided into two evolving discursive constructs, namely readiness for learning and readiness for school. The former is perceived as developmental progress, which is manifested in the child's ability to interiorize certain educational content. It is influenced by motivation, physical development, intellectual ability, emotional maturity and health. In terms of readiness for school, it is seen as a set of physical, intellectual and/or social skills whose sufficient development level is necessary for the child to meet the school environment demands (Lumaurridlo et al., 2021). The significance of this viewpoint is corroborated by scientists from Brazil, Norway, and Ukraine, presenting practical insights to accomplish the primary objective of early childhood education. According to Brazilian scientists, to develop the necessary level of child's readiness for school, neuropsychomotor conditions are necessary for learning, and those must be placed in an environment that promotes and stimulates learning (Dias Coelho et al., 2024). This opinion is supported by Ukrainian scientists (Sas et al., 2023), who believe that the educational environment should contribute to the introduction and implementation of innovative ideas, projects, systems and forms of education aimed at developing cognitive interest and implementing the

principle of combining learning with life. Teaching methods should promote the student's active, independent and proactive position in the learning process and underscore the development of critical thinking and creativity. Interestingly, a study conducted in Norwegian preschools found that a comprehensive approach to child development that combines physical activity with a variety of tasks, cognitive and engaging games and engaging in educational pursuits presents a genuine prospect to favorably impact diverse facets of juveniles' physiological and mental growth, while also offering remedies for public well-being and life-long learning in advance (Aadland et al., 2020).

Saudi Arabian researchers posit that it is profoundly efficacious to construct a digital environment for cultivating a child's physical, intellectual, and emotional faculties that affords them the opportunity to learn from their own experiences and engages all of the children's sensory modalities. Encouraging the young learners' active engagement in the educational process helps to enhance understanding, preserve memory and increase student achievement. Moreover, owing to the introduction of digital technologies into the educational process, children have the opportunity to develop the relevant digital skills.

The purpose of the article is to study the role of interactive methods of preparing preschool children for school, as well as examining how the utilization of digital technologies presents opportunities and benefits for the provision of a technologically advanced learning environment, which ultimately enhances the education efficacy. To achieve the goal, the following tasks were set:

- to develop a conceptual scheme for the elaborating an interactive methodology aimed at developing preschoolers' readiness for school;

- to design a model of the educational environment to implement the interactive teaching methodology with the experimental and control groups of young learners within the course "Journey to the School of the Future";

- to conduct an educational experiment with the participation of 170 children aged 5-6 from 10 full-time and part-time pre-school educational institutions of Ukraine;

- to assess the degree of readiness to study at school in children from the experimental, control and additional groups, followed by results comparison.

Methods and Materials

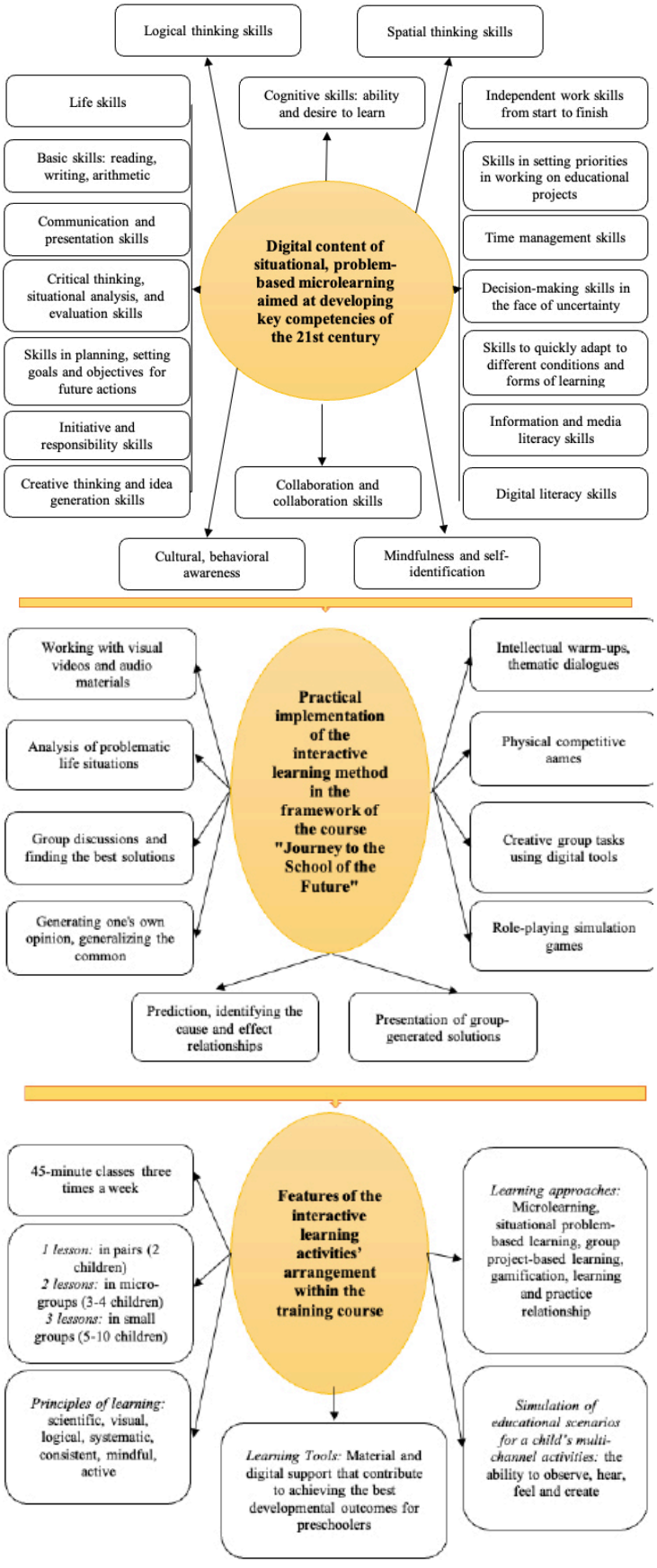
Study Design

In order to explore the feasibility of incorporating interactive approaches to prepare children for school and evaluate their efficacy, a six-month educational experiment was conducted (from October 2023 to February 2024). The development of educational content for the experiment was carried out by 2 teachers from the Department of Theory and Methods of Preschool Education at the Faculty of Pedagogy (Kamianets-Podilskyi Ivan Ohiienko National University). Assistance in the implementation of training sessions was provided by 12 tutors and 2 moderators – graduate students and master students from the Faculty of Pedagogy. The expert group consisted of 12 professional psychologists specialized in "Child Psychology" (Specialty 012. 00.01 Preschool Education).

Arrangement of pedagogical activities within the framework of an educational experiment. The conceptual scheme of arranging the interactive methodology for the development of preschoolers' readiness for school, implemented within the framework of the educational experiment, is presented in Figure 1. The model of the educational environment for implementing the interactive teaching methodology with children of the experimental and control groups is presented in Figure 2. Children's participation in an educational experiment. Pedagogical activities within the framework of the course "A Journey to the School of the Future" were carried out on the premises of educational institutions for children. Three times a week, 45-minute classes were conducted with children in their conventional conditions. Participants in the control and experimental groups were taken to different rooms. In each group, training sessions were held under the guidance of 2 tutors and 2 experts – psychologists, who analyzed the favorable learning environment, the general mood in the group, the degree of student involvement in learning and the perception of educational content on a 5-point scale (from negative to positive).

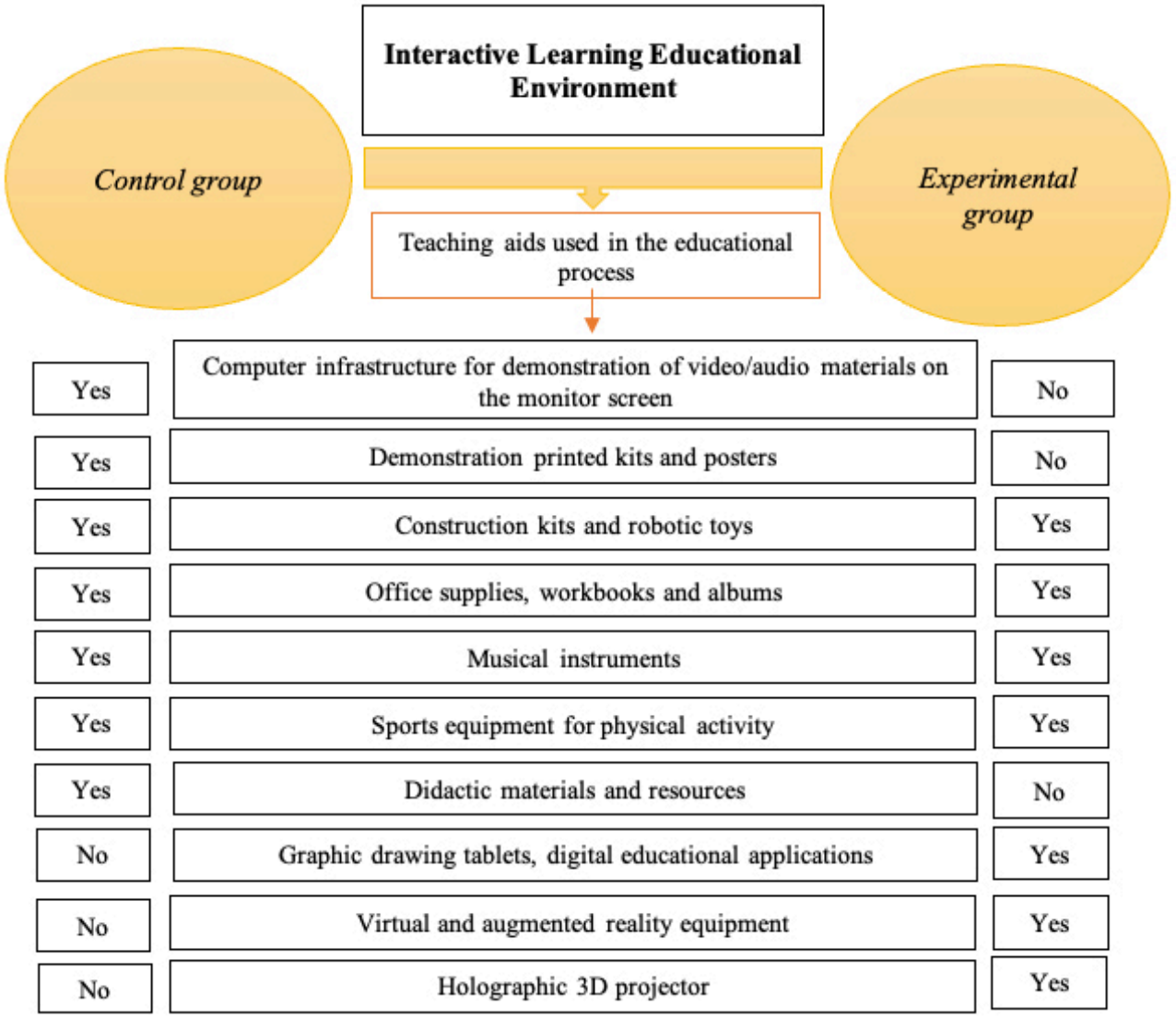
Teachers' participation in the educational experiment. Preschool teachers participated only in surveys and were not involved in experimental classes, taking the position of an educational process observer. Parents' participation in the educational experiment. The educational experiment moderators created a group on WhatsApp (https://www.whatsapp.com/?lang=uk), where parents whose children participated in the educational experiment were invited. The group participants had the opportunity to get additional answers to questions that arise in the process of conducting an educational experiment, share their opinions with other trainees and participate in discussions. What is more, relevant educational content for parents was created, in particular mini-recommendations to help children prepare for school. To that end, the moderators daily made 3 posts in the form of short video clips and engaged parents in the dialogue by offering their questions for discussion.

Figure 1.
Conceptual scheme of arranging the interactive methodology for the development of preschoolers' readiness for school, implemented within the framework of an educational experiment



Source: elaborated by the author

Figure 2.
The model of the educational environment for the implementation of the methodology of interactive teaching of children of the experimental and control groups



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Methods

To conduct the study, such empirical methods as experiment, observation, questionnaire and expert evaluation were used. The quantitative and qualitative methods were used to analyze the study results. Experimental data were processed using Microsoft Office Excel software. The assessment of children's readiness for school was carried out under the guidance of the toolkit for assessing the readiness of senior preschool age children to study in the context of reforming the Ukrainian school, namely "Magic Transformations", developed in the laboratory of preschool psychology of the G. S. Kostiuk Institute of Psychology of the National Academy of Pedagogical Sciences of Ukraine (Pirozhenko et al., 2023). The teachers of the course "Journey to the School of the Future" and psychologists carried out an individual assessment of the readiness for school of each participant of the educational experiment and each participant of the additional group with the help of the proposed set of diagnostic tasks "Magic Transformations" in the format of game interaction. Based on the summation of the total number of points, a report on the child's readiness for learning was formed (Table 1).

Table 1.
Evaluation of child's readiness level for school

Total points	Interpretation
63 – 47 points	Child's readiness to study at school is fully formed
46 – 32 points	Child's readiness for school is sufficiently formed
31 – 16 points	Child's readiness for school is at the stage of formation
15 – 7 points	Child's readiness for school is conditional
6 – 0 points	Child is not ready for school

Surveys of parents and teachers were conducted using the online tool for conducting questionnaires, namely Google Forms (https://www.google.com/intl/ru_ua/forms/about). The survey used the psychometric Likert scale in 5 gradations: 1 – strongly agree; 2 - disagree; 3-partially agree; 4 – agree to a large extent; 5 – I completely agree. After sorting the questionnaires, they were marked and sorted by relevance. An independent T-test was performed, and the results showed no significant difference ($p>0.051$). Further, in order to test the systematic error of the general method, Harman's one-factor method was used. Hence, it was established that the degree of explanation of the first factor variance was 28.28% (below 50%), which confirms the absence of a significant systematic error in the general method of this study.

Study Sample

The educational experiment involved 170 children from 4 public and 6 private pre-school educational institutions of full and part-time (Ukraine, the city of Kamianets-Podilskyi) aged 5-6 years (Appendix A, Table 3). The children participating in the educational experiment were divided into 2 groups (experimental group and control group) using a random method, so that the groups consisted of no more than 10 people and at least 5 (Appendix A, Table 4). To study the attitude of teachers and children's parents to the methodology of preparing children for school, at the beginning and after the end of the educational experiment, a survey was conducted. The respondents who took part in the survey were as follows: 21 teachers aged 27 to 49 and 170 parents of children aged 24 to 43 (Appendix A, Tables 5-6). In February 2024, to identify the difference in school readiness of children who are trained in typical conditions in preschool educational institutions and children who study according to the interactive learning methodology in the framework of the course "Journey to the School of the Future", additional 46 children were recruited to test the level of readiness for school. Accordingly, their parents also took part in the survey (Appendix A, Table 7).

Ethical Issues

The study was developed in accordance with the recommendations of the Declaration of Helsinki. Parents gave written consent to the children's participation in the educational experiment and the processing of their personal data. For ethical reasons, the interviewed parents were given the opportunity to understand the study objectives and ask questions about the research and the participants' rights at the initial stage of the educational experiment. This questions and answers session was carried out in the form of a video conference held on the online communication platform Zoom (https://zoom.us/).

Limitations of the study

The overriding limitation of the study is the narrow territorial framework of the educational experiment, the participants of which were from the same geographical region – Ukraine, the city of Kamianets-Podilskyi. Moreover, the assessment of a child's readiness for school was conducted under the guidance of the "Magic Transformations" toolkit, which was adapted specifically for evaluating the readiness level of Ukrainian preschoolers. Therefore, the method for assessing the readiness of preschoolers from other countries requires adapting the toolkit to national specifics. Additionally, only 46 children were included in the supplementary group, which does not allow for a sufficient level of reliability in identifying differences in school readiness between children trained in typical conditions at preschool institutions and those who studied using the interactive learning method proposed by the course "Journey to the School of the Future." Furthermore, the survey of parents whose children made up the supplementary group was conducted only once, which allowed for the identification of their attitude towards innovative pedagogical methods and approaches at that time. At the same time, the survey of parents whose children participated in the training and teachers who observed the learning process was conducted at the beginning and end of the experiment, which helped to identify changes in the respondents' attitudes toward the proposed educational methodology.

Results and Discussion

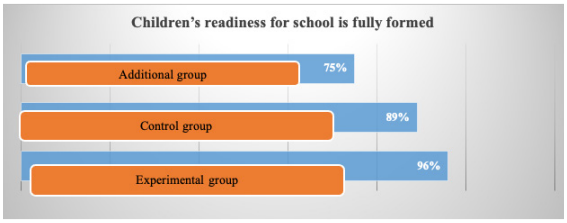
The educational experiment proved the feasibility of using a playful, interactive method in children's education to develop the key skills necessary for a child to study at school. The results of the diagnostic evaluation of children's readiness for school are presented in Table 2. The results of the evaluation showed that 96% of the children from the experimental group, 89% from the control group and 75% from the additional group scored from 47 to 63 points, which indicates the children's readiness for comprehensive learning. In 2% of children from the experimental group, readiness for learning was defined as sufficiently formed (46 – 32 points) and in 2% – readiness for school was at the stage of formation (31 – 16 points). In 6% of children from the control group, readiness for learning was defined as sufficiently formed, and in 2% - readiness for school was at the stage of formation. In 18% of children from the additional group, readiness for learning was defined as sufficiently formed, and in 7% - readiness for school was at the stage of formation.

Table 2.
Results of diagnostic assessment of children's readiness for school

Diagnostic evaluation results	Experimental group	Control group	Additional group
63 – 47 points	96%	89%	75%
46 – 32 points	2%	6%	18%
31 – 16 points	2%	5%	7%
15 – 7 points			
6 – 0 points			

Overall, the evaluation results demonstrated that participants of the educational experiment, wherein interactive teaching methodology was implemented, exhibited superior levels of preparation compared to their peers who received conventional training in preschool educational institutions. Furthermore, the participants of the experimental group showed better results in preparation compared to the children of the control group (Figure 3), which suggests that interaction with digital tools, such as virtual and augmented reality, digital applications and educational games, had a positive impact on the development of skills necessary for schooling.

Figure 3.
Evaluation of children's readiness for school



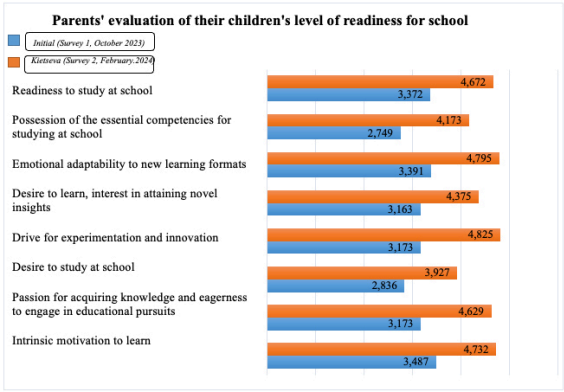
Source: author's development

According to expert psychologists, the degree of children's involvement in learning was higher among students from the experimental group compared to students in the control group, which affected the perception and memorization of educational content, as well as the development of general skills. The psychologists overall estimated the general mood in the group at 4.72 points in the experimental group and 4.32 points in the control group. The favorability of the learning environment was assessed at 4.83 points in the experimental group and 4.79 in the control group. The degree of students' involvement in educational practices was estimated at 4.59 points in the experimental group and 3.78 points in the control group.

As per the parental accounts, engagement in the educational trial had a profound impact on augmenting their children's school preparedness.(by 1,245 points), the acquisition of the necessary skills for school (by 1,456 points), the increase in emotional adaptability to new learning formats (by 1,091 points), the development of desire and interest in learning and the acquisition of new knowledge (by 1,652 points); to develop the desire to experiment and invent something new (by 1,212 points), to develop the desire to study at school (by 1,404 points), to form enthusiasm for learning and the desire to participate in educational activities (by 1,424 points), to develop intrinsic motivation to learn (by 1.3 points). The results of the parents' survey are presented in Figure 4.

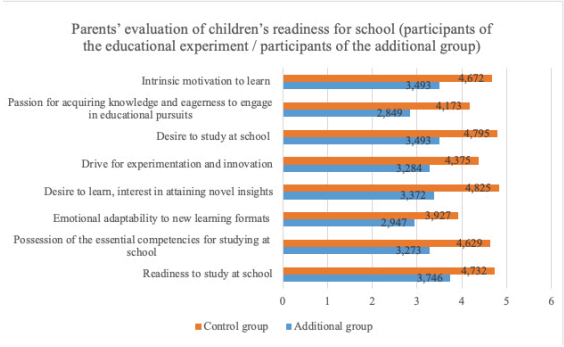
The results of surveying the parents at the end of the educational experiment showed an increase in their confidence that the use of cutting-edge digital technologies in education is safe for child's mental and physical health (+1.562 points). Moreover, the assumption was confirmed that modern interactive digital learning environment can benefit the improvement of the child's readiness for school (0.951 points). At the same time, significant differences were found while surveying the parents of an additional group in order to find out their opinion on their children's readiness for school, as compared to the opinion of parents whose children participated in the educational experiment (Figure 5). The results of the survey of preschool teachers are shown in Figure 6.

Figure 4.
Parents' evaluation of the level of children's readiness for school at the beginning and at the end of the educational experiment



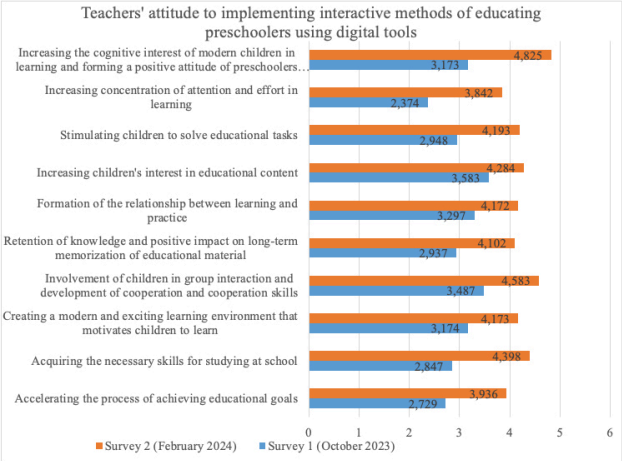
Source: elaborated by the author

Figure 5.
Parents' evaluation of their children's readiness for school (participants of the educational experiment/ additional group)



Source: elaborated by the author

Figure 6.
Teachers' attitude to implementing the interactive methodology into educating preschoolers using digital tools



Source: elaborated by the author

The implementation of an interactive approach to preparing children for school through state-of-the-art digital resources is an urgent necessity facing educators in preschool academic institutions. By employing interactive pedagogical techniques, youngsters are empowered with greater autonomy and self-reliance, they form and develop the skills of thinking, analysis, generating conclusions, expressing and defending their own opinions, constructive communication, discussion, and discussion (Kadirova & Umarova, 2020).

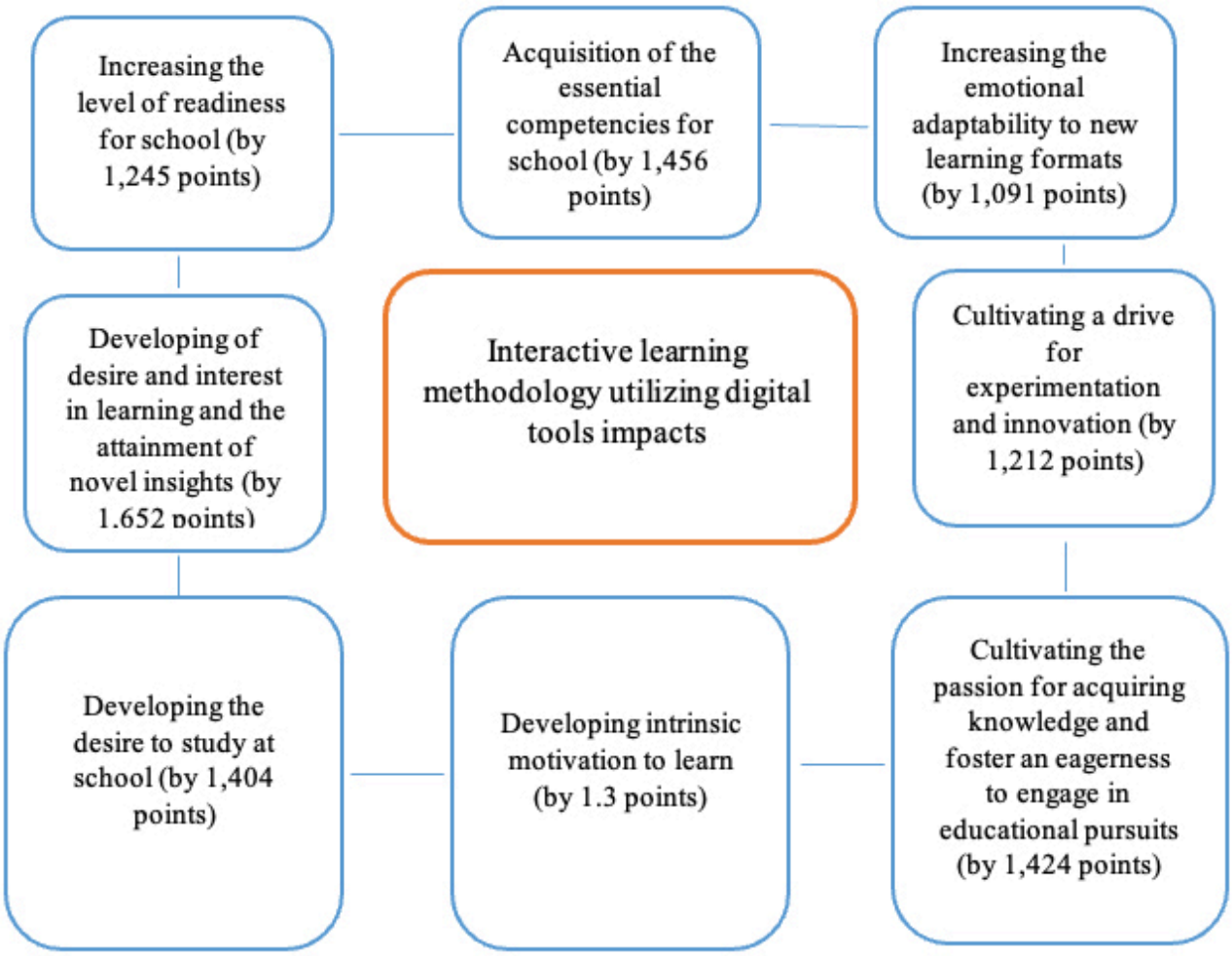
The outcomes of the research on the interactive system design for preschool education, carried out by Chinese scholars, led them to deduce that interactive learning is actualized through a reciprocal exchange of support and aid between pupils and instructors. The equitable and self-governing involvement of both educators and learners holds paramount importance, being focused around a specific problem or topic in a microlearning situation (Pan & Cheng, 2022). In our study, the authors proposed a conceptual scheme for elaborating an interactive methodology for preparing preschoolers for school, the main focus of which was on the development of modern interactive digital content and the practical implementation of an interactive teaching method in the environment of preschool education.

Australian scientists have confirmed the need to search for optimal solutions for the effective implementation and realization of such interactive educational approaches as inquiry-based learning, project-based learning, personalized learning, problem-based learning, and gamified learning (Larkin & Lowrie, 2023). In the process of implementing our educational experiment, approaches such as microlearning, situational problem-based learning, group project-based learning, gamification, and the integration of learning with practice have proven to be effective and have significantly contributed to better outcomes in children's readiness for school.

A research conducted in China revealed that the utilization of digital capabilities for interactive learning can enhance pedagogical approaches, improve students' comprehension and learning, and open up new opportunities to improve the quality of children's preparation for school. The educational environment should instil children's autonomy while directing their interest in achieving educational goals and increasing their motivation to learn (Zheng, 2023). The study conducted in England showed that children develop a wide range of skills through interacting with a digital play space, in particular subject knowledge and understanding, digital, social, emotional, cognitive, physical and creative skills (Scott, 2021). The findings of a study conducted in Australia posit that the use of VR, AR, and MR (virtual, augmented, and mixed reality) technologies in early childhood education can yield a positive impact on children's learning motivation and creativity, as well as increase children's learning outcomes virtually in all areas of the curriculum (Neumann et al., 2022). While delving into the possibilities of using virtual reality technologies to promote children's social and emotional learning, Chinese scientists have concluded that Educators ought to endeavor to combine a diverse range of pedagogical strategies with the virtual reality technology in order to enhance the education quality (Zhang et al., 2024). Indonesian scholars conclude that passion for learning should be fostered through the implementation of a contemporary and all-encompassing educational framework, proposing in their study an interactive digital system for teaching young children using the technology of 3D figures and virtual tutors. From their standpoint, in early childhood digitization of learning tools is an innovative educational solution that can enable children to learn and develop independence throughout process of knowledge acquisition (Purnamasari et al., 2023). In the course of conducting our research, we provided the children in the experimental group with access to cutting-edge digital technologies, including graphic drawing tablets, educational software programs, and virtual and augmented reality platforms. Our team of expert psychologists confirmed that these resources resulted in a greater level of engagement among students in the experimental group compared to those in the control group. This heightened involvement had a positive impact on their ability to perceive and retain educational content as well as develop more general skills (Figure 7).

According to Uzbek scientists (Mashrabjonovich & Abdurashid kizi, 2023), the main obstacles to the active implementation of interactive teaching methods

Figure 7.
Interactive learning methodology utilizing digital tools impacts



Source: elaborated by the author

in preschool educational institutions are the lack of experience in effectively using technologies in the educational process and fears associated with their use. A study involving preschool teachers from Greece and Turkey showed that for the effective implementation of modern pedagogical innovations, educators' competence in the field of digital technologies is crucial. Therefore, the development of digital literacy among preschool teachers and 21st-century skills should be a priority in the development of teacher education programs (Gözüm et al., 2022).

Conclusions

The educational experiment proved the feasibility of using a playful, interactive method of children's education to cultivate the essential competencies required for a child to excel academically. The evaluation of children's school readiness revealed that those who participated in the interactive training program showed superior preparation outcomes (readiness for school: experimental group - 96% of children, control group - 89%) than children who did not take part in the course (75%). This indicates the effectiveness of interactive teaching methods in preparing children for school and the feasibility of its implementation in preschool education. According to the parents, participation in the educational experiment influenced the increase in the level of readiness for school (by 1,245 points), the acquisition of the essential competencies for school (by 1,456 points), the increase in emotional adaptability to new learning formats (by 1,091 points), the development of desire and interest in learning and the attainment of novel insights (by 1,652 points); to cultivate a drive for experimentation and innovation (by 1,212 points), to develop the desire to study at school (by 1,404 points), to cultivate a passion for acquiring knowledge and foster an eagerness to engage in educational pursuits (by 1,424 points), to develop intrinsic motivation to learn (by 1.3 points). The educational experiment's observation resulted in a shift in teachers' attitudes towards the practical application of interactive learning methodology utilizing digital tools. In particular, they acknowledged that incorporating digital tools into pedagogical activities presents an opportunity to enhance modern children's cognitive interest in education and instil positive attitude among preschoolers regarding future education.

The prospects for further research lie in the development of a program for training educators to implement interactive teaching methods for preschool children using modern software and digital tools. Additionally, the authors plan to develop a universal assessment toolkit for evaluating school readiness, suitable for use in international assessment studies.

References

Aadland, E., Tjomsland, H. E., Johannessen, K., Nilsen, A. K. O., Resaland, G. K., Glosvik, Ø., ... Aadland, K. N. (2020). Active Learning Norwegian Preschool(er)s (ACTNOW) – Design of a Cluster Randomized Controlled Trial of Staff Professional Development to Promote Physical Activity, Motor Skills, and Cognition in Preschoolers. *Frontiers in Psychology, 11*, article 1382. https://doi.org/10.3389/fpsyg.2020.01382

Bondar, T., Pinzenik, O., Fentsyk, O. & Kobal, V. (2021). Pre-service Primary School Teacher Efficacy to Implement the New Ukrainian School Reform Objectives. *Revista Romaneasca pentru Educatie Multidimensionala, 13*(1Sup1), 458-474. https://doi.org/10.18662/rrem/13.1Sup1/406

Byhar, H., Pits, I., Prokop, I., Shevchuk, K., Shestobuz, O., & Makoviichuk, O. (2022). Interactive Learning in the Preparation of Students 1-4 Grades. *Journal of Curriculum and Teaching, 11*(1). https://doi.org/10.5430/jct.v11n1p87

Dias Coelho, R. M., Ellero Grisi, S. J. F., Brentani, A. V. M., & Scoleze Ferrer, A. P. (2024). Assessment of school readiness and the importance of executive functions for learning. *Revista Paulista de Pediatria, 42*, e2022196. https://doi.org/10.1590/1984-0462/2024/42/2022196

Filatova, L., Zhvava, O., Kharchuk, O., Kosarieva, H., Zyniakova, A., & Shestopalova, T. (2023). The main aspects of new ukrainian school: child-centeredness, competence approach, pedagogy of partnership. *Revista Românească pentru Educaţie Multidimensională, 15*(4), 383-399. https://doi.org/10.18662/rrem/15.4/800.

Gözüm, A.İ.C., Papadakis, S., & Kalogiannakis, M. (2022). Preschool teachers'STEM pedagogical content knowledge: A comparative study of teachers in Greece and Turkey. *Frontiers in Psychology, 13*, article 996338. https://doi.org/10.3389/fpsyg.2022.996338

Hamidova, G. (2020). The importance of using interactive techniques in preschool education system. *EPRA International Journal of Multidisciplinary Research, 6*(11). https://doi.org/10.36713/epra2013

Józsa, K., Zaw, T., Borbélyová, O. D., & Zentai, G. (2023). Exploring the Accuracy and Consistency of a School Readiness Assessment Tool for Preschoolers: Reliability, Validity and Measurement Invariance Analysis. *Journal of Intelligence, 11*(10), 189. https://doi.org/10.3390/jintelligence11100189

Kadirova, D. N., & Umarova, M. M. (2020). Improving the effectiveness of education through the use of interactive methods in preschool education. *International Journal of Academic Research in Business, Arts and Science, 2*(4), 35-41. https://doi.org/10.5281/zenodo.3758707

Kholova, D. F. (2022). Usage of Interactive Methods and Innovative Technology in Preparing Preschool Children for School Education. *Multidimensional Research Journal, 1*(7). https://doi.org/10.17605/OSF.IO/VEWBZ

Khyzhniak, I., & Viktorenko, I. (2021). Primary School Teachers' Attitude to the New Ukrainian School Reform. *Advances in Economics, Business and Management Research, 170*, 299-305. https://doi.org/10.2991/aebmr.k.210320.051

Kravchenko, O., Kochubei, T., & Shturba, A. (2022). New educational space in New Ukrainian School. *3rd International Conference on History, Theory and Methodology of Learning (ICHTML 2022), 142*, article 01005. https://doi.org/10.1051/shsconf/202214201005

Larkin, K.& Lowrie, T. (2023). Teaching Approaches for STEM Integration in Pre-and Primary School: A Systematic Qualitative Literature Review. *International Journal of Science and Mathematics Education, 21*, 11–39. https://doi.org/10.1007/s10763-023-10362-1

Lumaurridlo, Retnawati, H., Kistoro, H. C. A., & Putranta, H. (2021). School readiness assessment: Study of early childhood educator experience. *Elementary Education Online, 20*(1), 468-478. https://doi.org/10.17051/ilkonline.2021.01.041

Mashrabjonovich, O. J., & Abdurashid kizi, A. D. (2022). Use of Interactive Learning Methods in the Classes in Preschool Institutions. *International Journal of Culture and Modernity, 17*, 427–432. https://doi.org/10.51699/ijcm.v17i.357

Neumann, M. M., Keioskie, M. K., Patterson, D., & Neumann, D. L. (2022). Virtual, Augmented, and Mixed Reality: Benefits and Barriers for Early Childhood Education. *Childhood Education, 98*(4), 68-79. https://doi.org/10.1080/00094056.2022.2108298

Orshanskyi, L., Krasnopolskyi, V., Fednova, I., Vysochan, L., Novalska, T., & Ivantsiv, O. (2020). Interactive Teaching Methods as a Change in the Purpose of Modern Education. *Systematic Reviews in Pharmacy, 11*(10), 549-555. Retrieved from https://www.sysrevpharm.org/articles/interactive-teaching-methods-as-a-change-in-the-purpose-of-modern-education.pdf

Otajonov, J. M., & kizi Akhmadjonova, D. A. (2022). Use of Interactive Learning Methods in the Classes in Preschool Institutions. *International Journal of Culture and Modernity, 17*, 427–432. Retrieved from https://ijcm.academicjournal.io/index.php/ijcm/article/view/357

Pan, R., & Cheng, J. (2022). Design and Application of the Digital-Oriented Interactive System for Teaching Preschool Art Education. *Mathematical Problems in Engineering, 2022*. https://doi.org/10.1155/2022/1242038

Pirozhenko, T., Karabaieva, I., Soloviova, L., & Khartman, O. (2023). *Toolkit for assessing the readiness of an older child preschool age to study in the conditions of Ukrainian reform schools*. Kyiv: Institute of Psychology named after H.S. Kostyuk of the National Academy of Sciences of Ukraine. Retrieved from https://mon.gov.ua/ua/npa/pro-informuvannya-shodo-instrumentariyu-ocinyuvannya-gotovnosti-ditini-starshogo-doshkilnogo-viku-do-navchannya-v-umovah-reformuvannya-ukrayinskoyi-shkoli

Purnamasari, I., Wahyuni, Iriaji, S., Aruna, A., & Surya, E. P. (2023). Digitalization of Early Childhood Learning Media Based on 3D Virtual Teacher Figures. Proceedings of the 2nd International Conference on Educational Management and Technology (ICEMT 2023). *Advances in Social Science, Education and Humanities Research, 801*, 79-97. https://doi.org/10.2991/978-2-38476-156-2_10

Rakhimov, R. N. (2022). Methods of using interactive methods in preschool educational organizations, conducting music classes. *Eurasian Journal of Learning and Academic Teaching, 10*, 29-32. Retrieved from https://www.geniusjournals.org/index.php/ejlat

Sas, N., Didenko, N., Sira, L., Mokan, N., & Vakerych, M. (2023). Innovative systems of Ukrainian education in the context of globalization: philosophical content of categories. *Revista Eduweb, 17*(2), 285-295. https://doi.org/10.46502/issn.1856-7576/2023.17.02.24

Scott, F. L. (2021). *Digital Technology and Play in Early Childhood*. CEECD. Retrieved from https://www.child-encyclopedia.com/pdf/expert/technology-early-childhood-education/according-experts/digital-technology-and-play-early-childhood

Yuldasheva, S. T. (2021). Interactive Methods of Teaching Children and Its Theoretical Basis and Personal and Professional Development of a Teacher. *International Journal for Research in Applied Science & Engineering Technology, 9*(11). https://doi.org/10.22214/ijraset.2021

Zhang, F., Zhang, Y., Li, G., & Luo, H. (2024). Using Virtual Reality Interventions to Promote Social and Emotional Learning for Children and Adolescents. A Systematic Review and Meta-Analysis. *Children, 11*(1), 41. https://doi.org/10.3390/children11010041

Zheng, J. (2023). Development of Interactive Teaching System for Preschool Education Classroom. *Atlantis Highlights in Computer Sciences, 9*, 759-764. https://doi.org/10.2991/978-94-6463-040-4_115

Appendix A. Study Sample

Table 3.

Participants of the educational experiment – preschool children

No.	Preschool	Number of participants – children	Gender	Age
1	Private Preschool (Full Day) (Group 1)	17	7 – boys 10 – girls	13 people – 5 years 4 people– 6 years
2	Private Preschool (Full Day) (Group 2)	14	8 – boys 6 – girls	11 people – 5 years 3 people – 6 years
3	Private Preschool (Full Day) (Group 3)	15	6 – boys 9 – girls	10 people – 5 years 5 people – 6 years
4	Private Preschool (part-time) (Group 4)	17	7 – boys 10 – girls	12 people – 5 years 5 people – 6 years
5	Private Preschool (Part-time) (Group 5)	20	9 – boys 11 – girls	17 people – 5 years 3 people – 6 years
6	Private Preschool (Part-time) (Group 6)	18	5 – boys 13 – girls	15 people – 5 years 3 people – 6 years
7	Public Preschool (Full Day) (Group 7)	14	6 – boys 8 – girls	9 people – 5 years 5 people – 6 years
8	Public Preschool (Full Day) (Group 8)	18	9 – boys 9 – girls	14 people – 5 years 4 people – 6 years
9	Public Preschool (Full Day) (Group 9)	20	8 – boys 12 – girls	16 people – 5 years 4 people – 6 years
10	Public Preschool (Full Day) (Group 10)	17	7 – boys 10 – girls	15 people – 5 years 2 people – 6 years
	Total	170	72 – boys 98 – girls	132 people – 5 years 38 people – 6 years

Table 4.

Structure of the educational experiment groups

No.	Preschool	Number of participants in the experimental group	Number of participants in the control group
1	Group 1	9 people	8 people
2	Group 2	7 people	7 people
3	Group 3	8 people	7 people
4	Group 4	9 people	8 people
5	Group 5	10 people	10 people
6	Group 6	9 people	9 people
7	Group.7	7 people	7 people
8	Group 8	9 people	9 people
9	Group 9	10 people	10 people
10	Group 10	8 people	9 people
	Total	86 people	84 people

Table 5.

Respondents – preschool teachers

Number (people)	Gender	Age	Teaching experience
21	3 – M 18 - F	27 – 49 years	4 – 20 years

Table 6.

Respondents – parents of children who participated in the educational experiment

Number (people)	Gender	Age	Education
170	40 – M 130 - F	24 – 43 years	Medium – 19 people Secondary professional – 48 people Higher – 103 people

Table 7.

Participants of the additional group, as well as their parents

Additional group participants	Number (people)	Gender	Age
Children	46	21 – boys 25 – girls	5 – 6 years
Parents	46	18 - M 28 - F	23 – 41 years
Total	92		

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Opinions and Suggestions about Teaching Mathematics from Teachers Who Support Pupils With Special Learning Difficulties in Primary Schools*

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Abstract

This study explores the experiences of primary school teachers providing remedial mathematics education to students with special learning difficulties (SLD). Through qualitative research and interviews with 22 teachers, findings highlight challenges such as insufficient knowledge of SLD, reliance on individual education plans, and students' difficulties in counting, operations, problem-solving, and memorization. Teachers use diverse methods like concrete materials, repetition, and games, along with tools such as worksheets and smart boards. Challenges include inadequate physical conditions, limited class time, and low student and parent engagement. Suggestions for improvement focus on better resources, teaching methods, professional development, and enhanced communication with parents and classroom teachers.

Keywords:

Inclusive Education, Special Learning Difficulties, Mathematics Learning Difficulties, Resource Room, Remedial Education

Introduction

Despite the existence of individuals with normal or even supernormal intelligence, a considerable number of them experience persistent and significant difficulties with fundamental academic skills, including reading, writing, reading comprehension, arithmetic operations, and problem solving. These skills are essential for independent living in modern society. The term 'learning disability' has gained increasing acceptance as a distinct disability group, particularly since the 1960s. This was a period during which many students were unable to benefit from the education provided in schools, leading to a shift in focus towards education based on student characteristics (Özyürek, 2003). While there are numerous definitions of specific learning disabilities (SLD), the most widely used and accepted definition is that provided in the Diagnostic and Statistical Manual of Mental Disorders (DSM-5). In accordance with this definition, a specific learning disability (SLD) is a neurodevelopmental disorder of biological origin that impedes the acquisition and utilisation of reading, writing and mathematics skills for a minimum of six months.

The prevalence of specific learning disabilities in school-age children from diverse linguistic and cultural backgrounds is estimated to be between 5% and 15% (American Psychological Association [APA], 2013). A variety of classifications of learning disabilities can be found in the literature. The widely used and accepted classification identifies three types of SLD. In accordance with this definition, SLD is classified as dyslexia (reading difficulty), dyscalculia (mathematics learning difficulty) and dysgraphia (writing difficulty) (Hopcan, 2017). The subject of this research is mathematics learning disability, which is defined as a learning disorder characterised by deficiencies in number sense, the ability to memorise arithmetic facts, the capacity to perform calculations accurately and fluently, and reasoning (APA, 2013). It is erroneous to suggest that students diagnosed with a mathematics learning disability (MLD) are incapable of learning (Kroesbergen, Huijmans, & Kleemans, 2022). Such students may be defined as those who learn in different ways and at a slower pace than their peers (Filiz, 2021; Lewis, Thompson, & Tov, 2022; Mononen, Niemivirta, & Korhonen, 2022). The prevalence rate of mathematics learning disability among school-age children has been estimated at 5-7% based on studies conducted in multiple countries (Mutlu, 2020). While there are various forms of SLD, including reading difficulties, mathematical difficulties and writing difficulties, in Turkey, all students with these difficulties are typically diagnosed with SLD. Mathematics learning disability, which is one of the types of SLD, is not diagnosed as a standalone condition. Students who have been diagnosed with SLD as a result of assessments conducted by guidance and research centres continue their education in general education classes with their peers through the provision of inclusive education.

The term "mainstreaming" is used to describe the process of providing special education services to students with special needs and their teachers, with the goal of integrating them into general education classes alongside their peers (Kargın & Sucuoğlu, 2006). In Turkey, support services for students with special needs and their teachers are provided through the DEO (support education room) practice. Furthermore, despite the absence of a formal diagnosis, one in four students identified with SLD receives special education services due to mathematical difficulties (Melekoğlu, 2022). These difficulties are frequently observed in individuals diagnosed with dyslexia (Dowker, 2004). A review of the literature revealed the existence of several studies that have been conducted in Turkey with the aim of systematically compiling and analysing research on the practices of classroom teachers in relation to RPA. These studies include those conducted by Yılmaz et al. (2021), Talas et al. (2022), Bozak & Çay (2023), Kaptan (2019), Filik (2019) and Demirhan (2023). The studies on the opinions and experiences of teachers in 2019 and subsequent years concerning PLC concentrate on the observations and experiences of classroom teachers, mathematics teachers, and pre-service teachers (Kaçar, 2018; Büyükkarcı & Akgün). The studies also encompass the experiences of parents (Doğan & Korkmaz, 2021), the identification processes of students with PLC and the development of diagnostic models (Mutlu & Akgün, 2017).

The effects of instructional interventions with students diagnosed with PLC on different learning areas of mathematics, including numbers, operations, and the number line, have been studied (Filiz, 2021; Uygun, 2019; Koç & Korkmaz, 2019; Özkubat et al., 2022; Kılınç (2023); Kumaş & Ergül (2017); Deniz (2019); Sertdemir (2023); Mutlu (2016) and Özkubat & Özmen (2018); Gencan (2020) have also contributed to this field. In DEO, studies on the mathematics teaching of teachers in support education with students diagnosed with Specific Learning Disabilities (SLD) and the impact of support education on their mathematics achievement were examined (Brownstein, 2016; Carpenter, 1985; Ünay, 2015). Moreover, the majority of the existing studies are primarily concerned with the implementation of support education practices with students diagnosed with SLD and the experiences of classroom teachers. PLC is one of the types of SLD and is a heterogeneous group. The research will be conducted with teachers who work one-to-one with these students in the support education room. This will provide detailed information about these students, who exhibit different characteristics.

The objective of this study is to ascertain the experiences of teachers who provide support education to students with special learning difficulties in primary schools with regard to mathematics teaching, and to examine in detail the positive and negative situations encountered during the teaching process.

In alignment with the aforementioned objectives, the following research questions were posed:

The opinions of support education teachers regarding the support education activities they have carried out with students with special learning difficulties are examined.

1. What are the opinions of students with special learning difficulties regarding their mathematical knowledge and skills, the difficulties they experience, the reasons for these difficulties, and the methods used to assess them?

2. What are their views on the planning, teaching strategies, methods and techniques, and evaluation of mathematics teaching with students with special learning difficulties?

3. What are the opinions of students with special learning difficulties regarding communication and collaboration with classroom teachers and parents?

4. What are their opinions regarding the challenges they face in their mathematics teaching practices with students with special learning difficulties, and what are the underlying causes of these challenges?

5. What recommendations can be made to enhance the efficacy of mathematics instruction for students with special learning needs?

The importance of research in this field cannot be overstated, as mathematics skills are one of the fundamental academic abilities that shape both academic and everyday life. For individuals with difficulties in mathematics, proficiency in this subject is not only crucial for success in academic settings but also essential for the maintenance of daily life skills. In Turkey, educational support services are provided through the use of support education rooms (SERs). In support education rooms, teachers provide supplementary educational support to students with SLD in the areas of reading, writing and mathematics, in accordance with their individual educational requirements. Given the absence of a discrete diagnosis for mathematical difficulties, it is crucial to ascertain the prevalence of such difficulties among students with SLD and to elucidate the experiences and perspectives of the support education teachers who interact directly with these students. It was postulated that one-to-one training of support education room teachers with these students would enable them to observe them more effectively and in greater detail, thus facilitating the collection of more data about students with mathematics difficulties. It is hypothesised that determining the level of mathematical difficulties experienced by students with SLD and the knowledge, experience and awareness of teachers working with them in the support education room about mathematical difficulties will prove useful for future studies. Furthermore, the findings of this study, which sought to ascertain the challenges encountered by educators in the SEA, will inform future research aimed at enhancing the quality of support education and facilitating the professional development of educators providing mathematics learning disabilities support.

The present study is limited in the following ways: The research is confined to the academic year 2022-2023.

1. The research is limited to 22 teachers who provide support education in nine primary schools with DEO in the Altınordu central district of the Ordu province.

2. The research is limited to the findings obtained from the interview form on mathematics teaching with students with special learning difficulties by the teachers working in the support education room.

3. The research is limited to the qualitative methods employed in the analysis of the data.

Methodology

Research Model

This study employs a holistic multiple case study approach, utilising qualitative research models. As posited by Stewart and Cash (1985), the interview, which constitutes one of the qualitative data collection methods employed in the study, represents a communication process based on a question-answer format, with a serious predetermined purpose and mutual interaction (Yıldırım & Şimşek, 2013, p.147). A semi-structured interview method, which is one of the qualitative data collection methods including open-ended questions, was employed in order to ascertain the experiences and opinions of teachers who provide support education with students with SLD about mathematics teaching in depth.

The research study group is comprised of teachers who provide special education services to students diagnosed with Specific Learning Disabilities (SLD) in the support education rooms of nine primary schools affiliated with the Ministry of National Education in Altınordu, the central district of Ordu province, during the 2022-2023 academic year. A total of 22 teachers were interviewed as part of the research process. In determining the study group, the criterion sampling method, one of the purposeful sampling methods, was employed, and the following criteria were established:

1. The study group was formed from teachers assigned to support education rooms within primary schools.

2. The participants in the study group continued to provide support education to at least one student with SLD in the DEO.

Data Collection Tool

In this study, a semi-structured interview form, developed by the researcher, was employed as the primary data collection instrument. The questions were presented to three experts for their input. In light of the expert feedback, amendments were made to the questions. Prior to commencing the interviews, two pilot interviews were conducted. At the conclusion of the interviews, participants were queried as to whether the interview was comprehensible. Based on the feedback obtained, no modifications were deemed necessary.

The data for this study were obtained from primary schools in the central district of Altınordu in Ordu, Türkiye. The participants were informed about the interview process and the ethical requirements that would be observed throughout. The audio recordings of the interviews conducted as part of this

research project were made with the consent of the participants. The audio recordings were subsequently transferred to a computer and converted into text. Three randomly selected audio recordings were presented to the thesis supervisor and a graduate student with expertise in qualitative research for verification and comparison with the corresponding transcripts. The content analysis method, one of the qualitative data analysis methods, was employed to analyse the data. In the existing literature, a variety of approaches to qualitative data analysis have been proposed. It can be argued that data analysis can be divided into two categories: descriptive analysis and content analysis. The distinction between these two categories is based on the depth of the analysis. The objective of content analysis is to identify concepts and relationships that can elucidate the collected data (Yıldırım & Şimşek, 2013, p. 259). The MaxQDA software was employed for the purposes of data analysis. The findings were represented visually using mind maps and graphics. The findings are supported by direct quotations, which are provided in conjunction with the relevant visuals.

Validity and Reliability

To enhance the credibility of this research, interviews were conducted in person and to the greatest extent feasible. Furthermore, to guarantee the veracity of the findings, the teachers were informed that they could review the written transcripts of the interviews at the conclusion of the session. In the Method section of the study, the characteristics of the participants, the criteria determined during the selection process, the process of developing the data collection tool, and the steps of data analysis were discussed in detail. Additionally, the studies conducted to realise the other dimension of credibility were explained in detail. In the sections pertaining to the determination and development of the data collection instrument, the conduction of interviews, and the analysis of data, the opinions of experts in qualitative research were sought and appropriate modifications were made in accordance with their recommendations. In order to ensure the study's transferability, direct quotations belonging to the sub-categories were included in the findings section. In order to ensure transferability, the sample was selected with great care and attention to detail. The criteria for selecting the study group were clearly defined, and the participants were chosen using the purposeful sampling method. In order to guarantee the confirmability of the research, all elements pertaining to the methodology and findings were presented in comprehensive detail. Once the analyses had been completed in accordance with the coder reliability study, two experts were invited to examine the compatibility of the findings and the content of the analysis. The evaluations indicated a consistency between the research data and findings.

Findings

The research findings indicate that the majority of teachers providing support education services for students with special learning difficulties do so because they are surplus to norms (*f* = 13). Other findings related to the reasons for providing support education include the desire to be useful to the student (*f* = 3), the presence of their own students (*f* = 4), and a genuine interest in doing so (*f* = 2).

The findings regarding the characteristics of students with SLD, as reported by teachers working in the support education room, are presented in Table 1. In consequence, the majority of teachers cited the difficulties encountered by their students in the cognitive domain.

Table 1.
Characteristics of Students with Special Learning Difficulties (SLD)

Category	Details
Cognitive Characteristics	Forgetfulness Difficulty learning to read and write Distractibility Difficulty understanding what is being read Learning late and with difficulty Being behind grade level Confusing similar letters Difficulty learning abstract concepts Difficulty with orientation skills
Social, Emotional, Behavioral Characteristics	Not wanting to study Lack of confidence Emotional problems Behavioural problems
Motor Skills	Weak fingers

With regard to the difficulty of forgetting what has been learned (*f* = 15), which is the most frequently mentioned issue in this area, P4 offered the following perspective: "Every activity we undertook, even after a relatively short period of time, typically around ten minutes, but sometimes even after a day, there was a significant issue with forgetting. This suggests that forgetfulness is a particularly pronounced challenge for these students." The most frequently cited attribute of students with SLD by support education teachers is their difficulty in learning to read and write (f=10). P18 stated that the subject in question was unable to read or write. "I focused my attention on developing his reading and writing abilities." She elucidated the challenges her students encountered in the domains of reading and writing. Teachers who provide support education to students with SLD indicate that their students typically demonstrate delayed and more challenging learning than their peers (*f* = 8).

Some participants (*f* = 6) also report that their students have limited attention spans, noting that children often have difficulty sustaining focus for

extended periods. P7 noted that the monotony of a lesson conducted solely with them at the table could become tedious. The participants indicated that they were reluctant to conduct lessons on the social, emotional, and behavioural characteristics of their students diagnosed with SLD (*f* = 6), that these students exhibited emotional and behavioural problems (*f* = 4), and that their self-confidence was insufficient (*f* = 4). While P13 articulated their students' reluctance to engage in learning activities, some participants also highlighted the lack of self-confidence among their students. P6 stated with regard to her students: "Both students exhibit a sense of disenchantment with the educational process, which manifests as a lack of engagement with the lesson at hand. In such instances, the child may lose significant ground in both academic and self-confidence terms. P4 observed that in the classroom, for instance, the child's peers are able to complete the task, yet the child's inability to do so leads to a withdrawal from the activity. The teacher also identified that the child's academic lag behind his peers was a source of concern. A teacher who provides supplementary educational support for a student with Specific Learning Disabilities (SLD) offered her perspective on the student's motor skills. P9: "In the classroom setting, he commenced at the earliest stage of the learning process. He becomes irritable when I request that he write the letters, and this is also the case in the classroom. Presently, he derives pleasure from the act of writing. Additionally, his finger development was also weak, as he was unable to write.

The second sub-problem of the study, which is the second sub-problem of the research, is to identify the mathematics learning areas in which students experience difficulties, to ascertain the reasons for these difficulties and to determine the methods for assessing these difficulties. The findings pertaining to the difficulties encountered by students with SLD in mathematics are illustrated in Table 2.

Teachers of mathematics in supportive education with students with SLD have indicated that rhythmic counting represents a significant challenge for their students within the domain of numbers (*f* = 16). P22: "Rhythmic counting represents a persistent challenge. Our students have not yet achieved proficiency in this area. If only we could stabilize the numbers, we would be in a position to advance. We maintain close communication with the class teacher on this matter. "We are attempting to resolve the issue with the numbers, but since the students have not made progress, we have not yet proceeded with rhythmic counting" (P6).

Furthermore, P6 highlighted the difficulties her student faced, particularly when counting backwards. "For instance, when counting backwards, he mentally processes the numbers as 1, 2, 3, 4, 5, 6, etc." He enumerates up to 20, then states 19. "Subsequently, he states 20, 19, and repeats this sequence each time, exhibiting a consistent forward and backward counting pattern." Furthermore, difficulties related to number perception (*f* = 8), writing numbers in reverse order (4), and forming patterns (*f* = 1) were identified as additional challenges encountered by the support teachers in their mathematics instruction with students diagnosed with Specific Learning Disabilities (SLD). In regard to the challenges encountered by the P10 student in number perception, the teacher noted that while the student is unable to demonstrate the requisite skills, he is nevertheless able to perform the associated counting task. "He is unable to select the appropriate numbers from the mixed numbers," while P9 highlighted his student's tendency to write numbers in an inverted orientation. "Furthermore, he is dyslexic and therefore displays a tendency to write letters in the incorrect orientation." To illustrate, the student in question wrote the numbers three and some other items in the incorrect orientation. After issuing a warning and providing corrective feedback, the student was able to demonstrate the correct writing of the numbers in question. A substantial proportion of the teaching staff (*f* = 13) indicated that their pupils encountered challenges in problem-solving. P7 indicated that only one of her five students with SLD was capable of solving problems involving a single operation. "Moreover, I am unable to facilitate problem-solving activities. Problem solving cannot be taught through problem solving; indeed, there are only a small number of students who are able to grasp the problem and then select the appropriate operation. The findings revealed that students with SLD encounter significant challenges in basic mathematical operations, particularly in subtraction and addition. P15 indicated that his student's challenges in backward rhythmic counting hindered his progress in learning subtraction. He observed that while his student demonstrated proficiency in addition and counting backwards, he encountered difficulties in subtraction. P12, conversely, indicated the challenge presented by his student's performance in addition with hands as follows: "He typically performs addition and subtraction without the use of hands, and when I transition to a hands-on approach for addition, he neglects to incorporate the additional hands into his calculations."

Furthermore, students with SLD also encounter difficulties in division operations. Some of the teachers who provided supplementary education (*f* = 6) indicated that their students encountered significant challenges in division operations. For instance, they encounter significant challenges when performing division operations (P1). P7 highlighted the challenges his student was facing in multiplication and division operations, noting that the student was unable to

progress to division due to difficulties in multiplication. The research findings indicate that another challenge faced by students with SLD in mathematics is the memorization of the multiplication table. P13 stated that the use of fingers to count, which is commonly observed in students with mathematics difficulties, was also evident in his student. He noted that while the student should be at a more advanced level, such as using the multiplication table when multiplying, they were still at the level of counting with their fingers or counting silently with their fingers. This indicates that they are unable to perform the operation in a more formal manner.

Table 3 shows the findings pertaining to the cognitive, affective, environmental, and genetic factors that contribute to these difficulties, as elucidated through the analysis of the opinions of teachers who provide supplementary education to students with SLD regarding the challenges their students encounter in mathematics.

The findings revealed that while some teachers (f = 4) attributed their students' difficulties in mathematics to a diagnosis of SLD, P14 stated, "The underlying cause remains unclear." "From my observation, it would appear that the family is already doing everything they can. It is possible that this is a characteristic of the family in question." Some of the participants indicated that their distracted attention was the underlying cause. P13 posited that their students' difficulties in mathematics were attributable to an inability to grasp abstract concepts. They observed that their students encountered greater challenges in grasping the abstract concepts inherent to the mathematics curriculum than they did with the more concrete concepts. Three teachers who provided supplementary education indicated that they observed their students' inability to recall previously learned material as a contributing factor to their difficulties in mathematics. P5 stated that, since the beginning of the academic year, there had been a persistent tendency for students to experience difficulties in retaining and recalling previously learned material. "A considerable amount of repetition is required."

Some participants postulated that the difficulties experienced by students with SLD in mathematics may be attributable to affective factors, such as anxiety and trauma, as well as an awareness of their own difficulties. P12 posited that traumatic experiences may be a contributing factor. While P4 asserted that anxiety is a significant contributing factor, P1 posited that another crucial element is the discrepancy between what their peers are able to accomplish and their own perceived limitations. Upon analysis of the opinions of support education teachers regarding the underlying causes of mathematics difficulties experienced by their students with SLD, it was observed that the majority of respondents cited the indifference of the families as a significant contributing factor (f = 8). P7 posited that the lack of interest on the part of the family may also be a contributing factor, given that the child was unable to learn in either the first or second grade, yet did not

Table 2.

Mathematics learning areas of difficulty

Findings Related to the Areas of Mathematics Learning in Which Students with SLD Experience Difficulty			
Natural Numbers	Basic Arithmetic Operations	Geometry	Measurement
Rhythmic counting Problem solving Number concept Writing numbers backwards Patterns	Addition Addition with carry Subtraction Division Memorizing the multiplication table Multiplication Difficulty with all four operations	Spatial relations Geometric shapes	Time

Table 3.

Causes of maths difficulties

Findings Related to the Causes of Mathematics Difficulties Experienced by Students with SLD			
Cognitive Causes	Emotional Causes	Environmental Causes	Genetic Causes
Because of the diagnosis of SLD Because of distraction Because of not being able to think abstractly Because of forgetting Because of different disabilities Because of not understanding what he/she reads	Trauma Anxiety Awareness of the difficulty experienced	Family indifference Distance education process Priority given to teaching reading and writing Not receiving preschool education	

receive any reinforcement. "He is currently in the third grade, but is receiving supplementary education from our institution at the fundamental level."

Some participants indicated that their students' inability to participate in distance education resulted in them falling behind the class level. P7 stated that in the fourth grade, two of their students were one level behind their classmates in mathematics. The reason for this lag in progress is distance education. As a consequence of their inability to participate in distance education, which is also a view expressed by their teachers, the children are falling behind, and this deficit is perpetuated. Two teachers indicated that prioritising the teaching of reading and writing was a contributing factor to their students' difficulties in mathematics. P7 posited that one of the reasons for the students' difficulties in mathematics was the lack of pre-school education. They observed that students who had started at kindergarten level one or two were receiving additional support, yet demonstrated less progress than their counterparts who had commenced their education at kindergarten. Three participants posited that the difficulties experienced by their students with SLD in mathematics were attributable to genetic factors. P5 posited that a health issue may be the underlying cause. "I postulate that there are some genetic congenital conditions related to health, but in general, I hypothesize that this is a health problem." The results obtained from the support education teachers regarding the methods of identifying the difficulties experienced by their students with SLD in mathematics are presented in Table 4.

Table 4.

Methods for identifying maths difficulties

Findings Related to the Methods of Teachers Providing Support Education to Determine the Mathematics Difficulties Experienced by Students with SLD	Determining the level of readiness
	According to in-class performance
	Getting information from class teachers
	By observation
	With question-and-answer method
	Using supplementary books
	According to the curriculum
	According to available documents
	By meeting with their families

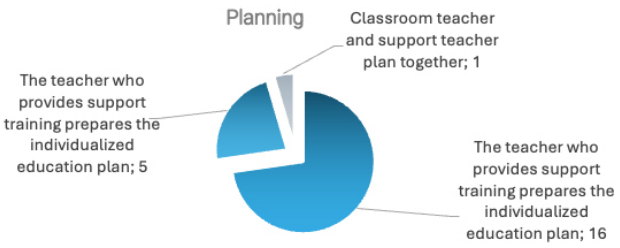
In order to ascertain the difficulties their students are experiencing in mathematics, teachers providing supplementary education undertake studies to determine their students' preparedness prior to instruction. In the course of the interviews, a number of teachers (*f* = 10) described the activities they undertake prior to the commencement of their teaching. P16 elucidated her students' preparedness for mathematical studies as follows: "Initially, the student is invited to attend the lesson, and no immediate preparation is undertaken. Instead, an initial period of approximately one to two weeks is allocated to familiarising oneself with the student. "I then take notes on the specific areas in which the student is deficient and subsequently create plans that address these gaps."

Some of the teachers (*f* = 8) indicated that they identified their students' difficulties in mathematics based on their in-class performance during the support education process. P16 indicated that she was able to identify her students' difficulties in mathematics during the lesson itself, stating, "As I spent time with the children, I was able to discern their deficiencies and adapt my approach accordingly." The finding (f=5) that the support education teachers received information from their students' class teachers while determining the difficulties of their students with SLD in mathematics is corroborated by K5's statement, "I am not the one who determines it, actually."

In more precise terms, the relevant information is sent to the CRC by the class teachers, who then proceed to make their plans. K1 states, "First and foremost, when the students first come to us, we discuss their situation with their teachers." Three of the interviewed teachers indicated that they identified their students' mathematical difficulties through observation. From the opinions of P11, who stated, "I mean, based on observation, based on what they do in the lesson," and P17, who asserted, "I determined it through observation," it was determined that they employed the observation method in their lessons. In addition, support education teachers employ a question-and-answer method (*f* = 2) to ascertain their students' mathematical difficulties. P13 expressed his opinion as follows: "While undertaking exercises, in a mutual question-and-answer relationship." Two teachers indicated that they identified their students' difficulties in mathematics by utilizing adapted activity books (UYET) developed by the General Directorate of Special Education for mainstreaming students and distributed to mainstreaming schools. P2 stated that the school also provides books for this purpose. The children's levels were determined by the researchers themselves, and the subsequent programme was initiated. P2 indicated that they had derived benefit from the UYET books.

The findings pertaining to the third sub-problem of the study, "Supporting the educational experiences of teachers in relation to mathematics teaching and adaptations for students with Specific Learning Disabilities (SLD)", were analysed according to the following sub-categories: planning, teaching methods and techniques, teaching materials, tools and equipment, and measurement and evaluation. The findings of the studies conducted by the support teachers at the planning stage of mathematics teaching are presented in Figure 1.

Figure 1.
Planning mathematics teaching in support education



A notable proportion of support education teachers (*f* = 15) indicated that they utilised the individualised education plans devised by the classroom teachers prior to commencing support education and mathematics instruction with their students with SLD. P1 stated that, at the planning stage, it is the responsibility of the classroom teachers to provide a plan, rather than that of the support education teachers. "We proceed in accordance with the aforementioned plan." Some of the support education teachers (*f* = 5) indicated that they conducted the planning independently. P22 expressed the following opinion on the matter: "Affirmative, I did so." The support plan was created following an in-depth understanding of the child's needs. It was developed independently and subsequently presented. "However, we must return to the initial point." One teacher indicated that the planning process was conducted in collaboration with the class teacher. P9 provided the following clarification: "Our objectives can be defined as follows: let us undertake these tasks, let us proceed in this manner, let us divide the work amongst ourselves."

The findings regarding the methods and techniques employed by the support teachers in teaching mathematics to their students with Specific Learning Disabilities (SLD) are illustrated in Table 5.

Table 5.
Teaching methods and techniques used in mathematics

Methods and Techniques Used by Support Education Teachers in Teaching Mathematics	By concretizing
	Continuous repetition
	By doing and living
	Question and answer method
	By way of presentation
	With daily life examples
	Teaching through games
	Drama
	Teaching through songs
	Induction
	Direct instruction
	Analogy
	one-on-one study
	Discussion
	Research-project method

The most common method employed by teachers of mathematics in support education rooms for students with SLD was found to be teaching by concretising (*f* = 13). P21: "In the context of mathematics lessons, we adopt a pedagogical approach that involves concretising the subject matter for the benefit of the child. In the event that additional resources, such as writing implements, art supplies, or a writing surface, are required, there is a greater range of options available due to the one-to-one ratio. P21 indicated that concrete materials, tools, and equipment are employed in mathematics lessons. The other method employed by teachers of mathematics in the support education room with students with SLD is learning through practical action and experience (*f* = 7). P8 articulated his perspective on the subject, stating, "Learning by doing and experiencing enables students to draw their own inferences."

Another method employed by support education teachers in mathematics lessons with their students with SLD is the question-and-answer approach (*f* = 6). P5 stated that the method of question and answer is employed on a repeated basis. P13 indicated that they employed a question-and-answer approach, stating, "I typically provide an explanation, then pose questions and assign exercises." In the course of the interviews, five of the teachers indicated that they employed presentational teaching in the context of mathematics instruction. P16 articulated his perspective as follows: "In the teaching of mathematics, which is predominantly conducted through the medium of presentation, I convey the requisite information and then prompt the student to apply it."

One pedagogical approach employed by mathematics educators is the use of real-world examples to illustrate mathematical concepts (*f* = 5). "The objective is to facilitate the children's mathematical operations in a way that is accessible to them in their daily lives. Therefore, academic success should be a secondary consideration, with the focus being on fostering familiarity with the practical aspects of life." P1 highlighted the value of incorporating real-world examples into his teaching. The research findings indicate that four teachers employ the game teaching method in mathematics lessons to support education. P5 expressed the following opinion: "Given the limited attention span of children, I attempt to incorporate games and play into my lessons." Other methods employed by teachers in mathematics lessons in support education include drama (*f* = 2), teaching with song (*f* = 2), and induction (*f* = 2). One participant identified the use of analogy, one-to-one work, direct instruction, discussion, and the research project method as methods employed in mathematics lessons in support education during the course of the interviews.

The findings regarding the teaching materials, tools and equipment employed by support education teachers in mathematics teaching are presented in Table 6.

Table 6.

Tools, equipment and materials used in mathematics

Teaching Materials, Tools and Equipment Used by Teachers Providing Support Education in Teaching Mathematics	Printed materials
	Standard mathematics materials
	Computer/internet resources
	Things/objects in the environment
	Teacher-made materials

In the context of mathematics lessons in support education, the analysis revealed that printed materials were the most frequently utilised tools, equipment and materials (*f* = 19). These materials include course books, adapted activity books prepared by the Ministry of National Education (MoNE) for mainstreaming students and sent to schools where mainstreaming is applied, as well as worksheets and other similar resources. P7 indicated that workbooks are a frequently utilized resource. P7 stated that they predominantly utilised printed materials in mathematics, citing workbooks as a particularly prevalent resource. In the case of some children, for instance, if they are in the third grade, there are two books from the MoNE books of the second grade, and one additional book for a lower grade. Following the observation of printed materials, it was also noted that teachers frequently utilised standard mathematical resources (*f* = 18). P8: "I prepared a variety of materials for use in rhythmic counting exercises, including puzzles, cardboard paints, dry paints, geometric shapes, and other objects." Subsequently, the range of available materials includes number blocks, base ten blocks, a geometry board and related geometric shapes. In addition, teachers employ computer and internet resources to support mathematics education (*f* = 12). P8 stated that the smart board was utilised extensively, with educational websites and videos displayed on it to capture the students' attention.

The findings regarding the measurement and evaluation methods employed by mathematics support teachers are shown in Table 7.

Table 7.

Measurement and evaluation methods in mathematics

Measurement and Evaluation Methods Used by Support Education Teachers in Teaching Mathematics	Observation
	According to individualized curriculum
	By doing the activities in the books
	Portfolio
	Verbal teaching/making the student explain
	Question-answer

One of the measurement and evaluation methods employed by support teachers in mathematics instruction was observation (*f* = 4). P12 stated, "As a consequence of observation, "Typically, this is conducted as part of our observation process." P19 indicated that he evaluated his students in accordance with their individualised education plans, which were related to measurement and evaluation in mathematics teaching. He stated, "I had already determined certain behaviours in the plans, as well as achievements." Three teachers indicated that they employed the activities outlined in the textbooks when conducting measurement and evaluation activities. P2 articulated his perspective on the subject as follows: "The textbooks already include questions directed at the students. I observe them. I ascertain their capabilities and limitations by posing a series of questions. "I am able to discern whether they have acquired the requisite knowledge or not." Two teachers indicated that they utilize homework and product files as a means of evaluating the work they have conducted in support of mathematics teaching. P19 indicates that homework and product files are utilized in measurement and evaluation, as evidenced by the statement, "These activities are compiled into a file." Other methods employed in the assessment of student performance include verbal evaluation and questioning (*f* = 2), as well as the use of question-and-answer sessions (*f* = 2). P13 outlined the assessment techniques utilized in mathematics lessons, noting that they employ a combination of questioning and observation to gauge student understanding.

The results pertaining to the fourth sub-issue of the study, namely the perceptions of DEO instructors regarding communication and collaboration with classroom instructors and the parents of students with special learning disabilities, are shown in Table 8.

Table 8.

Communication and co-operation

Findings Regarding the Communication and Collaboration of Teachers Providing Support Education with Classroom Teachers and Families of Students with SLD	
Sharing with class teachers	Sharing with families
Academic studies in support education and in the classroom	Repetition of work done at school
Behavioral problems	Other (health problems, family problems, etc.)

Teachers who provide mathematics support to students with SLD in the support education room share their academic work with the students' class teachers (*f* = 15). P8 states that they receive information from the classroom teachers about the students they provide support education for as follows: "Contact with the class teacher is established from the outset. "What is the situation of this child? What can we do to assist them? What can they do in class? What cannot

they do?" P9 stated that they shared homework with the class teacher, noting that this included both the homework they assigned and the homework assigned by the class teacher. On occasion, they will request assistance with a specific task, such as providing help with a particular assignment. On occasion, I will inform the teacher that I have provided the student with a specific task and request their input. P19 stated that she disseminated the educational materials she had created for the student to the student's class teacher. She gave the following example: "For example, with the class teacher, the student learned this today, or the student could not perceive this, or the student could not understand this. We learned about this subject." The findings of the research indicated that three teachers reported sharing behavioural issues with the classroom teacher. Teachers who taught mathematics to students with special educational needs (SEN) in the support education room indicated that they primarily discussed the repetition of schoolwork with their students' families. P1 articulated her perspective as follows: "We have made significant progress in the lessons with them. They are able to complete the same tasks at home. If the children are attending another educational facility, we provide guidance on how to proceed." The research findings indicate that some teachers (n=7) also reported sharing various issues with families. P12 indicated that some families discussed their specific challenges. "Undoubtedly, some individuals proffer their concerns, while others voice grievances about their spouses. They disseminate their problems in a multitude of ways. I endeavour to refrain from delving into these matters, yet I am compelled to address them nonetheless. The educators also highlighted the beneficial impact of their communication with the students' class teachers and families on the students and their families. P3: "When I present my student to his teachers, he responds positively. He appears to appreciate it when his teacher offers praise in his presence." "It is, undoubtedly, an invaluable resource." The results of the study indicate that some of the teachers who reported sufficient communication with families were also the classroom teachers of the students who received support education.

The findings pertaining to the fifth sub-problem of the research, namely "Support education teachers' opinions about the difficulties they encounter in mathematics teaching with students with special learning difficulties and the reasons for these difficulties", are presented in Table 9.

The majority of teachers who instruct mathematics to students with special educational needs (SEN) in a support education setting have indicated that the allocated support education hours are insufficient (f=6). P9 stated that they believed that removing students from the classroom for 1-2 hours on the support education day was an ineffective solution. It is this author's opinion that students receiving support education should be provided with a dedicated classroom. The findings of the research indicate that some teachers encountered difficulties due to insufficient physical conditions (f=5). In particular, there is a consensus that a separate classroom for support education is lacking, that departments such as libraries are being used for this purpose, and that the existing classrooms are suboptimal in terms of their physical environment. P9: "It is this researcher's opinion that students receiving support education should be provided with a dedicated classroom." The teacher is able to work with two or three students simultaneously, thereby significantly altering the nature of the classroom environment for students in the support education programme. "We are currently engaged in instruction within the library." Two of the interviewed teachers posited that providing support education outside of school hours is a burdensome undertaking for students. P17 posited that maintaining an excessive number of students on school grounds outside of scheduled classes can prove fatiguing for them. In regard to the challenges posed by the student population, the support education teachers indicated that a subset of students exhibited behavioural issues (f=5). P22 offered the following insights on the matter: The class teacher advised me to exercise caution, as the student in question has a history of violent behaviour. "He can vacate the classroom with minimal effort and relocate to any desired location with equal ease."

Table 9.

Difficulties encountered in DEO applications

Findings on the Difficulties Encountered by Teachers Providing Support Education in Teaching Mathematics to Students with SLD		
Difficulties with VIDEO Applications	Student-Related Difficulties	Difficulties Caused by the Teacher
Insufficient class hours	Behavioral problems	Lack of Knowledge and Experience
Insufficient physical conditions	Disinterest in the lesson	Other
Extra-school support education is tiring	Late and difficult learning	
	Not doing homework	
	Other	
Difficulties Originating from Families	Difficulties Experienced with Awareness	
Lack of interest from families	Families' perception of support education as a course	
Lack of awareness from families	Students' different perceptions of support education	
	Other	

Another challenge faced by educators is the lack of engagement exhibited by students with SLD in the learning environment (*f* = 4). P5: "He displays a notable lack of interest in the lesson, and thus requires some degree of compulsion to attend." P22 also identified a further challenge, namely that the student in question tends to adopt a defensive and uncooperative stance towards the learning process. He does not attend of his own volition. He attends class merely to engage in conversation with his companion and play with his cards. "Indeed, the child's willingness to learn is a crucial aspect that should be considered." The participants articulated their perspectives on the students' apparent reluctance to engage in learning activities. Some of the teachers indicated that delayed and challenging learning among students with SLD represented a significant challenge in the provision of specialised educational support (f=3). P15 proceeded to share his views on the matter as follows: "Other students with typical cognitive abilities demonstrate a higher level of comprehension, achieving at a commensurate level of proficiency. In contrast, these students exhibit a prolonged period of comprehension." Two teachers indicated that the students had not completed the assigned homework. P9 stated that none of his students had completed their homework and returned it by the designated deadline.

Indeed, we consulted with the counselling service on one occasion regarding one of my students. They consider the homework assigned by the teacher to be of greater value and importance. P9 indicated that his student had not completed the homework assigned in the support education programme. Some of the teachers (*f* = 3) indicated that they encountered challenges associated with the students, including memory lapses, inadequate preparation, and health issues. Teachers providing support education indicated that some families exhibited indifference (*f* = 8) and a lack of awareness (*f* = 5). P10 stated that the indifference of some families was a source of distress. "The lack of appreciation demonstrated by the family in response to the considerable effort invested by the educator is perplexing. Despite the seemingly minor nature of the contribution, the expectation is that the family will dedicate a similar amount of time on a daily basis to facilitate a more expedient outcome. However, when this commitment is not forthcoming, the educator is left with a sense of frustration." The interviewed teachers indicated that they encountered challenges related to awareness, including instances where students perceived support education in a distinct manner (*f* = 5), families viewed support education as a standalone course (*f* = 2), and a lack of awareness regarding the benefits and significance of support education within their local context (*f* = 2). P22: "They perceive it as a course in particular." He will attend the course and participate in private lessons. P22 also indicated that families have a different perception of support education.

The findings pertaining to the sixth sub-problem of the research, "Suggestions of support education teachers for increasing the effect of mathematics teaching with students with special learning difficulties", are presented in Table 10.

Teachers providing support education proffered suggestions for the improvement of the physical conditions in support education and mathematics teaching with their students with SLD (*f* = 6). P9 proffered his views on the subject. "As previously stated, it is my recommendation that a class be established under the designation of 'support education'. It is my further recommendation that this class be constituted as a serious academic undertaking." P4 posited that an appropriate educational environment and an adequate supply of teaching materials, tools and equipment should be provided. He further suggested that more enriching books could be purchased, which would be beneficial in that regard. Three of the interviewed teachers proposed an increase in the allocated support education hours. P8 posited that the duration of support education for the mathematics course should be equivalent to that

Table 10.

Suggestions for DEO applications

Suggestions of Teachers Providing Support Education Regarding Support Education Room Applications and Teaching Mathematics to Students with SLD	
Recommendations Regarding DEO Applications	Suggestions for Teachers Providing Support Education
Physical conditions should be improved.	Should know the student well.
Support education hours should be increased.	Should establish communication and emotional bond with the student.
Support education should be given by the student's classroom teacher.	Should be patient.
Legal regulations should be made	Should use appropriate teaching methods for the student.
Other	Should solve the student's behavioral problems.
	Should communicate with the student's classroom teacher and family.
Recommendations Regarding Awareness	Should give importance to repetition.
Education should be given to families.	Should be planned.
	Should be willing.
	Should gain students' self-confidence.
	Should make an effort for their professional development.

of the mathematics course itself. They stated, "For example, the standard Turkish curriculum comprises five hours of mathematics. It would be optimal for students to receive at least five hours of mathematics support." P21: "It is preferable to have one's own student." Indeed, having my own student proved to be of significant benefit. "I was therefore able to identify their deficiencies more accurately and ascertain where they were experiencing difficulties."

Two of the interviewed teachers posited that legal regulations should be established pertaining to ESL practices. In regard to the recommendations for educators providing supplementary instruction, all of the interviewed teachers (*n* = 22) asserted the importance of developing a comprehensive understanding of their students. P14 stated, "It is possible to overcome many academic challenges, but it is also essential to have a comprehensive understanding of the family and the child. Additionally, it is crucial to prepare the child for the future. Having a thorough knowledge of the child is of paramount importance." P15 emphasised the significance of the teacher developing a comprehensive understanding of the child, noting that this should be done from the outset, with the child's interests and abilities taken into account. The findings of the research indicated that teachers considered the establishment of communication and an emotional bond with the student to be a crucial aspect of their role. P1 articulated his perspective on the matter as follows: "It is essential to demonstrate that you comprehend his or her perspective." "If the student believes that he or she is not understood or that his or her trust is not warranted, he or she may respond in a manner that is incongruent with the desired outcome."

One of the suggestions put forth by the participants (f=8) is the utilisation of pedagogical approaches that are well-suited to the individual student. P10: The use of repetition and concrete materials, such as games, puzzles, and number blocks and cards, is recommended. "It is essential that concrete materials appeal not only to the brain but also to the five sensory organs of the child. This is particularly crucial in mathematics, as in all subjects." P10 highlighted the significance of employing pedagogical approaches and tangible resources that align with the learner's needs, particularly in the context of mathematics instruction. The findings of the research indicate that the resolution of behavioural issues among students is a key recommendation put forth by the teaching staff (f=5). P14: "I have previously addressed behavioural change in the context of supportive education, so I consider the academic aspect to be relatively less important." "If behavioural issues are present, they should be addressed initially," P14 asserted, indicating that behaviour change should be the primary focus.

Among the suggestions put forth by those who provide support education, there are also opinions that teachers should not prioritize their own professional development (*f* = 4). P17 emphasised the necessity for comprehensive training on SLD and its various manifestations, as well as on supportive education, for all classroom teachers. They asserted, "It is imperative that every classroom teacher undergoes training on the most prevalent characteristics of this type of student, both theoretically and practically." "It would undoubtedly be beneficial for them to gain experience in this area under the guidance of a teacher." Furthermore, he highlighted the importance of gaining experience. The research yielded several noteworthy findings. Among these was the opinion expressed by some of the teachers who provided support education services (*f* = 3) that communication between teachers and students' families, as well as between teachers and classroom teachers, is of great importance. P1 stated that it is necessary to meet with the parents and the class teacher individually in order to obtain their suggestions.

Three teachers proffered suggestions regarding the importance of repetition. P10 asserted that repetition is a crucial element in mathematics instruction, stating, "Effective planning and repetition are indispensable, particularly in mathematics." The findings revealed that the teachers in question also shared their opinions and suggestions regarding the importance of planning and enthusiasm among those providing support education. Additionally, they emphasised the significance of fostering self-confidence in students (f=6). P10: "It should be planned." "It is essential that the educator has a comprehensive understanding of the child and has prepared the necessary materials in advance." K8 highlighted the significance of meticulous planning and emphasised the importance of providing support education with genuine enthusiasm. They stated, "One should not engage in such activities merely for the sake of it. Instead, one should only undertake them if they are genuinely beneficial and if they are driven by a genuine desire to help." P14 posited that self-confidence is a crucial factor. In the absence of self-confidence, the child is unable to respond effectively to support education. I posit that these are of greater consequence for him. "I believe that the curriculum should be addressed at a later stage. It is also crucial to instill self-confidence in students." In terms of raising awareness, two participants emphasised the importance of family education. P5 stated that families lack sufficient awareness. "First and foremost, families require training."

Discussion and Conclusion Related to the First Sub-Problem

With regard to the initial sub-question of the study, namely, "What are the opinions of teachers engaged

in the provision of support education in the support education room with respect to the activities they undertake with students experiencing special learning difficulties?", it was determined that the majority of teachers in the support education room engage in support education as a result of their exceeding the norms for their respective roles. Additionally, other teachers opt for support education as a matter of choice, motivated by their desire to be of service to students. The Special Education Services Regulation (MoNE, 2018) sets out the legal framework for the assignment of special education teachers, pre-school teachers, classroom teachers and other field teachers in the support education room. The absence of norms for support education teachers in schools has resulted in the assignment of surplus teachers to this role.

Furthermore, classroom teachers with students diagnosed with SLD who are willing to do so provide support education to their own students or other students outside of school hours. In particular, classroom teachers of these students have indicated that they provide supplementary educational services outside of school hours, and that such services are beneficial for their students. As evidenced in the literature, individuals with SLD exhibit challenges in attention, perception, conceptual development, memory, problem-solving, and executive function skills. It is essential to investigate the causes of memory problems in order to guarantee that students derive benefit from the intensive information provided in schools and to ensure academic success (Yıldız, 2023). The difficulties they experience with attention have an adverse effect on their ability to learn effectively in other areas (Özmen, 2017).

Consequently, students with SLD tend to underperform academically and are more likely to fail. The findings of the study indicate that reading, writing and reading comprehension are the areas where teachers of students with SLD frequently encounter difficulties. Indeed, it can be stated that dyslexia is the underlying cause of approximately 80% of learning difficulties (Salman et al., 2016). Furthermore, the majority of individuals with learning difficulties also experience difficulties with reading (Çakmak, 2017). Furthermore, approximately 75% of students with SLD exhibit deficiencies in social skills (Kavale & Mostert, 2004). Furthermore, individuals with SLD may encounter difficulties in social relationships, such as exhibiting low self-confidence and a lack of social support (Cortiella & Horowitz, 2014).

Discussion and Conclusion Related to the Second Sub-Problem

With regard to the second sub-problem of the study, namely "the knowledge and skill levels of students with specific learning difficulties in mathematics, the difficulties they experience, the reasons and the methods of determination", it was established that students with SLD encountered difficulties in rhythmic counting, in acquiring the concept of number, and that there were students who wrote numbers upside down in the learning domain of natural numbers. One participant indicated that their students exhibited difficulties with pattern recognition. The fundamental operations of addition and subtraction provide the basis for more complex arithmetic operations. During the primary school period, students may exhibit a tendency to make systematic errors in addition and subtraction operations. It is crucial to conduct a thorough analysis of the source of errors in order to ascertain whether they are attributable to deficiencies in knowledge, misunderstandings, or dyscalculia. PLC is a specific developmental disorder that impedes the acquisition of arithmetic skills (Polat, 2021).

Multiplication can be defined as a repeated addition operation. A fundamental prerequisite for multiplication is a comprehensive understanding of the multiplication table. In particular, students who experience difficulties with memory and the recognition of specific patterns in multiplication are prone to challenges in memorising the multiplication table. As a consequence of these difficulties, they learn multiplication at a slower pace than their peers. Division is the inverse operation of multiplication. As students with mathematics learning difficulties experience challenges with multiplication, they also encounter difficulties with division (Cumhur, 2021). The ability to solve problems is a crucial skill that is integrated into mathematics curricula. The Turkish primary school mathematics curriculum includes problem-solving as a learning outcome at each grade level, commencing with the first grade. A review of the literature reveals that students with PLC experience challenges in problem-solving (Akgün, 2021). The findings of the study indicate that a minority of participants reported that their students with SLD experienced challenges in understanding spatial relationships, geometric shapes, and time concepts. It is hypothesised that this is due to the fact that teachers working in DEO prioritise numbers, arithmetic operations and problem solving in their studies.

The results of the study indicated that the most common reason for the difficulties experienced by students with Specific Learning Disabilities (SLD) in mathematics was the lack of interest from the family. Subsequently, it was posited that the presence of a diagnosis of SLD was the underlying cause of the observed difficulties in mathematics. Other reasons include genetic predisposition, distraction, inability to think abstractly, the distance education process, and the prioritisation of reading and writing instruction. The results of the research indicate that the teachers who provide support education in schools perceive the family's indifference to be the most common reason

for learning difficulties in mathematics. This may be interpreted as an indication that they perceive the causes of MLD to be environmental conditions. Furthermore, teachers cite additional environmental factors, namely the distance education process and inadequate education, as contributors to these difficulties. It can be posited that these factors contribute to the difficulties experienced by students with PLC. As Mutlu (2021) notes, Kaufmann et al. (2013) posit that individuals with dyscalculia exhibit disparate characteristics due to a confluence of environmental, cultural, prenatal, and postnatal factors, as well as social and emotional challenges. Nevertheless, environmental factors do not constitute the causes that lead to MLD. These factors result in students with mathematics learning difficulties exhibiting a type of SLD with heterogeneous characteristics. Furthermore, the teachers' attribution of certain PLC characteristics, such as anxiety, as causes indicates a lack of comprehensive understanding of the subject matter. The absence of a diagnosis for PLC also presents challenges for educators in differentiating these students from those with SLD. Furthermore, the teachers' limited understanding of the subject hinders their ability to provide informed opinions regarding the characteristics of students with and without SLD, as well as the underlying causes of their mathematical difficulties. Furthermore, it is a documented fact that students with SLD also experience difficulties with mathematics. To address these challenges, it is essential to diagnose the specific types of SLD and provide teachers in support education rooms with comprehensive information about the potential causes of mathematics learning difficulties and the criteria for diagnosis.

The teachers working in DEO stated that they determined the mathematical readiness of their students diagnosed with SLD predominantly at the outset of the instructional period. Subsequently, it was determined that the aforementioned educators ascertained their students' mathematical difficulties during the course of the lesson through a combination of observation, consultation with classroom teachers, question-and-answer sessions, and the utilisation of supplementary resource materials. One participant indicated that they determined mathematics difficulties in accordance with the curriculum, utilising existing documentation and conducting interviews with families. The findings indicate that support education teachers primarily identify their students' mathematical difficulties based on their observations and experiences during lessons. The findings of the study indicate that teachers do not employ systematic and documented measurement and evaluation techniques that can be implemented in the classroom. Instead, they determine the abilities of their students during lessons in collaboration with the teaching staff. It was found that teachers working in DEO do not employ a variety of methods concurrently when conducting assessments and evaluations. Furthermore, it would be more beneficial to ascertain the difficulties encountered by the student prior to the commencement of instruction by obtaining information from alternative sources (class teacher, families, etc.) external to the lesson.

Discussion and Conclusion

Discussion and Conclusion Related to the Third Sub-Problem

In light of the findings pertaining to the third sub-problem of the study, which pertain to the opinions of support education teachers on mathematics teaching with students with SLD, teaching strategies, methods and techniques employed, and evaluation, it can be concluded that the teachers primarily utilise the individualised education plan (IEP) prepared by the classroom teachers during the mathematics teaching planning stage. The remaining findings indicate that the planning is conducted by teachers who specialise in support education for students with SLD, and that the classroom teacher and the teacher providing support education collaborate in the creation of individualised education plans. It was not mentioned by any of the participants that the IEP unit forms part of the support education planning process. In accordance with the Regulation on Special Education Services, the responsibilities of the individualised education programme (IEP) development unit established in schools include ensuring coordination in studies related to the preparation, implementation, monitoring and evaluation of the IEP. The IEP unit is chaired by the school principal or deputy principal and comprises the school counsellor, the student's class teacher, field teachers, the student's parents and the student. The IEP unit bears responsibility for the preparation, implementation, monitoring and evaluation of the IEP (MoNE, 2018). It is recommended that this process be carried out not only by the class teacher of the mainstreaming student or the teacher working in the support education room, but also by the IEP unit. However, the findings indicate that the planning process is primarily focused on implementing the IEP, which is prepared by either the student's classroom teacher or the teacher providing support education. A single participant indicated that they collaborated with the classroom teacher in preparing the IEP. The findings of the study indicate that the utilisation of experiential and hands-on learning approaches, coupled with the incorporation of tangible materials and real-world scenarios, has a positive impact on student outcomes. The findings of the research indicate that teachers do not employ a range of evidence-based teaching methods as recommended in the literature. It can thus be argued that there is a need to ensure that teachers are informed about different evidence-based teaching methods. The findings revealed that

the majority of support teachers employed printed materials (textbooks, UYET books, worksheets, etc.) as instructional resources in their mathematics instruction with students diagnosed with Specific Learning Disabilities (SLD). Kunwar (2021) posits that the utilisation of concrete materials is an effective method for the presentation of content, particularly when employing multisensory techniques. Furthermore, greater emphasis should be placed on visualisation in mathematics teaching, with the utilisation of modern technology. The findings of the study indicate that the teachers surveyed reported utilising a range of tools and materials, including concrete materials, computer/internet resources and printed materials, to a significant extent in their mathematics lessons. The findings of the study indicate that teachers employed by DEO rely on multiple-choice tests, worksheets and examinations as the primary means of evaluating their mathematics teaching practices with students diagnosed with SLD. In their study, Yıldız and Atamtürk (2024) sought to ascertain the views of teachers on the support education room practices in primary schools. The researchers discovered that the teachers conducted evaluations in a manner consistent with those employed in general education. These included observation, progress reports, examinations, assessments of their students' abilities, and subject repetition. The results of this study yielded comparable findings. Furthermore, the IEP should be employed as a tool for monitoring and evaluating the teaching process with the student. The limited number of participants who stated that they took the IEP into consideration in their evaluations raises questions about the functionality and adequacy of the IEP.

Discussion and Conclusion Related to the Fourth Sub-Problem

The findings obtained from the fourth sub-problem of the study, which concerns the opinions of teachers working in DEOs regarding communication and cooperation with classroom teachers and parents of students with SLD, are as follows: The majority of teachers disclosed academic information and homework assignments to their students' classroom teachers. A minority of participants indicated that they had shared information about behavioural issues with their classroom teachers. The majority of teachers providing supplementary education indicated that their communication with their students' class teachers was adequate. Interpreting the findings, it can be stated that the students' status as classroom teachers enables them to communicate with families with greater ease. One of the most effective strategies for ensuring academic success is to engage families in their children's education. Furthermore, parents constitute a significant source of support in addressing the social needs of the student. The research indicates that family involvement in the educational process is associated with positive mental, emotional, and social development in children (Çalışkan, 2021). In order to facilitate effective communication with families and enhance school-family collaboration, it is essential to ensure the functionality of the IEP unit within educational institutions. Furthermore, the family of the mainstreaming student, and if appropriate, the student themselves, may also participate in this team. It is hypothesised that when the IEP unit fulfils its duties in a truly functional manner and includes families in the educational process, the difficulties experienced will decrease, and more communication and cooperation with families can be established. The frequent change of teachers working in support education may be a contributing factor to the lack of continuity in communication and cooperation with families.

Discussion and Conclusion Related to the Fifth Sub-Problem

During the course of the research, it was observed that some of the schools visited had repurposed rooms such as libraries and warehouses to serve as support education rooms. Furthermore, the research revealed that teachers perceive a lack of sufficient teaching materials, tools and equipment. This situation has a detrimental impact on teachers providing support education. In some cases, classroom teachers provide supplementary education outside of school hours. While research findings indicate that students benefit more from education provided by their class teachers, there are also opinions that this type of education outside school hours is exhausting for the students. Some participants indicated that students exhibited a lack of interest in the lesson and a reluctance to complete homework assignments because they were not their class teachers. Teachers who provide supplementary education to these students indicate that their knowledge and experience in this area are inadequate. During the interviews, it was observed that there was a lack of awareness among the participants regarding the distinction between special learning disabilities and dyslexia, with many conflating the two terms. Additionally, there was a lack of understanding about the specific nature of mathematics learning disabilities as a distinct form of SLD. With regard to the provision of support education, the fact that a considerable proportion of teachers are assigned to support education rooms on the grounds that they exceed the norm results in their participation in this practice without having the requisite knowledge in advance and in the face of significant challenges. The fact that teachers providing support education are required to perform this task on a temporary basis, the frequent change of teachers for this reason, and the high number of students in the classes may contribute to the emergence of these issues.

Discussion and Conclusion Related to the Sixth Sub-Problem

The sixth sub-problem of the research, which concerns the recommendations of supportive education teachers for enhancing the efficacy of mathematics instruction for students with SLD, was classified as recommendations pertaining to DEO practices, supportive education teachers, and awareness. It was thus determined that the most prevalent recommendation put forth by supportive education teachers with regard to DEO practices and mathematics instruction pertained to the enhancement of physical conditions. The suggestions included an increase in the number of support education hours, the provision of support education by the student's class teacher, the making of legal arrangements, and other recommendations, such as the involvement of different teachers in the provision of support education and the delivery of some courses online. Upon analysis of the suggestions put forth by support education teachers for teachers who provide support education and mathematics teaching, it became evident that a fundamental aspect of their recommendations was the importance of a thorough understanding of the student in question. Other suggestions include the establishment of an emotional bond and communication with the student, the demonstration of patience, the utilisation of teaching methods that are appropriate for the student, and the resolution of behavioural issues. Furthermore, the suggestions provided to teachers who provide support education and mathematics teaching include the implementation of professional development, communication with families, class teachers, repetition, structured planning, willingness, and the fostering of self-confidence in students.

In Turkey, students with specific learning disabilities (SLD) are not diagnosed separately according to the types of SLD. Nevertheless, it is a documented fact that there are students diagnosed with SLD who also have MLD. The subject of this research, mathematics learning disability, is less well-known among teachers than dyslexia. Some participants even employed the terms "dyslexia" and "learning disability" as synonyms. In order to differentiate between students who experience difficulties in mathematics as a result of MLD and those who do so due to environmental factors, it is essential to conduct a separate diagnosis. The inconsistency model, which is a valid diagnostic model, results in students being referred for diagnosis only after a period of time has elapsed since they commenced their education. This consequently leads to the identification of existing difficulties in students being delayed. Nevertheless, children who are at risk of developing PLCD display some indications of vulnerability from an early age. The findings of the study indicate that teachers lack the requisite knowledge and experience to provide effective educational and PLC support. It has been established that teachers lack sufficient knowledge regarding teaching methods, evidence-based teaching interventions, and measurement and evaluation methods employed in mathematics instruction for students with SLD. The IEP unit in schools is responsible for a range of duties and obligations, spanning the planning stage of supportive education, through to evaluation and monitoring. Nevertheless, none of the participants in the study made any reference to the IEP unit. Those providing supplementary education tend to perceive their role as primarily that of implementing the IEP devised by the classroom teacher. Furthermore, the lack of functionality of this unit may also result in inadequate communication and collaboration with families. A further issue is that of the physical conditions. Some of the educational establishments that were the subject of this study do not have a dedicated room for the delivery of special educational needs support. Consequently, such provision is made in other areas of the school, for example, libraries. A further issue is the lack of appropriate tools, equipment and materials. In the course of the interviews, a number of teachers indicated that they had attempted to procure the requisite tools, equipment and materials through their own efforts.

On the basis of the findings of the present study, a number of recommendations can be put forward for consideration in practice and for future research.

It is recommended that in-service training be provided to classroom teachers and teachers providing support education services on the types of specific learning disabilities, with particular emphasis on mathematics learning disabilities. Such training should include awareness, professional knowledge, and effective teaching methods.

It is recommended that these training sessions be conducted in the form of workshops.

It would be beneficial to implement a standardised approach to the role of support education teachers within educational institutions. It can thus be ensured that support education practices are carried out in a more efficient and regular manner.

It is recommended that the IEP unit, established in schools where inclusive education is implemented, be fully operational, and that support education services be carried out in collaboration with the relevant team.

It is recommended that prospective teachers receive training to enhance their awareness of OSA and its various manifestations.

It would be beneficial for teacher candidates to have the opportunity to observe training sessions in support education rooms during their teaching practice.

It is imperative that families are educated about SLD and its various manifestations.

It would be beneficial for researchers to include long-term longitudinal studies on mathematics learning disabilities in their work. Therefore, a contribution can be made to the diagnostic process related to MLD.

References

Akgün, L. (2021). Diskalkulik çocuklara problem çözme öğretimi [Teaching problem solving to dyscalculic children]. In Y. Mutlu, S. Olkun, L. Akgün ve M. H. Sarı (Eds.), *Diskalkuli-matematik öğrenme güçlüğüne sahip çocuklara matematik öğretimi* [Teaching mathematics to children with dyscalculia-mathematics learning difficulties] (pp. 237-260). Vizetek.

Amerıcan Psychıatrıc Assocıatıon (APA). (2013). Diagnostic and statistical manual of mental disorders: (DSM-5). Washington, D.C: American PsychiatricAssociation.

Bozak, B. & Çay, E. (2023). Destek eğitim odalarının kaynaştırma uygulamasındaki yeri ve önemine ilişkin öğretmen görüşleri [Teachers' opinions on the place and importance of support education rooms in inclusion practice]. *Mustafa Kemal Üniversitesi Eğitim Fakültesi Dergisi, 7*(11), 1-18.

Brownstein, E. (2016). *Closing the Achievement gap in mathematics for students with learning disabilities utilizing the resource room as an intervention* (Order No. 13808738). Available from ProQuest Dissertations & Theses Global. (2199540988). Nova Southeastern University.

Carpenter, R. L. (1985). Mathematics ınstruction in resource rooms: ınstruction time and teacher competence. *Learning Disability Quarterly, 8*(2), 95-1.

Cortiella, C. & Horowitz, S. H. (2014). The state of learning disabilities: facts, trends and emerging issues. New York: *National Center for Learning Disabilities, 25*(3), 2-45.

Cumhur, F. (2021). Diskalkulik çocuklara çarpma ve bölme işlemi öğretimi [Teaching multiplication and division to dyscalculic children]. In Y. Mutlu, S. Olkun, L. Akgün & M. H. Sarı (Eds.), *Diskalkuli- matematik öğrenme güçlüğüne sahip çocuklara matematik öğretimi* [Teaching mathematics to children with dyscalculia-mathematics learning difficulties] (pp. 209-236). Vizetek.

Çakmak, Z. (2017). *Rehberlik ve araştırma merkezi personelinin öğrenme güçlüğü olan bireylerin değerlendirilme süreçlerine ilişkin görüşleri* [Guidance and research centre staff's views on the evaluation processes of individuals with learning difficulties] [Master's thesis, Anadolu University], Eskişehir.

Çalışkan, E.F. (2021). Diskalkulik çocukların eğitiminde ebeveyn katılımı [Parental involvement in the education of dyscalculic children]. In Y. Mutlu, S. Olkun, L. Akgün, & M. H. Sarı (Eds.), *Diskalkuli- matematik öğrenme güçlüğüne sahip çocuklara matematik öğretimi* [Teaching mathematics to children with dyscalculia-math learning difficulties] (pp. 21-40). Vizetek.

Demirhan, M. (2023). Classroom teachers' views on support education room applications. *Pearson Journal, 8*(25), 486-499. https://doi.org/10.5281/zenodo.8362276

Deniz, S. (2019). *Özel öğrenme güçlüğüne sahip öğrencilerle çalışan öğretmenler için geliştirilen öğretmen yeterlikleri eğitim programının etkililiği* [The effectiveness of the teacher competencies training programme developed for teachers working with students with special learning difficulties] [Doctoral dissertation, Necmettin Erbakan University], Konya.

Doğan-Temur, Ö., & Korkmaz, N. (2021). Parents' experiences about the maths-learning process of children with specific learning disabilities: a case study. *Journal of Special Education, 22*(3), 591-609. https://doi.org/10.21565/ozelegitimdergisi.729195

Dowker, A. (2004). *What works for children with mathematical difficulties*? Dfes Publications Nottingham.

Ergül, C., Yılmaz, Ç. Ö. & Demir, E. (2018). A-10 yaş grubu çocuklara yönelik geliştirilmiş çalışma belleği ölçeğinin geçerlik ve güvenirliği [The validity and reliability of the working memory scale developed for children aged A-10 years]. *Eğitimde Kuram ve Uygulama, 14*(2), 187-214

Fırat, T., & Erdem, E. (2019). Matematik öğrenmede güçlük yaşayan ilkokul öğrencilerinin 1. ve 4.sınıftaki süreçlerine ilişkin sınıf öğretmenlerinin görüşleri [Classroom teachers' views on the processes of primary school students who have difficulty in learning mathematics in the 1st and 4th grades]. *Erzincan Üniversitesi Eğitim Fakültesi Dergisi, 22*(1), 66-86. https://doi: 10.17556/erziefd.504004

Filik, R. (2019). *Sınıf öğretmenlerinin destek eğitim odaları hakkındaki görüşlerinin belirlenmesi* [Determining the opinions of classroom teachers about support education rooms] [Master's thesis, Necmettin Erbakan University], Konya.

Filiz, T. (2021). Matematik öğrenme güçlüğü yaşayan öğrencilere yönelik öğretimsel müdahalelerin öğrencilerin akademik başarılarına etkisinin incelenmesi [Examining the effect of instructional interventions for students with mathematics learning difficulties on students' academic achievement]. *Ankara Üniversitesi Eğitim Bilimleri Fakültesi Özel Eğitim Dergisi, 22*(4), 1025-1055. https://doi.org/10.21565/ozelegitimdergisi.713496

Gencan, N. (2020). *Uyarlanmış bunu çöz! stratejisinin öğrenme güçlüğü olan öğrencilerin matematik problemi çözme becerisindeki etkisi* [The effect of adapted solve this! strategy on the mathematics problem solving skills of students with learning difficulties] [Master's thesis, Necmettin Erbakan University], Konya.

Hopcan, E. P. (2017). *Design, development and evaluation of a tangible mobile application for students with specific learning disabilities* [Doctoral dissertation, Middle East Technical University], Ankara.

Kaçar, H. (2018). *Investigation of mathematics learning difficulties of primary school students according to the observations and experiences of classroom teachers* [Master's thesis, Ann Arbor], United States

Kaptan, Ö. (2019). *Kaynaştırma okullarındaki özel gereksinimli bireylere destek eğitim odasında eğitim veren öğretmenlerin süreç içerisinde karşılaştıkları güçlüklerin belirlenmesi* [Determination of the difficulties encountered by teachers who provide education in the support education room for individuals with special needs in mainstreaming schools [Master's thesis, Necmettin Erbakan University], Konya.

Kavale, K. A., Spaulding, L. S. & Beam, A. P. (2009). A time to define: making the specific learning disability definition prescribe specific learning disability. *Learning Disability Quarterly, 32*(1), 39-48. http://doi.org/10.2307/25474661

Koç, B. (2012). *Sınıf öğretmenlerinin sınıflarındaki öğrenme güçlüğü çeken öğrencilerine yönelik uygulamalarının incelenmesi* [Examination of classroom teachers' applications for students with learning difficulties in their classrooms] [Master's thesis, Necmettin Erbakan University], Konya.

Polat, K. (2021). Diskalkulik çocuklara toplama ve çıkarma işlemi öğretimi [Teaching addition and subtraction to dyscalculic children]. In Y. Mutlu, S. Olkun, L. Akgün, & M. H. Sarı (Eds.), *Diskalkuli- matematik öğrenme güçlüğüne sahip çocuklara matematik öğretimi* [Teaching mathematics to children with dyscalculia-mathematics learning difficulties] (pp. 177-206). Vizetek.

Kılınç, N. (2023). *Özel öğrenme güçlüğü olan bir ilkokul dördüncü sınıf öğrencisinin matematik becerilerini geliştirmeye yönelik bir eylem araştırması* [An action research on the development of mathematics skills of a primary school fourth grade student with special learning difficulties]. [Master's thesis, Ordu University], Ordu.

Kroesbergen, E. H., Huijmans, M. D. E., Kleemans, T. (2022). The Heterogeneity of Mathematical Learning Disabilities: Consequences for Research and Practice. *International Electronic Journal of Elementary Education, 14*(3), 227-241. http://doi.org/10.26822/iejee.2022.241

Kunwar, R. (2021). Dyscalculia in learning mathematics: underpinning concerns for delivering contents. *Dristikon: A Multidisciplinary Journal, 11*(1), 127-144.

Lewis, E. L., Thompson, G. M., & Tov, S. A. (2022). Screening for Characteristics of Dyscalculia: Identifying Unconventional Fraction Understandings. *International Electronic Journal of Elementary Education, 14*(3), 243-267. http://doi.org/10.26822/iejee.2022.242

Millî Eğitim Bakanlığı [Ministry of National Education] [MEB] (2018). *Özel eğitim hizmetleri yönetmeliği* [Special education services regulation]. https://orgm.meb.gov.tr/meb_iys_dosyalar/2018_07/09101900_ozel_egitim_hizmetleri yonetmeligi_07072018.pdf (Date of access: 13.01.2024).

Melekoğlu, M. A. (2022). Özel öğrenme güçlüğü ve matematik [Special learning disabilities and mathematics]. In M. A. Melekoğlu (Ed.), *Matematik güçlüğü diskalkuli tanılama ve müdahale* [Mathematics difficulty dyscalculia diagnosis and intervention] (pp. 2-19). Pegem Akademi.

Merriam, B. Sharan (2023). *A guide to qualitative research design and practice*. Fatma Koçak Canbaz, Muhammed Öz. (trans.) Selahattin Duran (Ed.). Ankara: Nobel.

Mononen, R., Niemivirta, M., & Korhonen, J. (2022). 352Predicting Mathematical Learning Difficulties Status: The Role of Domain-Specific and Domain-General Skills. *International Electronic Journal of Elementary Education, 14*(3), 335-352. http://doi.org/10.26822/iejee.2022.248

Mutlu, Y. (2016). *Bilgisayar destekli öğretim materyallerinin matematik öğrenme güçlüğü yaşayan öğrencilerin sayı algılama becerileri üzerindeki etkilerinin incelenmesi* [Examination of the effects of computer supported teaching materials on the number perception skills of students with mathematics learning difficulties]. [Doctoral dissertation, Atatürk University], Erzurum.

Mutlu, Y. & Akgün, L. (2017). Matematik öğrenme güçlüğünü tanılamada yeni bir model önerisi: çoklu süzgeç modeli [A new model proposal in diagnosing mathematics learning disability: multiple filter model]. *İlköğretim Online, 16*(3), 1153-1173.

Mutlu, Y. (2020). Gelişimsel diskalkuli nedir? [What is developmental dyscalculia?]. In Y. Mutlu, S. Olkun, L. Akgün, & M. H. Sarı (Eds.), *Diskalkuli matematik öğrenme güçlüğü tanımı, özellikler, yaygınlığı, nedenleri ve tanılanması* [Dyscalculia mathematics learning disability definition, characteristics, prevalence, causes and diagnosis] (pp. 1-9). Pegem Akademi.

Özkubat, U. (2022). Matematik güçlüğünde öğretim stratejileri 1:temel aritmetik işlemler ve akıcılık [Teaching strategies in mathematics difficulties 1: basic arithmetic operations and fluency]. In M. A. Melekoğlu (Ed.), *Matematik güçlüğü diskalkuli tanılama ve müdahale* [Mathematics difficulty dyscalculia diagnosis and intervention] (pp. 128-154). Pegem Akademi.

Özkubat, U. & Özmen, E. R. (2018). Öğrenme güçlüğü olan öğrencilerin matematik problemi çözme süreçlerinin incelenmesi: sesli düşünme protokolü uygulaması [Investigation of mathematics problem solving processes of students with learning disabilities: think aloud protocol application]. *Ankara Üniversitesi Eğitim Bilimleri Fakültesi Özel Eğitim Dergisi, 19*(1), 155-180. doi:10.21565/ozelegitimdergisi.299494

Özmen, E. R. (2017). Öğrenme güçlüğü hakkında temel bilgiler ve uygulamalar [Basic information and practices about learning disabilities]. In E. R. Özmen (Ed.), *Öğrenme güçlüğü sınıf içi destek seti* (1. Kitap) [Learning disability in-class support set (1st book)]. Eğiten Book.

Özyürek, M. (2003). Öğrenme güçlüğü gösteren çocuklar [Children with learning difficulties]. In A. Ataman (Ed.), *Özel gereksinimli çocuklar ve özel eğitime giriş [*Children with special needs and introduction to special education] (pp.217-230). Gündüz Eğitim ve Yayıncılık.

Salman, U., Özdemir, S., Salman, A. B. & Özdemir, F. (2016). Özel öğrenme güçlüğü "disleksi" [Special learning disability "dyslexia"]. *İstanbul Bilim Üniversitesi Florence Nightingale Tıp Dergisi, 2*(2), 170-176.

Sertdemir, Ö. F. (2021). *Özgül öğrenme güçlüğü olan öğrencilerin çarpma işlemi akıcılığı becerisinde işlem ailesi ve oku-yaz-karşılaştır öğretim yöntemlerinin etkililik ve verimliliklerinin karşılaştırılması* [Comparison of the effectiveness and efficiency of process family and read-write-compare teaching methods in multiplication fluency skills of students with specific learning difficulties] [Master's thesis, Biruni University], İstanbul.

Sucuoğlu, B. & Kargın, T. (2006). *İlköğretimde kaynaştırma uygulamalarında yaklaşımlar yöntemler teknikler* [Approaches, methods and techniques in inclusion applications in primary education]. Morpa Kültür Yayınları.

Talas, S., Türkoğlu, G., & Seçil Karamuklu, E. (2022). Türkiye'de destek eğitim odası üzerine sistematik bir derleme [A systematic review on support education room in Turkey]. *Cumhuriyet Uluslararası Eğitim Dergisi, 11*(3), 575-586. https://doi.org/10.30703/cije.1126957

Uygun, N. (2019). *Matematik öğrenme güçlüğü risk grubu olan bir dördüncü sınıf öğrencisi için destek eğitim programı geliştirilmesine yönelik bir eylem araştırması* [An action research on the development of a support education programme for a fourth grade student with mathematics learning disability risk group] [Doctoral dissertation, Necmettin Erbakan University], Konya.

Yıldırım, A. & Şimşek, H. (2013). *Sosyal bilimlerde nitel araştırma yöntemleri* [Qualitative research methods in social sciences]. Seçkin.

Yıldız, M. (2023). *Özel öğrenme güçlüğü riski olan okul öncesi dönem çocuklarına yönelik bilişsel erken müdahale programının etkililiği* [The effectiveness of the cognitive early intervention programme for pre-school children with special learning difficulties] [Doctoral dissertation, Osmangazi University], Eskişehir.

Yıldız, H. & Atamtürk, N. (2024). İlkokullarda uygulanan destek eğitim odası hizmetine ilişkin öğretmen görüşleri [Teachers' opinions on the support education room service implemented in primary schools]. *Educational Academic Research, (52*), 123-143. https://doi.org/10.33418/education.1421792

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Navigating Math Minds: Unveiling the Impact of Metacognitive Strategies on 8th Grade Problem-Solvers Abilities

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Abstract

The current study was designed to examine the effect of metacognitive instruction strategies on the development of metacognition in grade 8 students and study variation in the development of metacognition in students with varying academic abilities. The study involved 80 grade 8 students from a public high school as a sample. A quasi-experimental non-equivalent control group research design was used to conduct research. The Junior Metacognitive Inventory Jr. MAI, developed by Sperling et al. (2002), was administered to assess metacognition in both experimental and control groups four times throughout the experiment, at baseline, and after each of the three stages. The experimental group was taught mathematical problem-solving using metacognitive teaching strategies (such as self-questioning, thinking aloud, modelling, and concept mapping). On the contrary, the control group received training using the traditional lecture method during the 18-week intervention. The results show that metacognitive instructional strategies used during the experiment significantly affect the growing metacognition, knowledge of cognition, and regulation of cognition of grade 8 students during Mathematical problem-solving teaching. Furthermore, the metacognition of all subgroups was significantly enhanced after teaching through metacognitive instructional strategies. Mathematics teachers are recommended to spread awareness about metacognition and metacognitive instructional design to improve math problem-solving skills among elementary-level students.

Keywords:

Metacognitive Instructions, Knowledge of Cognition, Regulation of Cognition, Teaching Strategies

Introduction

Over the last few decades, metacognition has been recognised as a powerful predictor of mathematical problem-solving skills. Substantial studies have demonstrated metacognition's function on students' instructional achievement. Students with better metacognition usually have more potential to display and adjust their cognitive abilities, allowing them to perform higher academically (Pintrich, 2002). The math achievement of eighth graders was strongly correlated with their metacognition. This helps to confirm that higher metacognition in students would lead to excel in mathematics (Habib & Rana, 2020).

A psychological concept called metacognition was coined by Flavell (1979). It is defined as a person's knowledge of one's thoughts and ability to control or govern them (De-Jager et al., 2005; Hacker & Dunlosky, 2003). It can be summed up as "thinking about thinking" in simple terms (Flavell, 1979). Metacognition is distinct from an individual's overall intelligence in that it can be considered a collection of general talents instead of domain-specific skills. In solving problems, metacognitive tendencies typically compensate for a person's lack of knowledge and general intelligence (Schraw, 1998).

Metacognitive knowledge and metacognitive control or regulations are the two subtopics covered when discussing metacognition (Otani & Widner, 2005; Sungur, 2007). Metacognitive knowledge is understanding a person's intellectual existence, capacities, and limits (Brown, 1987; Jacobs & Paris, 1987; Schraw et al., 2006). The second sub-concept of metacognition, known as metacognitive control or regulation, refers to "the behaviours utilised to manage and oversee learning" (Brown, 1987). These are called the steps taken to manage and regulate learning.

Developing metacognitive skills was a challenging task after the acknowledgement of metacognition and its importance. Furthermore, enormous research supports this belief that metacognition is a skill that can be learned and improved (Dignath et al., 2008; Kramarski & Mevarech, 2003; Ozsoy & Ataman, 2009).

The development of metacognition in a being is a continuous but stable process. Previous research supports the belief that metacognition development does not inherently progress with age (Baker & Beall, 2014). Instructions are more helpful than ageing and experience in helping people build their metacognitive skills (Veenman et al., 2004). Through knowledge and self-regulation of their skills, students may be able to keep track of their learning processes using metacognitive instructions (Brown, 1982).

There is considerable literature suggesting instructional strategies to develop metacognition. However, the most effective approaches combine theory and practice (Amjad et al., 2023; Aslam et al., 2021). Declarative, procedural, and conditional knowledge is acquired through theoretical lessons, and metacognition regulation is supported by practising effective strategies (Livingston, 2003).

Self-questioning, teacher and peer modelling, scaffolding, think-aloud, and checklists are research-based examples of metacognitive educational practices. These techniques help students stimulate their cognitive skills and regularly regulate an individual's intellect for all tasks (Amjad et al., 2022; a, b; Gama, 2005). It is inevitable to equip our teachers with the knowledge of explicit metacognitive strategies and the effective use of those to develop metacognition among students (Schraw, 1998; Schraw et al., 2006). Researchers have always found it difficult to evaluate metacognition since it is a complex concept that cannot be observed through people's direct, explicit actions (Sperling et al., 2002). Since 1979, various tools have been used to measure metacognition. Each technique has advantages and disadvantages (Panaoura & Philippou, 2005).

Various tools have been used to measure metacognition from the beginning of the construct (e.g. questionnaires, observation, interviews, Thinking aloud, stimulated recall, etc). All of the instruments used possess their context-based strengths and challenges (Veenman & van Cleef, 2019). Metacognitive Awareness Inventory (MAI) has been used extensively to measure metacognitive since 1979. Metacognitive Awareness Inventory MAI consists of self-report questions based on two main components: knowledge of cognition and regulation of cognition (Schraw & Dennison, 1994). Simultaneously, Jr.MAI, by Sperling et al. (2002), is a widely used tool for measuring the metacognition of children of two different age groups. These two inventories will likely be considered independent of domain rather than domain-specific (Ellah et al., 2023).

A recent study concluded after two experiments that reevaluating metacognition improves the previous results after providing feedback to the subjects (Elosegi et al., 2024). Veenman and van Cleef (2019) conducted another interesting study to compare the metacognition measurement through five different instruments at different instances, and the results were compared.

The think-aloud approach is one of the operational methods to assess metacognition. Students are asked to express their mental processes, which are then recorded, transcribed and subjected to scientific analysis (Akram et al., 2023; Veenman & Spaans, 2005). The metacognitive interview by Myers and Paris (1978) is one of the first instruments to measure metacognition for older readers. The most common technique for evaluating Mc is thought to be a metacognitive questionnaire.

Due to the simplicity of administration, even for a large sample, and ease and comfort, they may be used to evaluate acquired data (McCormick et al., 2013). Schraw and Dennison (1994) created the Metacognitive Awareness Inventory (MAI), widely used to assess metacognition. There are 52 items, each worth five points, making up a complete self-report inventory for adults founded on knowledge, regulation, and sub-constructs of these fundamental Mc components. Adult metacognition is measured using the Schraw and Dennison (1994) metacognitive

awareness inventory. To measure Mc in kids of two different age groups, Sperling et al. (2002) adjusted this as Jr.MAI.

Junior Metacognitive Inventory Jr. MAI, Versions A and B, each containing 12 items for grades 3-5 and 18 for grades 6–9. As previously noted, the above inventories are frequently employed to assess adults and children's metacognition (Panaoura & Philippou, 2005).

Significance of the Study

Mathematical problem-solving is one of the thought-provoking processes which needs higher-order skills like metacognitive abilities. Adequate research literature is available to support the effective use of self-regulative skills like metacognitive abilities for a self-assured effort for a Mathematical problem. Metacognition is likely to be a substantial pre-requisite for self-regulated learning, comprised of two basic constructs: knowledge and regulation of cognition (Dörr & Perels, 2019). Regardless of the considerable effects of metacognitive strategies in research classrooms, such inspirational activities could hardly be found in real classrooms. The problem is possibly rooted in the dearth of teachers' friendly instructional strategies in real-world classrooms for problem-solving (Ozturk, 2022). Generally, struggling students in Mathematics are intrinsically less motivated and possess low metacognitive levels as compared to high performers (Desoete & De-Craene, 2019). At the same time, the effective use of metacognitive instructional strategies for developing Mathematical problem-solving skills has been a neglected area in the Pakistani context. Metacognition-related literature lacks the study of variation in developing Mathematical problem-solving skills among elementary students with diverse academic abilities. Investigating an effective use of metacognitive instructional strategies for a real classroom teaching on the diversity of groups of students in Mathematical problem-solving skills settings is an evolving gap in metacognitive research. The present study aimed to compare the Mathematical problem-solving abilities of above-average, average and below-average achievers with metacognitive instructional strategies.

Objectives of the Study

The objectives of the present study were the following.

1. To compare the metacognition of eighth graders taught through the lecture method and metacognitive instructional strategies.

2. To compare the effectiveness of metacognitive instructional strategies on above-average, average, and below-average students' metacognition during Mathematical problem-solving.

Hypotheses of the Study

The following hypotheses were developed to achieve the objectives of the study.

> H_{01}: There is no significant difference between the mean scores of metacognition of the 8th graders, those taught through the lecture method, and those using metacognitive instructional strategies.
>
> H_{02}: There is no significant variation in the effectiveness of metacognitive instructional strategies in mean metacognition scores from eighth graders with varying abilities.

Delimitation of the Study

Private schools use a range of curricula, instructional techniques, suggested reading lists, and assessment techniques. Due to the uniformity in their curricula and evaluation procedures, the present study was limited to eighth graders studying in government schools. Only those units containing problem-solving themes were chosen from the Mathematics 8 of Punjab textbook board for the study.

Methodology

The nature of the study was quantitative. To conduct the study, a quasi-experimental nonequivalent control group pretest-posttest design was used. Nonrandom assignment was used to choose two intact groups, an experimental group (n=40) and a control group (n=40). Metacognitive instructional strategies were the study's independent variable, while metacognition values of grade 8 students were the dependent variable.

The experimental group was exposed to teaching mathematical problem-solving skills by using metacognitive teaching techniques like self-questioning, teacher and peer modelling, scaffolding, think-aloud, and checklists. However, the same content was taught to the control group using the traditional method (lecture). Both groups were comparable in using the same course materials, schedule, and assessments. A pretest and post-test design perfectly compares the degree of change resulting from the intervention. Participants in this study were 80 8th-grade female students from the Government Girls High School in the Lahore district. The average age of the research participants was about 12 or 13 years during the experiment.

During the twenty weeks of the experiment, both groups were taught five lessons per week, each lasting 40 minutes. The content for teaching was taken from the Punjab Mathematics textbook board, related to ratio/proportion, percentage, and simultaneous linear equations, as these topics cover mathematical problem-solving (statement questions). All the topics were planned through lesson plans

involving metacognitive instructional strategies for the experimental group.

The walls of the classroom of the experimental group were covered with a few charts related to the concept of "metacognition" and its elements. Teaching aids, including a checklist and instructional tactics, were also displayed on the walls. These specific arrangements were made to conduct the experiment more effectively. The teacher herself vocalised her thinking developed during the Mathematical problem-solving process to train the students for modelling techniques to establish the regulation of cognition. After presenting new challenges to the experimental group, regular classroom instruction also used the students' modelling and concept mapping strategies. To control students' metacognitive growth, students were given cards describing a checklist (Schraw, 1998) of self-questioning while working through issues. On the other hand, the control group was taught the same topics using the traditional teaching method.

Researchers have always found it difficult to evaluate metacognition since it is a complex concept that cannot be observed in people's immediate, explicit actions (Sperling et al., 2002). Since 1979, researchers have used various tools effectively to assess metacognition. For the present study, Sperling et al. (2002) Junior Metacognitive Inventory or Jr. MAI was used to measure metacognition in grade 8 students. It is a modified version of the metacognitive awareness inventory developed by Schraw and Dennison (1994), which assesses adults' metacognition. With a Cronbach alpha of .85, we recalculated in our study, which was found to be .84, above the threshold level of .70 for the social sciences. The Junior Metacognitive Inventory Jr. MAI by Sperling et al. (2002) is acknowledged as a trustworthy tool (Sperling et al., 2002). The metacognitive inventory consists of 18 statements. Nine statements assess cognition knowledge, while the remaining nine measure cognition regulation.

Jr. MAI. Aydin and Ubuz (2010) transformed it into Turkish and used it to collect data about students' metacognition. Their study found Cronbach's alpha of the Turkish version to be .88 of Jr. MAI. Subsequently, Kirbulut (2014) also used the same version.

Considering the limited English language skills of Pakistani students, Jr. MAI has been translated into Urdu (an innate language) by a group of language experts to help the kids understand the statements and answer quickly.

To ensure appropriate comprehension of the content in both languages, the Urdu translation of the inventory was translated back into English. The expert opinion of a few educational researchers ensured the instrument's content validity. Through a pilot study on 100 students in grade 8, data were collected using the Jr. Junior Metacognitive Inventory. MAI (Urdu version) and construct validity were ensured by factor analysis of the data collected—the Urdu version of the Jr. The MAI metacognitive inventory reliability score was 0.92.

The Metacognitive Inventory Jr. MAI (Sperling et al., 2002) was administered four times throughout the experiment to measure metacognition before and after each step. The factor loadings given in Table 1 show the results of the factor analysis.

The Jr. MAI factor analysis produced five-factor solutions. The results showed that a five-factor solution loaded the statements to explain 64.68 percent of the variation. Table 2 shows the features of the factors and the matching statements.

In Table 2, the researchers presented five overall factors for MAI: knowledge of cognition, eight statements; planning and information management, two statements for each factor; and monitoring and evaluation, three statements for each factor.

Table 3 shows the mean, standard deviation and reliability analysis of five factors of Jr. MAI.

H_{01}: There is no significant difference between the mean scores of metacognitions of the 8th graders, those taught through the lecture method and using metacognitive instructional strategies.

Hypothesis H01 was tested using repeated-measure ANOVA. Its foundation is the sphericity assumption, which verifies that the variance of scores based on the population difference is independent of any two conditions, i.e., remains the same for any two conditions. In such a situation, the Mauchly test of sphericity is applied to gauge the validity of this assumption. Although it is unfortunate that this assumption is frequently broken, there are ways to compensate.

The assumption of sphericity has been broken since the significant value of 0.000 is less than the crucial value of 0.05, indicating substantial differences between variances of differences. Fortunately, we can simply alter the degrees of freedom, for the impact of data does not conform to the sphericity assumption. The range of the Greenhouse-Geisser estimate () is 1/k-1 to 1. (where k is the number of degrees). 1/k-1 for the observed data is 0.25, which is less than 0.75. The data are, therefore, corrected for sphericity violations using the Greenhouse-Geisser estimate of sphericity (Girden, 1992; Barcikowski & Robey, 1984; Huynh & Feldt, 1976).

Our null hypothesis H01 is rejected because the results of Table 5 demonstrate that the value of metacognition is significantly influenced by metacognitive instructional

Table 1

Factor loadings by Principal Component Factor Analysis of Metacognitive Inventory Rotated by Varimax with Kaiser Normalization

Statement no.	Factor 1 Knowledge	Factor 2 Planning	Factor 3 Information Management	Factor 4 Monitoring	Factor 5 Evaluation
S12	0.782				
S13	0.642				
S16	0.648				
S1	0.568				
S2	0.549				
S14	0.546				
S4	0.384				
S5	0.381				
S18		0.733			
S9		0.649			
S11			0.918		
S6			0.801		
S10				0.787	
S8				0.778	
S15				0.703	
S17					0.783
S7					0.740
S3					0.626

Table 2

Factor-wise Statements after Factor Loadings

Factor	Statements	Item conceptual affiliation
Factor 1	S1, S2, S4, S5, S12, S13, S14, S16	Knowledge of cognition
Factor 2	S9, S18	Planning
Factor 3	S6, S11	Information management
Factor 4	S8, S10, S15	Monitoring
Factor 5	S3, S7, S17	Evaluation

Table 3

Descriptive and Reliability Analysis of Jr. MAI Inventory with its Major Factors

Factor	Primary affiliation	N	No. of items	Mean	SD	Cronbach Alpha
1	Knowledge of cognition	100	8	19.21	3.816	0.794
2	Planning	100	2	3.42	1.703	0.939
3	Information management	100	2	5.94	1.530	0.921
4	Monitoring	100	3	5.61	2.324	0.960
5	Evaluation	100	3	5.78	2.373	0.887

Table 4

Mauchly's test of the sphericity of metacognition measures

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.	Greenhouse-Geisser (Epsilon[b])
MAI	.674	28.537	5	.000	.767

Table 5

Metacognition Scores of Three Intervention Steps for the Control and Experimental Group

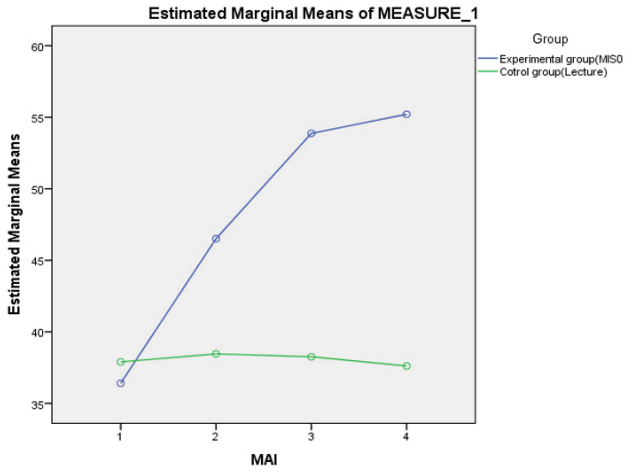
	Control			Experimental		
	N	Mean	SD	N	Mean	SD
M1 Pre-intervention	38	37.80	5.655	38	36.42	6.133
M2 Post-intervention Stage 1	38	38.47	6.522	38	46.52	6.202
M3 Post-intervention Stage 2	38	38.25	3.624	38	53.86	6.713
M4 Post-intervention Stage 3	38	37.52	4.602	38	55.23	7.848
F	162. 292					
Df	2.332					
Sig.	.000					
Partial Eta squared	.681					

strategies, F (2.332, 177.236) = 162. 292, p = 0.000 at the level of significance 0.5. Accordingly, it can be said that metacognitive instructional strategies significantly affect the metacognitive scores of eighth graders in mathematics.

A partial Eta squared value (.681) further documented the significant effect of metacognitive teaching techniques on Mc values during three stages of the intervention for the current study, strongly suggesting a very large effect size. Figure 1 below shows the graphical representation of metacognition in the experimental and control groups at various stages.

Figure 1

Graphical Representation of Metacognition of Experimental Group and Control Group at Four Stages



The experimental group's metacognition mean scores clearly change (rise), while the control group's mean scores stay the same during the study's four measuring instants. The experimental group's mean Mc scores increased significantly after the intervention. This supports the finding that metacognitive instructional strategies significantly affect 8th graders' metacognition when they are completing mathematical problems.

H_{02}: There is no significant variation in the effectiveness of metacognitive instructional strategies on mean metacognition scores of eighth graders with varying abilities.

Table 6

Mauchly's Test of Sphericity for Effect on Metacognition of 8th Graders with Varying Abilities

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.	Greenhouse-Geisser (Epsilon[b])
The gain in MAI scores with varying ability	.805	15.279	5	.008	.854

As a significant value of 0.008 is less than the critical value of 0.05, it means that there are significant differences between variances of differences and therefore, the condition of sphericity has been violated. Fortunately, if data violate the sphericity assumption, we adjust the degrees of freedom for effect. The Greenhouse-Geisser estimate () varies between 1/k-1 and 1(where k is a number of degrees). For the current data, 1/k-1 is 0.25, which is less than 0.75. Therefore, Greenhouse-Geisser's estimate of sphericity is used to correct the data to avoid violations of sphericity (Barcikowski & Robey, 1984; Girden, 1992; Huynh & Feldt, 1976).

Table 7

Descriptive analysis of mean score scores of cognitive behaviours of students with varying abilities before intervention and in three steps of intervention

Groups	Metacognition	Control			Experimental		
		N	M	SD	N	M	SD
Above Average	M1	9	44.1	1.968	9	44.1	2.827
	M2	9	45.4	1.775	9	53.4	2.977
	M3	9	41.7	3.916	9	60.11	2.377
	M4	9	42.5	2.954	9	62.71	2.358
Average	M1	18	38.16	4.030	18	36.25	2.977
	M2	18	37.53	3.703	18	45.67	3.903
	M3	18	37.79	2.551	18	55.38	4.548
	M4	18	37.53	2.912	18	56.33	5.974
Below Average	M1	11	33.1	1.594	11	36.91	2.602
	M2	11	31.4	2.592	11	47.61	3.922
	M3	11	33.8	2.574	11	58.51	2.067
	M4	11	32.8	2.572	11	60.71	2.626
F	227.556						
df	2.581						
Sig.	0.000						
Partial Eta square	0.770						

The results of Table 7 show that the value of metacognition is significantly affected by metacognitive instructional strategies, F (2.581, 186.538) = 227.556, p = .000 < .05 at the p = 0.000 significance level, our null hypothesis H02 is rejected. It is concluded that metacognitive instructional strategies significantly affect Mc of students with varying abilities (above average, average, and below average students) of eighth graders in Mathematics. Furthermore, the partial Eta squared value (0.770) also supported

the significant effect of metacognitive instructional strategies on the metacognition of students with varying abilities (above average, average, and below average) of eighth graders in Mathematics.

Figure 2

Effect of cognitive instruction strategies on the metacognition of the experimental group and control group with variable abilities

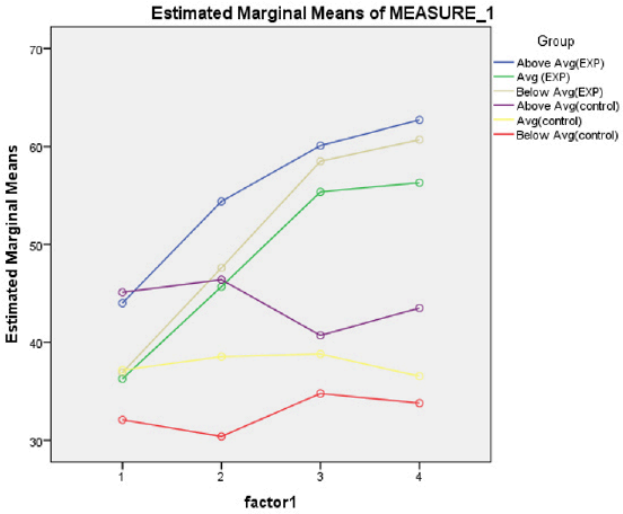


Figure 2 represents the metacognition of all subgroups of the experimental and control groups at different steps in a graphical form.

Discussion

Figure 2 shows the changes in Mc of above-average, average, and below-average students of the experimental and control groups in different colours. In the experimental group, uniformity in the increase of Mc is observed in above-average and average students. In contrast, the graph of below-average shows rather a jump in Mc scores and outperforms even average students. Overall, the metacognitive teaching tactics used in the experimental group significantly increased Mc.

The above graph shows that there is no significant change in Mc scores of above-average, average, and below-average students of the control group. The Mc of the students was found to be positively impacted by metacognitive instructional tactics. These findings demonstrated that teaching using metacognitive instructional strategies can improve students' metacognitive ability. These findings likewise support the results of earlier investigations by Huff and Nietfeld (2009). The results of the above studies all pointed to students who were taught using metacognitive instructional methodologies with much more metacognition. The major goals of metacognitive teaching strategies are to help students recognise and stimulate their thought processes, which in turn helps people improve their metacognition (Mc) (Ozsoy & Ataman, 2009). Since Mc involves reflecting on one's thought process, Amjad and Tabasam (2024) suggested meta-level instructions rather than performance.

Metacognition of average and below-average students was examined before and after all three intervention steps to explore differences in the effects of metacognitive instructional tactics in above-average and below-average students. Generally speaking, after receiving an intervention, all groups show a significant growth in their levels of metacognition. After all intervention measures, students in the above-average group still demonstrate the highest levels of Mc, while those in the below-average group exhibit an astonishingly large increase.

After completing the first step of the intervention, these children even outperformed the average group of students. However, the average students also improved, but the below-average pupils exceeded their Mc level. These findings support earlier research (Pennequin et al., 2010; Iqbal et al., 2016). Metacognitive instructional techniques allowed low achievers to access such a comfortable classroom environment where they could learn to reflect on their deficiencies. This awareness also helps pupils to strengthen their ability to control cognition for efficient learning (Cardelle-Elawar,1995). The surprising achievement of metacognitive training techniques on lower achievers to improve students' metacognition motivates them to utilise such tactics in teaching-learning.

As Schraw (1998) suggested, raising awareness of Mc's existence and importance in academic achievement is the first step to stimulating it. Then comes the ability to employ effective tactics and, perhaps most importantly, awareness regarding when and where to use them. In conclusion, metacognitive instructional strategies greatly impact how well eighth graders at all levels (above average, average, and below average) can solve mathematical and MC problems. Metacognitive instructional tactics help students accelerate their ventures to improve their self-instructional skills.

Recommendations

Metacognitive teaching strategies should be introduced to increase mathematics teachers' knowledge of Mc. Metacognitive instructional methodologies greatly improve the mathematics problem-solving abilities of students who perform below average. To strengthen the weak areas of grade 8 mathematics, it is recommended that the curriculum be expanded to include specific metacognitive teaching tactics such as self-questioning, modelling, thinking aloud, cooperative learning, and scaffolding. In the current study, Mc was only assessed using a metacognitive awareness inventory. Future research

should triangulate the data to validate it using student interviews, think-aloud activities, and observational techniques in the classroom while students solve mathematical problems. It is encouraged to do an experimental study to examine the effectiveness of different metacognitive instructional strategies to assist students in developing their Mc and mathematical problem-solving skills.

Declarations and Conflicts of Interest

Research Ethics Statement

The Research Ethics Committee of The University of Lahore, Pakistan, has approved this study.

Consent for Publication Statement

Not applicable to this paper

Conflict of Interest Statement

The researchers have no conflict of interest over authorship ranking and publication of this paper.

References

Akram, H., Al-Adwan, A. S., Aslam, S., & Khan, M. I. (2023). Pedagogical practices and challenges in cultivating moral values: A qualitative study of primary school teachers in Pakistan. *Education 3-13*, *51*(4), 607-619. https://doi.org/10.1080/03004279.2021.1992471

Amjad, A. I., & Tabbasam, U. (2024). Effect of Brain-Based Learning on Students' Extrinsic Motivation to Learn Mathematics: Introducing Neuroscience to Schools. *Journal of Sustainable Education1*(1), 1-12. https://journals.uol.edu.pk/jse/article/view/2617

Amjad, A. I., Habib, M., & Saeed, M. (2022b). Effect of brain-based learning on students' mathematics performance at the elementary level. *Pakistan Journal of Social Research*, *4*(03), 38-51. https://doi.org/10.52567/pjsr.v4i03.684

Amjad, A. I., Habib, M., Tabbasam, U., Alvi, G. F., Taseer, N. A., & Noreen, I. (2023). The impact of brain-based learning on students' intrinsic motivation to learn and perform in mathematics: A neuroscientific study in school psychology. *International Electronic Journal of Elementary Education*, *16*(1), 111–122. https://doi.org/10.26822/iejee.2023.318

Amjad, A. I., Tabbasam, U., & Abbas, N. (2022a). The effect of brain-based learning on students' self-efficacy to learn and perform mathematics: Implication of Neuroscience into school psychology. *Pakistan Languages and Humanities Review, 6*(3), 683-695. http://doi.org/10.47205/plhr.2022(6-III)60

Amjad, A. I., Tabbasam, U., & Ara, N. (2022). Neuroscientific study on the effect of brain-based learning on students' intrinsic motivation to learn mathematics. *Annals of Human and Social Sciences, 3*(2), 728-742. https://doi.org/10.35484/ahss.2022(3-II)69

Aslam, S., Saleem, A., Hali, A. U., & Zhang, B. (2021). Promoting sustainable development in school classrooms: Using reciprocal teaching in mathematics education. *TEM Journal*, *10*(1), 392-400. https://doi.org/10.18421/TEM101-49

Aydin, U., & Ubuz, B. (2010). Turkish version of the junior metacognitive awareness inventory: The validation study. *Education and Science, 35*(157), 30-45.

Baker, L., & Beall, L. C. (2014). Metacognitive processes and reading comprehension. In *Handbook of Research on Reading Comprehension* (pp. 397-412). Routledge. https://doi.org/10.4324/9781315759609-30

Barcikowski, R. S., & Robey, R. R. (1984). Decisions in single group repeated measures analysis: Statistical tests and three computer packages. *The American Statistician*, *38*(2), 148-150. https://doi.org/10.1080/00031305.1984.10483187

Brown, A. L. (1982). Learning how to learn from reading. *Reader meets author: Bridging the Gap*, 26-54.

Brown, A. L. (1987). Metacognition, executive control, self-regulation, and other more mysterious mechanisms. *Metacognition, Motivation, and Understanding*, 65-116.

Cardelle-Elawar, M. (1995). Effects of metacognitive instruction on low achievers in mathematics problems. *Teaching and Teacher Education*, *11*(1), 81-95. https://doi.org/10.1016/0742-051X(94)00019-3

De-Jager, B., Jansen, M., & Reezigt, G. (2005). The development of metacognition in primary school learning environments. *School Effectiveness and School Improvement*, *16*(2), 179-196. https://doi.org/10.1080/09243450500114181

Desoete, A., & De-Craene, B. (2019). Metacognition and mathematics education: An overview. *ZDM*, *51*, 565-575. https://doi.org/10.1007/s11858-019-01060-w

Dignath, C., Buettner, G., & Langfeldt, H. P. (2008). How can primary school students learn self-regulated learning strategies most effectively? A meta-analysis on self-regulation training programmes. *Educational Research Review*, *3*(2), 101-129. https://doi.org/10.1016/j.edurev.2008.02.003

Dörr, L., & Perels, F. (2019). Improving metacognitive abilities as an important prerequisite for self-regulated learning in preschool children. *International Electronic Journal of Elementary Education*, *11*(5), 449-459. https://doi.org/10.26822/iejee.2019553341

Ellah, B. O., Oche Omaikwu, S., Obinne, A. D. E., & Adikwu, O. (2023). Development and Factorial Validation of Meta-Cognitive Awareness Inventory in Physics (MAIP) for Senior Secondary Students in Benue State, Nigeria. *Journal of Research in Science and Mathematics Education (J-RSME)*, *2*(1), 1-12. https://doi.org/10.56855/jrsme.v2i1.174

Elosegi, P., Rahnev, D., & Soto, D. (2024). Think twice: Re-assessing confidence improves visual metacognition. *Attention, Perception, & Psychophysics*, *86*(2), 373-380. https://doi.org/10.3758/s13414-023-02823-0

Flavell, J. H. (1979). Metacognition and cognitive monitoring: A new area of cognitive–developmental inquiry. *American Psychologist*, *34*(10), 906-911. https://doi.org/10.1037/0003-066X.34.10.906

Gama, C. A. (2005). *Integrating metacognition instruction in interactive learning environments* (Doctoral dissertation, University of Sussex).

Girden, E. (1992). ANOVA. 2455 Teller Road, Thousand Oaks, California 91320 United States of America. *SAGE Publications, Inc.* https://doi.org/10.4135/9781412983419

Habib, M., & Rana, R. A. (2020). Exploring 8th graders' metacognition and its relationship with mathematical academic achievement. *Pakistan Journal of Education*, *37*(1), 61-74. https://doi.org/10.30971/pje.v37i1.1053

Hacker, D. J., & Dunlosky, J. (2003). Not All Metacognition Is Created Equal. *New Directions for Teaching and Learning*, *95*(1), 73-79. https://doi.org/10.1002/tl.116

Huff, J. D., & Nietfeld, J. L. (2009). Using strategy instruction and confidence judgments to improve metacognitive monitoring. *Metacognition and Learning*, *4*(2), 161-176. https://doi.org/10.1007/s11409-009-9042-8

Huynh, H., & Feldt, L. S. (1976). Estimation of the Box correction for degrees of freedom from sample data in randomised block and split-plot designs. *Journal of Educational Statistics*, *1*(1), 69-82. https://doi.org/10.2307/1164736

Jacobs, J. E., & Paris, S. G. (1987). Children's metacognition about reading: Issues in definition, measurement, and instruction. *Educational Psychologist*, *22*(3-4), 255-278. https://doi.org/10.1080/00461520.1987.9653052

Kirbulut, Z. D. (2014). Modeling the Relationship between High School Students' Chemistry Self-Efficacy and Metacognitive Awareness. *International Journal of Environmental and Science Education*, *9*(2), 177-196.

Kramarski, B., & Mevarech, Z. R. (2003). Enhancing mathematical reasoning in the classroom: The effects of cooperative learning and metacognitive training. *American Educational Research Journal*, *40*(1), 281-310. https://doi.org/10.3102/00028312040001281

Livingston, J. A. (2003). Metacognition: An overview. (ERIC Document Reproduction Service No. ED474273). *Education Resources Information Center*.

McCormick, C. C., Dimmat, C., & Sullivan, F. R. (2013). Metacognition, Learning and Instruction: In Willima M. Reynolds, Gloria E. Miller, Irving B. Weiner (Ed.), *Handbook of Psychology* (pp.69-97). NJ: Wiley & Sons, Inc. https://doi.org/10.1002/9781118133880.hop207004

Myers, M., & Paris, S. G. (1978). Children's metacognitive knowledge about reading. *Journal of Educational Psychology*, *70*(5), 680.-690. https://doi.org/10.1037/0022-0663.70.5.680

Otani, H., & Widner, R. L. (2005). Metacognition: New Issues and Approaches Guest Editors' Introduction. *The Journal of General Psychology*, *132*(4), 329-334. https://doi.org/10.3200/GENP.132.4.329-334

Ozsoy, G., & Ataman, A. (2009). The effect of metacognitive strategy training on mathematical problem-solving achievement. *International Electronic Journal of Elementary Education*, *1*(2), 67-82.

Ozturk, N. (2022). A pedagogy of metacognition for reading classrooms. *International Journal of Education and Literacy Studies*, *10*(1), 162-172. https://doi.org/10.7575/aiac.ijels.v.10n.1p.162

Panaoura, A., & Philippou, G. (2005). The measurement of young pupils' metacognitive ability in mathematics: The case of self-representation and self-evaluation. In *Proceedings of Cerme*, 4, 1-10.

Pennequin, V., Sorel, O., Nanty, I., & Fontaine, R. (2010). Metacognition and low achievement in mathematics: The effect of training in the use of metacognitive skills to solve mathematical word problems. *Thinking & Reasoning*, *16*(3), 198-220. https://doi.org/10.1080/13546783.2010.509052

Pintrich, P. R. (2002). The role of metacognitive knowledge in learning, teaching, and assessing. *Theory into Practice*, *41*(4), 219-225. https://doi.org/10.1207/s15430421tip4104_3

Schraw, G. (1998). Promoting general metacognitive awareness. *Instructional Science*, *26*(1), 113-125. https://doi.org/10.1023/A:1003044231033

Schraw, G., & Dennison, R. S. (1994). Assessing metacognitive awareness. *Contemporary Educational Psychology*, *19*(4), 460-475. https://doi.org/10.1006/ceps.1994.1033

Schraw, G., Crippen, K. J., & Hartley, K. (2006). Promoting self-regulation in science education: Metacognition as part of a broader perspective on learning. *Research in Science Education*, *36*(1), 111-139. https://doi.org/10.1007/s11165-005-3917-8

Sperling, R. A., Howard, B. C., Miller, L. A., & Murphy, C. (2002). Measures of children's knowledge and regulation of cognition. *Contemporary Educational Psychology*, *27*(1), 51-79. https://doi.org/10.1006/ceps.2001.1091

Sungur, S. (2007). Contribution of motivational beliefs and metacognition to students' performance under consequential and nonconsequential test conditions. *Educational Research and Evaluation*, *13*(2), 127-142. https://doi.org/10.1080/13803610701234898

Veenman, M. V., & Spaans, M. A. (2005). Relation between intellectual and metacognitive skills: Age and task differences. *Learning and Individual Differences*, *15*(2), 159-176. https://doi.org/10.1016/j.lindif.2004.12.001

Veenman, M. V., & van Cleef, D. (2019). Measuring metacognitive skills for mathematics: students' self-reports versus on-line assessment methods. *ZDM*, *51*(4), 691-701. https://doi.org/10.1007/s11858-018-1006-5

Veenman, M. V., Wilhelm, P., & Beishuizen, J. J. (2004). The relation between intellectual and metacognitive skills from a developmental perspective. *Learning and Instruction*, *14*(1), 89-109. https://doi.org/10.1016/j.learninstruc.2003.10.004

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Integrating Theatrical Arts into Storytelling Instruction in Primary Education: A Theoretical Framework and Practical Applications

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Abstract

This paper analyzed the integration of theatrical arts into storytelling instruction for primary school students. The study aimed to evaluate the impact of theatrical arts on the effectiveness of storytelling teaching, identify suitable theatrical techniques for the content and conditions of teaching, and propose methods for integrating these techniques. The research demonstrated that using theatrical techniques such as facial expressions, gestures, voice modulation, props, and sound enhanced students' engagement, thinking, and memory retention. The selected techniques were detailed and guided for easy application by teachers in the classroom. The study also highlighted important considerations for effectively integrating these techniques into lessons. The primary contribution of this research was the provision of a specific theoretical framework for applying theatrical arts in primary education, offering a more flexible and effective approach to teaching.

Keywords:

Primary Storytelling, Theatrical Arts, Integration, Primary Education, Teaching Innovation

Introduction

Teaching storytelling to elementary school students played a crucial role in the comprehensive development of children's language skills, thinking, and character. Storytelling not only helped students improve their expressive abilities but also stimulated their imagination and critical thinking through the analysis of situations and characters in the stories (Can, 2018; Binder, 2014; Korosidou & Griva, 2024; Yamac & Ulusoy, 2016; Zipes, 2004). Moreover, stories often carried moral lessons and values that helped children absorb and develop their character from an early age. Storytelling also created opportunities for emotional connection between students and teachers, while enhancing communication skills and mutual understanding among students, fostering a positive and humane learning environment (Elenein, 2019; Ramalingam & Mathiyazhagan, 2022).

In the past context, the activity of teaching storytelling to elementary students faced many challenges, particularly

in finding and applying effective and positive teaching methods. One of the biggest challenges was teachers' uncertainty in selecting and implementing active storytelling methods. Teachers often struggled to refresh their teaching content, making lessons less creative and failing to capture students' interest. Traditional storytelling methods often faced difficulties in engaging students' attention and encouraging active participation (Kayılı & Erdal, 2021; Matamit et al., 2020; Satriani, 2019). Therefore, the issue of innovating teaching methods was of great interest to educators.

According to research by Brock (2011) and Catterall (2012), using interactive techniques and integrating multiple media forms could significantly improve the effectiveness of storytelling activities, making them more engaging and effective for students. Other researchers pointed out that applying theatrical techniques to storytelling in education could bring substantial benefits. These techniques not only helped create a lively and engaging learning environment but also tapped into students' artistic creativity (Goldberg, 2021; Kisida et al., 2020). Additionally, incorporating theatrical elements helped students express themselves more confidently and enhanced learning outcomes through highly interactive activities (Russell & Zembylas, 2007). This suggested a promising new method for teaching storytelling to increase its appeal and effectiveness in the past elementary education context.

However, to effectively use theatrical arts in storytelling at a specific educational level like elementary school, it was crucial to explore not only the impact of integrating theatrical arts into storytelling but also to identify suitable theatrical techniques for the past storytelling content and teaching environment in elementary schools. Therefore, the objective of this study was to answer research questions including:

How will integrating theatrical arts impact the effectiveness of storytelling for elementary students? Which theatrical techniques are suitable for the storytelling content and conditions in elementary education to be integrated into the teaching process? And what is the most effective way to integrate these techniques?

Integrating theatrical arts provides new insights into how to improve storytelling teaching methods. This not only helps teachers overcome their uncertainties but also contributes to the broader discussion on creative teaching methods in the context of elementary education today. In this article, we have combined methods such as theoretical research, quantitative survey research, and field observations to address the above research questions.

Literature Review

To gain a deeper understanding of the effectiveness of integrating theatrical arts into storytelling instruction for primary school students, a comprehensive overview of existing research in this field was essential. The objective of this literature review was to analyze key aspects related to the application of theatrical arts in education, including its impact on skill development, the use of storytelling and role-playing, and the benefits to confidence and social skills. Although there was extensive research covering various perspectives, this review focused on a selection of significant and relevant studies that clarified the main points and identified existing gaps. This section also highlighted the limitations of current research, providing a foundation for identifying issues that required further investigation in this paper.

Research on the Impact of Theatrical Arts on Education and Skill Development: Bandura's research on social learning theory laid the groundwork for understanding the impact of creative educational methods, including theatrical arts, on student skill development (Bandura, 1977). Some other research emphasized that artistic activities, such as theater, supported the development of multiple intelligences, including linguistic and bodily-kinesthetic intelligence (Farmer, 2011; Gardner, 1983, 2012; McFadden, 2012; Russell & Zembylas, 2007).

Recent studies demonstrated that integrating theatrical arts into the classroom not only enhanced communication skills but also fostered critical thinking and empathy in students (Agarwal & Verma, 2023; Bigsby, 2000; Giagazoglou & Papadaniil, 2018; Hoan, 2019; McFadden, 2012). However, there remained a significant gap in research regarding the specific effects of various theatrical techniques on other facets of personal development and student learning.

Research on the Application of Drama in Storytelling Education: Research by Anh (2016), Booth (2005), Daniel (2013), Isbell et al. (2004), Milord (2007), Norris (2000), and Satriani (2019) highlighted the role of storytelling and role-playing in developing students' language skills and cultural understanding. These methods were shown to positively impact children's cognitive abilities and storytelling skills, helping them better understand and retain academic content.

McFadden's (2012) study pointed out that while there were clear benefits, challenges remained in effectively applying these methods in the classroom. Previous research did not fully address how and under what conditions these methods could be implemented consistently and effectively across different educational levels.

Research on the Impact of Theatrical Arts on Confidence and Social Skills: The use of theatrical techniques could boost students' confidence and social skills (Bamford & Wimmer, 2012; Carter & Sallis, 2016). These activities not only helped students build relationships with peers but also encouraged the development of teamwork and problem-solving skills.

However, other studies indicated that evaluating the impact of these methods was still limited in terms of data and research contexts (Kyirimi & Tsiaras, 2021). Further studies were needed to examine the long-term effects of theatrical techniques and the cultural factors that influenced their effectiveness.

Limitations and Gaps in Research: Despite numerous studies demonstrating the benefits of theatrical arts and storytelling in education, several significant limitations and gaps remained. One major issue was the hesitation and subjectivity of teachers in applying theatrical techniques to storytelling. This made evaluating the impact of theatrical arts on students challenging and inconsistent.

Moreover, current research often lacked a deep analysis of the influence of specific techniques, cultural factors, and contexts when using theatrical techniques in teaching. This deficiency led to the inappropriate application of theatrical techniques for students' age and the educational environment in primary schools.

Research emphasized the need to expand studies to explore more specific methods and techniques in integrating theatrical arts into the curriculum (Dima et al., 2021; Chang & Winston, 2013). The authors suggested that more experimental research was necessary to provide concrete evidence of the effectiveness of these methods in various educational settings.

Therefore, our focus is on highlighting the benefits of integrating theatrical arts into storytelling instruction for primary school students, identifying appropriate theatrical techniques, and proposing ways to integrate them into the curriculum, thereby providing both experimental and theoretical evidence to improve current educational practices.

Theoretical Framework and Methodology

Art of Storytelling

Storytelling is a creative and structured method of conveying messages and connecting with audiences through narratives. According to Powell (2001), storytelling utilizes words, imagery, and sound to create a profound emotional experience, effectively engaging the audience. Bottomley-O'looney (2012) highlights the role of storytelling in preserving and transmitting culture, arguing that stories uphold cultural values and traditions across generations. Mistry (2017) adds that storytelling not only influences the audience's perceptions and actions but also serves as a crucial tool for exploring and expressing ideas in a vivid and emotional manner. Additionally, Philp (2009) from a teacher's perspective emphasizes the importance of storytelling in education, noting that it aids students in developing language skills and creative thinking. These definitions and perspectives provide a solid foundation for the study of storytelling, highlighting its diversity and power in conveying messages and preserving cultural heritage.

Stage Artistry

Theatre Arts is an intricate and collaborative form of art that brings narratives or concepts to life on stage through a blend of various artistic components. It relies on the skills of actors, along with the strategic use of sound, lighting, set design, costumes, and props. These elements work together to create a rich, multidimensional experience, making Theatre Arts an effective medium for conveying ideas and engaging audiences directly. This art form is frequently applied across different genres, including drama, dance, music, and other stage performances. By integrating various elements from different art forms, Theatre Arts serves as a comprehensive and dynamic means of artistic expression. (Bigsby, 2000; Bogart & Landau, 2004).

The above concepts demonstrate that both storytelling and theatrical arts share fundamental aspects such as using artistic elements to create emotional experiences, connecting and communicating with audiences, exploring and expressing ideas, as well as preserving and transmitting culture. This similarity suggests that integrating these two art forms can enrich the artistic experience and enhance the value of each form.

Theoretical Framework

To investigate the effectiveness of integrating theatrical arts into storytelling education for elementary school students, we employed two main theoretical frameworks: Howard Gardner's Multiple Intelligences Theory and David Kolb's Experiential Learning Theory. These theories provided a robust theoretical basis for analyzing theatrical techniques suitable for student characteristics and developing effective teaching methods.

Multiple Intelligences Theory: Howard Gardner's Multiple Intelligences Theory posited that individuals possessed various types of intelligence, such as linguistic, spatial, bodily-kinesthetic, musical, and logical-mathematical intelligence (Gardner, 2012). In the educational context, this theory emphasized that

teaching methods should be adapted to align with students' different types of intelligence. Applied to this study, the theory helped analyze how theatrical techniques could cater to various intelligences in elementary students. For instance, acting techniques could support bodily-kinesthetic intelligence, while music could engage musical intelligence. Implementing this theory in storytelling education fostered flexible teaching methods suited to diverse intelligences, enhancing student engagement and learning effectiveness.

Experiential Learning Theory: David Kolb's Experiential Learning Theory emphasized that students learned most effectively through real experiences and reflection (Kolb et al., 2014). According to this theory, the learning process involved four main stages: concrete experience, reflective observation, abstract conceptualization, and active experimentation. In the study, theatrical techniques such as role-playing and storytelling created opportunities for experiential learning, allowing students to engage in practical activities and reflect on their experiences. This approach not only deepened students' understanding of storytelling content but also developed soft skills. Applying Experiential Learning Theory helped design learning activities based on real experiences, such as role-playing scenarios and performances, to enhance teaching effectiveness and facilitate learning through action and reflection.

To study the effectiveness of integrating theatrical arts into storytelling education for elementary students, we applied a mixed-methods research approach, combining qualitative and quantitative methods with theoretical analysis. The research methodology was conducted through the following specific steps:

Research Design: The study was designed using an action research method combined with qualitative and quantitative analysis to evaluate the effectiveness of theatrical techniques in storytelling education, identify the most suitable techniques, and determine effective integration methods.

Theoretical Analysis: We applied two main theoretical frameworks: Howard Gardner's Multiple Intelligences Theory and David Kolb's Experiential Learning Theory. The Multiple Intelligences Theory helped explore students' types of intelligence, while the Experiential Learning Theory explained the learning process through real experiences and reflection. The theoretical analysis included synthesizing previous research and educational practice models to build a solid theoretical foundation for the study.

Data Collection: We selected 36 teachers from 9 elementary schools, including both public and private institutions, to gather information on their experiences and views regarding the use of theatrical arts in storytelling education. Surveys and interviews were conducted with random and representative sampling to enhance data accuracy.

We conducted direct observations of classrooms where theatrical techniques were applied to record the implementation process and student participation. Observation and recording forms were used to collect detailed data on students' behavior, interactions, and reactions.

Data Analysis: Content analysis was performed from interviews and classroom observations to identify key themes, trends, and feedback from teachers and students about theatrical techniques. Analysis of survey data assessed the popularity and effectiveness of theatrical techniques based on quantitative indicators such as scores and percentages.

Effectiveness Evaluation and Integration: We assessed the success of theatrical techniques in improving storytelling skills and student engagement. We analyzed results from surveys, interviews, and observations to identify the most effective techniques and contributing factors.

We developed teaching methods based on research findings to integrate theatrical arts into storytelling curricula effectively. Guidelines and teaching materials were developed to support teachers in applying theatrical techniques in the classroom.

Research Ethics Statement: All research procedures were conducted with strict adherence to ethical research principles. We ensured that consent from all participants (both teachers and students) was obtained before conducting surveys and interviews. Collected information was kept confidential and used solely for research purposes. We also adhered to regulations and guidelines for protecting participants' rights.

Research Findings

Benefits of Integrating Stage Arts into Storytelling for Primary School Students

Integrating stage arts into storytelling for primary school students offers several significant benefits:

Improved communication skills: According to Batdi and Elaldi (2020) and Eckersley (2016), incorporating stage arts into teaching helped students develop better communication skills. Students learned to express emotions and ideas through speech and actions, enhancing their ability to communicate effectively.

Enhanced social skills: Stage arts also reinforced social skills such as cooperation and teamwork. Participation

in group activities and performances helped students learn to work together to achieve common goals (Erbay & Dogru, 2010; Remziye et al., 2019).

Encouraged creativity: Using theater arts stimulated students' creativity. Eckersley (2016) pointed out that activities such as role-playing and storytelling helped students develop communication skills while increasing their confidence and ability to express themselves in a multilingual classroom. Similarly, Goldberg (2021) emphasized that integrating the arts into teaching, including storytelling and theater, promoted creativity, social skills, and multicultural understanding among students in a diverse environment.

Characteristics of Students, Storytelling, and Criteria for Selecting Stage Techniques

Primary school students are in a stage of significant cognitive and emotional development, so stories and activities need to be understandable, with emotions appropriate for their age. Stage techniques should be designed to be simple and accessible, matching the psychological development of the children. Given their short attention spans, stage activities must be engaging and not overly lengthy to maintain students' attention (Akmeşe & Kanmaz, 2021; Cornell et al., 1992; Proctor & Burnett, 2004).

The content of stories for primary students is usually simple and educational, including moral lessons and values. Therefore, stage techniques need to support clear and vivid storytelling while encouraging active student participation (Booth, 2005; Daniel, 2013; Sun et al., 2018).

In primary schools, the educational environment often features limited space, short teaching periods of about 40 minutes, and requires that stage techniques be concise, simple, and effective. Stage activities need to be adapted to the restricted classroom space, using available resources, classroom materials, and local supplies to save costs.

When selecting and applying stage techniques for storytelling in primary education, careful consideration is needed to ensure they align with age psychology, story content, educational environment, and teaching time. Techniques that require excessive props or large spaces, do not meet psychological needs, or are too abstract or complex should be avoided as they may not be effective and could pose challenges for students.

Recommended Stage Techniques

Integrating stage techniques into storytelling for primary students not only makes lessons more engaging but also helps develop communication and creativity skills. Here are recommended stage techniques along with their selection reasons and benefits:

Facial Expressions: Use facial expressions to convey the emotions of characters in the story. Facial expressions are a visual tool that helps students easily recognize and feel the emotions of characters, which is crucial for their cognitive and emotional development. This technique helps students visualize and connect with characters, making the story more vivid. It also aids in developing students' ability to recognize and express emotions.

Gestures and Actions: Use gestures and actions to illustrate events and actions in the story. Gestures and actions enhance the liveliness of the story and help students better understand the situations depicted. This approach helps students visualize and retain story details more effectively. It also encourages active participation and develops coordination skills.

Varying Tone and Voice: Change tone and voice to reflect characters, situations, or emotions in the story. This variation helps differentiate characters and makes the story more engaging, keeping students' attention and making learning more enjoyable. This technique improves students' listening and communication skills and helps them develop the ability to express emotions and character traits through voice.

Using Simple or Imaginative Props: Use simple, locally made props to illustrate story elements. Imaginative props, such as hats, scarves, or fake objects, can be easily created and are cost-effective, helping students visualize story elements like characters and events. Pictures and drawings are also powerful tools for highlighting story details.

Props enhance story illustration and appeal while being simple enough to fit within classroom time and resource constraints. They create a lively learning environment, facilitate visualization, and encourage creativity, helping students quickly engage with and act out story elements.

Creating Simple Stage Backdrops: Use materials like whiteboards, drawings, or available items to create stage backdrops for the story. Simple backdrops help set the scene without requiring significant financial or spatial investment. They also make it easier for students to imagine and follow the story. This technique provides a visual space for the story, helps students practice crafting skills and creativity, and enhances focus and interest during lessons.

Role-Playing Storytelling: Conduct storytelling segments with role-switching between students and teachers or among students. Role-switching allows students to experience different aspects of the story and develop role-playing skills.

This technique increases engagement and helps students gain a deeper understanding of characters and situations. It also enhances communication and collaboration skills.

Using Sound and Music: Create or use background sounds and music to enhance the story's effect. Sound and music highlight situations and emotions, making the storytelling experience more dynamic.

Sound and music create a vivid context, helping students imagine and feel different emotions in the story, stimulating imagination and focus.

Methods for Using Selected Techniques to Teach Storytelling

Facial Expressions: Explain to students the role of facial expressions in conveying character emotions. Use images or videos to illustrate how facial expressions enhance storytelling.

Have students practice facial expressions for specific situations in the story, such as happiness, sadness, or fear. Conduct small games where students freely express emotions.

While storytelling, encourage students to use facial expressions to highlight character emotions and help the audience better understand the story.

Gestures and Actions: Explain the role of gestures and actions in clarifying character actions in the story.

Organize group activities where students practice gestures and actions corresponding to different scenarios in the story. For example, simulate actions like walking, jumping, or handling objects.

Encourage students to use gestures and actions while storytelling to enhance the visual appeal and engagement of the story.

Varying Tone and Voice: Explain how changing tone and voice can represent different characters and emotional states.

Have students practice altering their voices for different characters in the story. Use voice modulation exercises to help students become familiar with this technique.

During storytelling, encourage students to vary their tone and voice to differentiate characters and make the story more engaging.

Using Simple or Imaginative Props and Illustrations: Explain how to use simple props or images to support storytelling.

Allow students to use simple props or create illustrations to represent parts of the story. They can also make their own props or drawings for use in the lesson.

Encourage students to integrate props and images into their storytelling to enhance visualization and make the story more vivid.

Creating Simple Stage Backdrops: Guide students on how to create a simple stage backdrop using available materials.

Organize activities for students to create backdrops from paper, fabric, or other materials. Provide guidance and support during the creation process.

Use the backdrops in storytelling sessions to set the scene and make the storytelling experience more engaging.

Role Reversal in Storytelling: Explain the concept of role reversal in storytelling and how it helps deepen understanding of characters and situations.

Have students practice role reversal by switching between characters in a story, changing how they portray each character to gain a deeper insight into the narrative.

Encourage students to use role reversal in storytelling activities to enhance their understanding and creativity in character portrayal.

Using Sound and Music: Guide students on how to use sound and music to create effects in storytelling.

Have students practice using sound and music to support their storytelling, such as using background music to set the mood or sound effects to illustrate events in the story.

Encourage students to integrate sound and music into their stories to make them more engaging and enhance the storytelling experience.

- Does the storytelling teaching method using stage techniques affect the attractiveness and stimulation of the lesson?
- Do these techniques stimulate students' curiosity and thinking?
- Do they increase student interaction and participation in class?
- Additionally, does this method enhance the effectiveness of knowledge transmission and student concentration?
- Do students provide positive feedback about the use of stage techniques?

- Is this method flexible and diverse in application while achieving high effectiveness and performance?
- Does this storytelling teaching method demonstrate creativity and adaptability to different situations?

These questions help gather detailed feedback from teachers on the effectiveness, applicability, and areas for improvement in using stage techniques. The collected data will be analyzed to assess the success of the method and provide recommendations for improving storytelling teaching at the elementary level.

Evaluation and Analysis: After collecting feedback from teachers, the data was analyzed to evaluate the effectiveness of the stage techniques. The results were summarized and presented in a summary table, showing the level of agreement or disagreement among teachers regarding the suitability and effectiveness of each technique. Issues encountered and suggestions for improvement were also summarized to provide recommendations for the future application of the method. This research process allowed teachers and researchers to gain a better understanding of how to integrate stage techniques into storytelling teaching, thus applying and adjusting methods to fit practical conditions and student needs.

The results were summarized in the following table:

The survey results indicated that the storytelling teaching method using stage techniques was highly rated by teachers. Specifically, 88.89% of teachers found that this method made lessons more engaging and interesting, thereby increasing students' enthusiasm for the lessons. Over 85% of teachers believed that this method stimulated students' curiosity and thinking, encouraging exploration and creativity. About 75% of teachers observed an increase in student participation and interaction, making the classroom more dynamic. Nearly 86% of teachers rated the method as effective in transmitting knowledge and improving students' understanding. More than 88% of teachers felt that the method helped enhance students' concentration in the classroom. Over 80% of teachers reported positive feedback from students, indicating that students were satisfied with the method. Around 72% of teachers appreciated the flexibility and diverse applicability of the method, while more than 91% thought the method was highly effective in practical teaching. About 80% of teachers found the method creative and easily adaptable to various learning situations. The interview results also reinforced these findings. In summary, integrating stage techniques into storytelling teaching not only significantly improves teaching quality but also creates a dynamic and engaging learning environment. This method effectively meets students' diverse learning needs and encourages creativity and active participation, contributing to a more comprehensive and effective learning experience.

Discussion

In this study, we further emphasized the benefits of integrating stage techniques into storytelling teaching. The survey results assessing the effectiveness of this

Table 1:

Quantitative Survey Results

Order	Criteria	Strongly Agree		Agree		Neutral		Disagree	
		Votes	Percentage (%)	Votes	Percentage (%)	Votes	Percentage (%)	Votes	Percentage (%)
1	Engaging and Stimulating	18	50.0	14	38.89	3	8.32	1	2.78
2	Stimulating Curiosity and Thinking	16	44.44	15	41.67	4	11.11	1	2.78
3	Student Interaction and Engagement	15	41.67	12	33.33	7	19.44	2	5.56
4	Effectiveness in Knowledge Transmission	16	44.44	15	41.67	4	11.11	1	2.78
5	Enhanced Student Focus	20	55.56	12	33.33	3	8.33	1	2.78
6	Positive Feedback from Students	14	38.89	15	41.67	5	13.89	2	5.55
7	Flexibility and Diversity	13	36.11	13	36.11	7	19.44	3	8.32
8	Efficiency and Effectiveness	18	50.0	15	41.67	2	5.55	1	2.78
9	Creativity and Adaptability	14	38.89	15	41.67	5	13.89	2	5.55

teaching method also demonstrated that applying stage techniques such as Facial Expressions, Gestures and Actions, Changing Tone and Voice, Using Subtle or Imaginary Props, Creating Simple Stage Backgrounds, Role-Playing in Storytelling, and Using Sound and Music had a significant positive impact on teaching quality and the learning environment.

Impact of stage techniques: The research results indicated that using facial expressions and gestures increased engagement and interaction in the classroom. This aligned with previous studies by Eckersley (2016), where similar techniques were shown to improve communication skills and student confidence. The difference in this study was that we detailed these techniques and demonstrated how they could be specifically applied in the context of storytelling teaching, thus clarifying their impact in elementary education settings.

Innovation and flexibility: Changing tone and voice, along with using sound and music, proved effective in enriching the lesson. This supported findings from previous research, such as Reis and Correia (2011), which indicated that sound changes could increase student interest. However, this study added that these techniques also helped improve students' thinking and curiosity, an area that previous research had less focused on.

Effectiveness and practice: Using props and creating simple stage backgrounds helped to establish a clear context for the story, which was consistent with findings from Saearani et al. (2019), where using props was evaluated as beneficial in enhancing students' understanding and retention. The novelty of this study was that we specifically showed how to select and use props based on the actual conditions of the classroom, thereby improving the applicability of stage techniques in different teaching environments.

Conclusion

This study provided new insights into integrating stage techniques into storytelling teaching for elementary school students, thereby clarifying and specifying how these techniques could enhance teaching quality and classroom interaction. The new findings included:

Expanding understanding of the comprehensive effects of stage arts in storytelling teaching for elementary school students. The study demonstrated that stage techniques not only increased student interest but also promoted thinking, interaction, and memory.

Analyzing, synthesizing, and identifying stage techniques suitable for age, storytelling content, and teaching environment that could be integrated into storytelling teaching for elementary students.

Providing detailed guidelines for using selected stage techniques in a way that was practical for elementary teachers and students, such as techniques like facial expressions, gestures and actions, changing tone and voice, using subtle props, creating simple stage backgrounds, role-playing in storytelling, and using sound and music.

Highlighting important considerations when integrating various stage techniques into a storytelling lesson in elementary schools, helping teachers and students be flexible in selecting techniques suitable for actual teaching situations.

The most significant contribution of this study was providing a specific theoretical framework, from criteria for selection to principles and methods for applying stage techniques in primary education. This framework helped teachers gain additional tools to improve their teaching methods. The study also demonstrated how these techniques could be adjusted to fit the practical conditions of individual classrooms and schools, thus opening up more flexible, expansive, and effective approaches in education.

However, the study also had some limitations. Firstly, due to the limited scope of the trial in a few elementary schools, the results may not have fully represented various educational environments, such as schools in remote areas with significant infrastructure challenges. Secondly, the relatively short trial period meant that the long-term impact of these techniques on students' learning processes had not been fully assessed.

Future research should expand the trial scope to different student groups and schools and extend the research period to evaluate long-term impacts. Simultaneously, additional research is needed to explore further how to integrate theatrical techniques with other teaching methods to enhance educational effectiveness.

References

Agarwal, M., & Verma, A. (2023). Integration of performing arts in education: A joyful, retentive and transformative learning. *Research Journal of Humanities and Social Sciences, 14*(2), 61-68. https://doi.org/10.52711/2321-5828.2023.00013

Akmeşe, P. P., & Kanmaz, S. (2021). Narrative to investigate language skills of preschool children. *International Electronic Journal of Elementary Education, 14*(1), 9-22. https://doi.org/10.26822/iejee.2021.14.1.1539

Anh, N. T. V. (2016). *Sử dụng hình thức đóng vai trong dạy học phân môn kể chuyện kiểu bài đã nghe, đã đọc cho học sinh lớp 4, 5* [Using role-play in teaching storytelling for 4th and 5th-grade students]. (Luận văn thạc sĩ, Trường Đại học Sư phạm Hà Nội). https://text.xemtailieu.net/tai-lieu/su-dung-hinh-thuc-dong-vai-trong-day-hoc-phan-mon-ke-chuyen-kieu-bai-da-nghe-da-doc-cho-hoc-sinh-lop-45-1306304.html

Bamford, A., & Wimmer, M. (2012). *The role of arts education in enhancing school attractiveness: A literature review*. EENC Paper, pp. 7-16. http://www.arhiv.kulturnibazar.si/data/upload/school_attractiveness_paper_final_website.pdf

Bandura, A. (1977). *Social learning theory*. Prentice Hall. https://www.asecib.ase.ro/mps/Bandura_SocialLearningTheory.pdf

Batdi, V., & Elaldi, S. (2020). Effects of drama method on social communication skills: A comparative analysis. *International Journal of Research in Education and Science, 6*(3), 435-457. https://eric.ed.gov/?id=EJ1258528

Bigsby, C. (2000). *Modern American drama, 1945-2000*. Cambridge University Press.

Binder, M. (2014). The storied lives children play: Multimodal approaches using storytelling. *Canadian Children, 39*(2), 11-20.

Bogart, A., & Landau, T. (2004). *The viewpoints book: A practical guide to viewpoints and composition*. Theatre Communications Group.

Booth, D. (2005). *Story drama: Creating stories through role playing, improvising, and reading aloud*. Pembroke Publishers Limited.

Bottomley-O'looney, J. (2012). The art of storytelling. *Montana: The Magazine of Western History, 62*(3), 42.

Brock, J. (2011). *Integrating theater arts into the classroom: The new responsibilities of the elementary school teacher* (ED519810). ERIC. Retrieved from https://eric.ed.gov/?id=ED519810

Can, M. V. (2018). *Hoạt động kể chuyện trong dạy học ở trung học cơ sở và trung học phổ thông* [Storytelling activities in teaching at secondary and high schools]. *TNU Journal of Science and Technology*, *191*(15), 205-210.

Carter, C., & Sallis, R. (2016). Dialogues of diversity: Examining the role of educational drama techniques in affirming diversity and supporting inclusive educational practices in primary schools. *Nurture and Care Journal*, *40*(1), 78-88.

Catterall, J. S. (2012). *The arts and achievement in at-risk youth: Findings from four longitudinal studies*. Research Report# 55. National Endowment for the https://eric.ed.gov/?id=ED530822

Chang, L. Y. S., & Winston, J. (2013). Using stories and drama to teach English as a foreign language at primary level. In *Second language learning through drama* (pp. 15-30). Routledge.

Cornell, D. G., Delcourt, M. A., Goldberg, M. D., & Bland, L. C. (1992). Characteristics of elementary students entering gifted programs: The Learning Outcomes Project at the University of Virginia. *Journal for the Education of the Gifted, 15*(4), 309-331.

Daniel, A. K. (2013). *Storytelling across the primary curriculum*. Routledge. https://www.taylorfrancis.com/books/mono/10.4324/9780203155370/storytelling-across-primary-curriculum-alastair-daniel

Dima, A., Kaiafa, E., & Tsiaras, A. (2021). Drama education through storytelling strategy develops students' critical thinking skills. In *3rd International conference on advanced research in education* (pp. 93-192).

Eckersley, M. (2016). Using drama to develop communication skills in the 21st century classroom. *International Journal of Bilingual and Multilingual Teachers of English, 4*(01), 45-49.

Elenein, A. H. A. A. (2019). The effect of utilizing digital storytelling on developing oral communication skills for 5th grade students at Rafah Primary Schools. *International Journal of Language and Literary Studies, 1*(1). https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3420857

Erbay, F., & Dogru, S. S. Y. (2010). The effectiveness of creative drama education on the teaching of social communication skills in mainstreamed students. *Procedia-Social and Behavioral Sciences, 2*(2), 4475-4479.

Farmer, D. (2011). *Learning through drama in the primary years*. David Farmer. Retrieved from Google Books

Gardner, H. (2012). The theory of multiple intelligences. In *Early professional development for teachers* (pp. 133-141). David Fulton Publishers.

Giagazoglou, P., & Papadaniil, M. (2018). Effects of a storytelling program with drama techniques to understand and accept intellectual disability in students 6-7 years old: A pilot study. *Advances in Physical Education, 8*(2), 224-237.

Goldberg, M. (2021). *Arts integration: Teaching subject matter through the arts in multicultural settings*. Routledge. https://www.taylorfrancis.com/books/mono/10.4324/9780367809805/arts-integration-merryl-goldberg

Hoan, N. T. (2019). *Giáo dục nghệ thuật trong việc hình thành, phát triển phẩm chất và năng lực của học sinh* [Arts education in forming and developing students' qualities and abilities]. Retrieved from https://moet.gov.vn/giaoducquocdan/giao-duc-trung-hoc/Pages/default.aspx?ItemID=6135

Isbell, R., Sobol, J., Lindauer, L., & Lowrance, A. (2004). The effects of storytelling and story reading on the oral language complexity and story comprehension of young children. *Early Childhood Education Journal, 32*, 157-163.

Kayılı, G., & Erdal, Z. (2021). Children's problem solving skills: Does drama based storytelling method work? *Journal of Childhood, Education and Society, 2*(1), 43-57.

Kisida, B., Goodwin, L., & Bowen, D. H. (2020). Teaching history through theater: The effects of arts integration on students' knowledge and attitudes. *AERA Open, 6*(1), 2332858420902712.

Kolb, D. A., Boyatzis, R. E., & Mainemelis, C. (2014). Experiential learning theory: Previous research and new directions. In *Perspectives on thinking, learning, and cognitive styles* (pp. 227-247). Routledge.

Korosidou, E., & Griva, E. (2024). Fostering Students' L2 Writing Skills and Intercultural Awareness Through Digital Storytelling in Elementary Education. *International Electronic Journal of Elementary Education, 16*(5), 585-597.

Kyrimi, K., & Tsiaras, A. (2021). Drama in education as a tool for enhancing self-efficacy in primary school children. *Drama Research: International Journal of Drama in Education, 12*(1), 1-18.

Matamit, H. N. H., Roslan, R., Shahrill, M., & Said, H. M. (2020). Teaching challenges on the use of storytelling in elementary science lessons. *International Journal of Evaluation and Research in Education, 9*(3), 716-722.

McFadden, L. B. (2012). Integrating theatre arts techniques into your curriculum. *Kappa Delta Pi Record, 48*(2), 87-91.

Milord, M. (2007). *The effects of using storytelling on reading comprehension through drama and theater* (Doctoral dissertation, SUNY College at Brockport). https://core.ac.uk/download/pdf/233571799.pdf

Norris, J. (2000). Drama as research: Realizing the potential of drama in education as a research methodology. *Youth Theatre Journal, 14*(1), 40-51.

Philp, M. (2009). The art of storytelling: A teacher's perspective. *Practically Primary, 14*(2), 7-10.

Powell, G. R. (2001). Opening statements: The art of storytelling. *Stetson Law Review, 31*, 89.

Proctor, R. M., & Burnett, P. C. (2004). Measuring cognitive and dispositional characteristics of creativity in elementary students. *Creativity Research Journal, 16*(4), 421-429.

Ramalingam, K., Jiar, Y. K., & Mathiyazhagan, S. (2022). Speaking skills enhancement through digital storytelling among primary school students in Malaysia. *International Journal of Learning, Teaching and Educational Research, 21*(3), 22-35.

Reis, S., & Correia, N. (2011). The Perception of Sound and its Influence in the Classroom. In *Human-Computer Interaction–INTERACT 2011: 13th IFIP TC 13 International Conference, Lisbon, Portugal, September 5-9, 2011, Proceedings, Part I 13* (pp. 609-626). Springer Berlin Heidelberg.

Remziye, C., Feride, G. C., & Betul, D. (2019). The effect of drama activities on five-year-old children's social skills. *Educational Research and Reviews, 14*(12), 434-442.

Russell, J., & Zembylas, M. (2007). Arts integration in the curriculum: A review of research and implications for teaching and learning. In *International handbook of research in arts education* (pp. 287-312). Springer.

Saearani, M. F. T., Alfarisi, S., Chan, A. H., Abdullah, Z., & Azib, N. M. (2019). Improvement of Children's Imaginative Abilities by using Props through Creative Movement Activities. *International Journal of Academic Research in Business and Social Sciences*, *9*(6).

Satriani, I. (2019). Storytelling and its impact on student engagement and learning: A study of English as a Foreign Language learners. *Journal of Language Teaching and Research, 10*(1), 1-10.

Sun, Z., Yao, X., You, J., Du, W., & Luo, L. (2018). Detecting the correlation between mobile learning behavior and personal characteristics among elementary school students. *Interactive Learning Environments*, *26*(8), 1023-1038.

Yamac, A., & Ulusoy, M. (2016). The Effect of Digital Storytelling in Improving the Third Graders' Writing Skills. *International electronic journal of elementary education*, *9*(1), 59-86.

Zipes, J. (2004). *Speaking out: Storytelling and creative drama for children* (1st ed.). Routledge. https://doi.org/10.4324/9780203338803

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Fieldwork Integration Into The Primary School Curriculum To Develop Complex Scientific Thinking

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Abstract

The study of complexity is an important part of science education. This paper presents a pedagogical option that includes potentially feasible field solutions for complex science teachers. This work aims to examine how fieldwork has appeared in the international literature over the past five years and to explore the algorithms that can be used to develop complex scientific thinking skills in children. This work can provide a basis for teaching science in other countries, as fieldwork can be adapted based on the learning results. We wish to draw attention to the need for a methodology for teaching fieldwork that includes examples of coenology and presents the relevant learning outcomes that could be achieved through fieldwork in primary schools.

Keywords:

Fieldwork, Networks, Thinking Skills, Outdoor Education

Introduction

Objectives for Understanding Systems, Complex Thinking, and Field Practice

Curricula are the defining units of educational systems that determine the direction and possibilities of the content of education. When we want to improve the content, for example, by integrating fieldwork with classroom teaching, it is necessary to review the curricula. Since this work aims to examine fieldwork in light of the development of systemic and complex thinking, it is essential to define the basic conceptual network.

A complex system has different smaller parts, that is, elements (Molnár et al., 2023), which perform specialized but not necessarily different functions and whose interactions result in an integrated response (Molnár et al., 2023). Many complex subnetworks are embedded in a master network at a higher level (Ngo et al., 2020).

The development of complex thinking is a cardinal issue in science education, as this challenge is always problem centered. We were curious to see whether the possibility of fieldwork in primary education is reflected in the international literature. As explained in this paper, we could not find any practical recommendations for fieldwork, therefore we set ourselves the challenge of reviewing the international

literature to review the established use of fieldwork, and secondly, given the highly interdisciplinary nature of science in its approach to inquiry, we wanted to explore the literature background of complex thinking. Curriculum development can only be effective if it integrates knowledge from transparent literature studies, so we want to take this into account when formulating curriculum recommendations that science education professionals can put into practice. Thus, our work is multilevel, as we want to establish the theoretical background by a transparent literature review, and then, by looking for common nodes in different standards, such as the Hungarian and the US standards, we can make concrete recommendations for the development of field practice and complex thinking, all in the context of primary school. Therefore, we evaluate and synthesize the existing literature and propose a pedagogical approach to integrate fieldwork into science education. Synthesis of literature is essential to develop a curriculum that can be applied to the harmonized unity of fieldwork and complex thinking.

In this paper, our main objective is to examine how fieldwork has appeared in the international literature over the past five years and to explore the algorithms that can be used to develop complex thinking. Is it possible for the possibility of fieldwork in science education to provide a complex teaching methodology? Can fieldwork in science education provide a pedagogical methodology for teaching complexity?

Complex Thinking and Fieldwork

Developing system thinking provides an interdisciplinary approach to tackling interdisciplinary problems (Norris et al., 2022).

Maison et al. (2020) show that scientific subjects need to be strongly linked to the learning process in the environment. Considering the lack of studies relating to primary education, what can we take from the studies related to secondary and post-secondary fieldwork and systems thinking and apply to primary education? To answer this question, we wanted to look for a context in the available literature on how the development of complex thinking is applied in secondary schools and higher education, and whether all these knowledge and algorithms can be converted to the development of primary school, and whether fieldwork can be linked to all this in a way that meets the requirements of the curriculum. In the following we want to present a theoretical framework that is a prerequisite for complex thinking, in a way that will also be focused on field practice.

Conditions of Complex Thinking

To be able to recommend an integrated approach, it is necessary to understand which basic- or higher-level thinking operations are involved in scientific thinking. We need to approach this from a critical perspective because we want to make our recommendations for curriculum development in primary schools. When reviewing the literature, field-based solutions have not been found in primary school practice, but they can represent a cardinal opportunity for the development of complex thinking. But what are the elements of thinking linked to science learning? This kind of learning is geared towards a systematic exploration of nature and, therefore, the basis for experiencing the joy of discovery and developing a scientific attitude. The joy of discovery is also an age-specific characteristic of primary school children, which curricula should help to capture, for example, by providing opportunities for children to carry out simple experiments to determine soil properties, record their results in drawings and/or writing, and thus learn the need to record and document data in nature. Since the direction of education is determined by the curriculum, the curriculum can contribute to scientific knowledge by enabling students to observe living and non-living materials in the environment, to make estimates of the size and age of deciduous trees in the forest, for example, while enriching their knowledge of species, measuring perimeter, and converting units of measurement during fieldwork. Based on the work of Momsen et al. (2022), three phases of system building are essential: 1. emergence, which means that complex systems evolve from the interaction of elements, 2. hierarchy, according to which complex systems are nested, and 3. control, which means the existence of feedback loops. Therefore, if we approach the use of fieldwork from the perspective of complex thinking, we need to synthesize the above-mentioned content when developing the curriculum. Ramírez-Montoya et al. (2022) suggests that complex thinking can be broken down into four main sub-competences: critical, systemic, scientific, and innovative thinking. Curriculum can contribute to the development of all of these by helping students understand living organisms and their communities as complex systems. The student will be able to distinguish the leaf shape of different plant species, draw it, and make a print of the trunk of a tree species, as allowed by the curriculum. According to Alsarayreh (2021), critical thinking involves extending the thinking process to make sense of context and has several components, such as interpretation, analysis, evaluation, interference, explanation, and self-regulation. These theoretical units should also form part of the curriculum linked to the field experience, as they provide the causal link between the part and the unit, but this requires conscious practical planning. It is important to note that critical

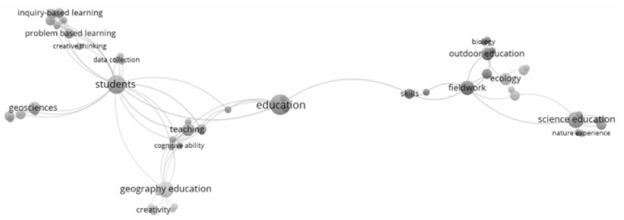
thinking and problem solving are closely correlated. Critical thinking is relevant in many disciplines, including business education (Calma & Davies, 2021). Critical thinking helps to evaluate different situations and contributes to the systematization of thinking (Aktoprak & Hursen, 2022). Systems reasoning is the metacognitive system that students need to develop to analyze complex global systems. Metacognitive skills play a crucial role in cognitive activities and processes such as communication, language, perception, and attention retention (Amran et al., 2021). The development of reflective thinking is essential for a science-demanding identity (Guo et al., 2022; Ünver & Yurdakul, 2020). During fieldwork, learning conditions should be created in such a way as to give students the opportunity to reflect on the events and changes they experience, which is also part of the planning phase. There is a link between scientific thinking and mathematical skills in problem solving, elementary calculations, and estimates are essential for field education. According to Akben's work (2020), structured, semi-structured, and free problem solving activities also improve students' problem solving skills. Science learning can be effective if it is fundamentally related to everyday problems. Thus, the curriculum can support the development of all these components by enabling students to observe the main features of forest communities through experiential learning in fieldwork, as they are able to interpret the forest as a community, to recognize and explain the habitat-lifestyle-body structure relationships in forest communities, and to construct food chains based on the forest plant and animal species encountered, all through the mental application of the elements mentioned above.

Can Fieldwork Support The Development of Complex Thinking?

As shown in the previous unit, systemic thinking can be the result of the harmony of several mental processes. But can practical possibility support this process? What skills, abilities, and attitudes are required during field practice? Can the information from the results of secondary and higher education be applied to the implementation of fieldwork in primary schools? Thinking operations can be a milestone in making fieldwork fit into the curriculum. Fieldwork is a distinct group of research works that is represented in several disciplines. The definitive approach to fieldwork is to say that fieldwork is nothing more than activities carried out at least semi-outdoors in a self-contained, uncontrolled environment, which is very different from the confined environment of laboratory work (Brinitzer & Benson, 2022). When combined with a research-based approach, fieldwork can be an outstanding tool for experiential learning while developing critical thinking, problem solving, interpersonal skills, and affective skills (Praskievicz, 2023). Bloom's taxonomies are thus closely associated with the development of higher-order thinking skills (Foo & Foo, 2022). The relationship between the key concepts associated with work is illustrated in Figure 1.

Figure 1

Keywords of the studies and connection nodes (made with VOSviewer)



Learning to see the Earth as a system can develop competencies that help students to see the relationships between Earth systems and enable individuals to approach their own role in the complex whole in a reflective way. Therefore, it is necessary to emphasize that analytical and reflective thinking must be embedded in effective curriculum development. To understand the environment, students need to integrate several aspects: on the one hand, the interaction between the Earth's systems, such as the geosphere, the hydrosphere, the atmosphere, the biosphere, and, on the other hand, the human being is part of this system. This requires a higher level of thinking, such as the ability to think in systems (Vasconcelos & Orion, 2021).

Of particular importance in this context is the process of learning, which is a specific process mechanism in human society (Downey et al., 2022). So, it is already clear that the use of the previously mentioned thinking operations is reflected in the fieldwork. A biocoenosis is a unit that is a set of populations linked by direct or indirect relationships, so during the fieldwork, we can examine not only a single population but the interconnected relationship of populations, while living systems are also linked to abiotic systems such as soil, air, water and are in balance, so the relationship of cause and effect allows the development of complex thinking. However, additional skills can also be developed, including spatial skills (McNeal & Petcovic, 2020). Pfeifer et al. (2020) emphasize the role of the multicontext model of fieldwork, in which the harmony of knowledge and action plays a key role; this harmonious dual principle must also be followed by curricular requirements to develop complex thinking in students, but it also brings to life the need to provide space for outdoor activities alongside classroom teaching.

Systems can evolve into dynamic and self-sustaining networks in which regulation is an important guiding factor (Doostmohammadian & Rabiee, 2023). From a curriculum theory perspective, it is the central set of laws that determines its elements and their functioning,

organizes the structure of the curriculum, and thus determines at each grade level, which elements must necessarily appear in the teaching of life communities. This must be developed in the minds of children, as it is necessary to know how or why forests, fields, lakes, etc., as communities, cannot return to their equilibrium state after the perturbations. In addition to classroom learning, fieldwork integrated into the curriculum can support the integration of theory and practice more strongly.

Fieldwork can be a good tool to improve complex thinking. From an epistemological point of view, the role of the observer (including the student who observes and analyzes in the field) is of particular importance in shaping knowledge, and the capacity to act is also distributed in a networked way, in which transdisciplinarity is of particular importance (Walsh et al., 2021; Blázquez-Salom & Blanco-Romero, 2020). Field activities are difficult to organize within the constraints of the school, but they are a way of activating the capacity for discovery and maintaining motivation, especially in science subjects where motivation to learn is significantly reduced (Aljuwaiber, 2022). To what extent can planned activities build on prior, learned, or new knowledge (Kervinen et al., 2020). In the case of new knowledge and concepts, there is an opportunity to observe the elements of a complex entity and the relationships between them (Ballantyne & Packer, 2002).

With advances in technology, Petersen et al. (2020) present the possibility of an expedition in a virtual environment. While virtual fieldwork undoubtedly contributes to the development of students' declarative knowledge, in this work, we want to emphasize the importance of immersion in a real nature. Virtual field trips support e-learning and can be a good complement to classroom instruction (Horota et al., 2023; Ocak et al., 2023). Fieldwork satisfies five essential educational development objectives: (1) environmental awareness, (2) knowledge transfer, (3) attitudes, (4) action skills, and (5) action experiences. A competency-based approach to science teaching in primary schools suggests that practical activities should be provided to children. This requires developing students' cognitive abilities, providing activities for cognitive processes, providing tasks for learners in a way that helps them to experience creative activities, and incorporating emotional elements in the cognitive process (Izatulloyevich, 2020).

Methods

Research Questions

To analyze the characteristics of complex thinking and fieldwork, two research questions were posed, as shown in Table 1.

Table 1

Themes and research questions (RQ)

Themes	Research questions (RQ)	Possible answers based on the literature
General characteristics of fieldwork	RQ1. What areas of competence can fieldwork develop?	Systematic thinking Complex thinking Critical thinking Innovative thinking
	RQ2. How can fieldwork be linked to primary education and curricula?	Curriculum analysis Key competencies

Bibliography Analysis

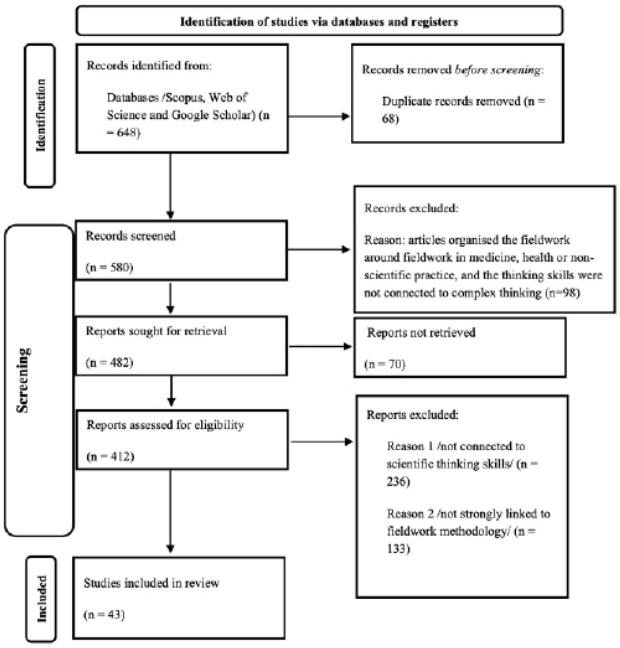
We considered review data collection to be important, as the theoretical basis for curriculum development requires the appropriate scientific information to be filtered. Based on the results, we intend to formulate our recommendations if we can find a link and get a relevant picture of the potential for developing fieldwork and complex thinking. Using a comprehensive literature search using three databases (Scopus, Web of Science, and Google Scholar), 648 studies were identified as relevant. Keywords used for the search were fieldwork, education, natural sciences, thinking skills, complex thinking, and primary school. The data retrieved from the searches were imported into a Microsoft Excel sheet and duplicates were removed. The following information was considered in the data extraction:

- study's characteristics,
- a bibliography including the first author,
- based on publications in the last five years.

After removing duplicates, 580 records remained. These were selected based on their titles, resulting in the exclusion of 98 reports, the exclusion was because the articles organized the fieldwork around fieldwork in medicine, health, or non-scientific practice, and the interpretations of thinking skills were not presented in a way that could be adapted to the work. The remaining reports were screened based on keywords, excluding another 70 reports. A total of 412 articles were selected to review their abstracts. After excluding another set of full-text articles for various reasons (370); only 43 articles made it to the final inclusion list, these articles have been the most effective in supporting the message of this work.

When selecting articles for the manuscript, the authors considered several criteria, including relevance, scientific reliability, and timely information. The focus was on fieldwork in education, fieldwork efficiency, and improvement of field education. Figure 2 illustrates the study selection process as per the PRISMA guidelines. In this work, the interpretation of the system theory background was not part of the review process, as the focus was on the pedagogical-psychological aspects.

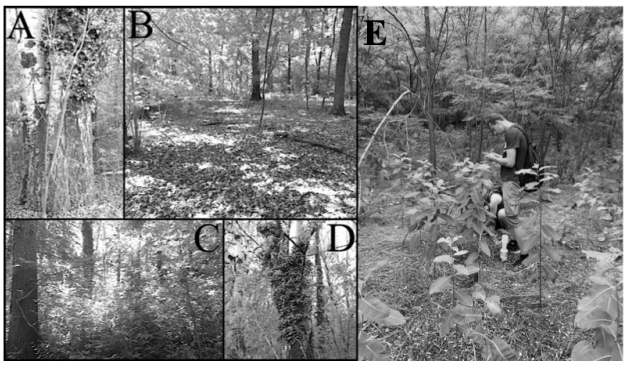
Figure 2
The principle of a work-linked review process



Potential Implementation Option for Field Education

The present work provides an opportunity to carry out a real-life habitat census in an outdoor educational setting with students, in a cooperative working format, where the roles of scribe, notary, timekeeper, and task manager are shared among the children, the teacher acting as facilitator. The pilot habitat is in the south-west part of the city of Hódmezővásárhely, Hungary. The pilot habitat is located close to the primary school, about 15 minutes away, so it is easily accessible on foot (Figure 3). There are residential buildings, a motorway, and a train line.

Figure 3
View of the studied forest: A: In the quadrat of the first group, with white poplar (Populus alba L.) in focus, B: In the quadrat of the second group, C: In the quadrat of the third group D: In the quadrat of the fourth group, E: working in the quadrat.



In the sampling area, 8 of the 10x10 m quadrats were designated; since this quadrat size correlates with the minimum areal size of the area, the individual plant species were assessed in the quadrats and categorized by the number of individuals and species. Families of plant species were also determined. The survey can be carried out by children working in groups and the results must be recorded in a common protocol. The students recorded the quadrat cover of seedlings and nonseedlings, which may provide them with perceptual experience of the buffering effect of forest air temperature.

Determination of The Age of Tree Species

We identified seedling and nonseedling tree species in the quadrats, then recorded the phylogenetic distribution of the nonseedling species and organized the data into a coenological table. Based on the mean diameter of the stem, the estimated age of the tree species studied within a given quadrat was determined following the work of Radó (Radó, 1999).

Associated Learning Outcomes

To adapt the work to education, we created a matrix in which we thematically identified the complex topic area to which the field study could be linked for primary school grades 5-6, and formulated learning outcomes according to Bloom's taxonomy. In outcomes-based education, learning outcomes must be clearly defined, as they determine the content and structure of the curriculum, the teaching methods and strategies, the assessment process, the learning environment, and the time allocation of the curriculum. They also provide a framework for the evaluation of the curriculum.

Limitations of The Work

The limitations of the methods described in the study are determined on the one hand by curricular requirements and on the other hand by the natural environment. However, to develop the skills and abilities needed to develop complex thinking skills related to natural sciences, it is necessary to educate and train children in nature. The methods described provide opportunities to develop thinking skills and complex scientific thinking, especially for primary school students. The limiting factor is the children's insufficient knowledge of the species, which requires pedagogical and methodological training, and the tools presented in this work make it possible to develop all these factors. The limit factor may be that we searched 3 databases for relevant literature.

Results

The results are organized thematically into three units to present the results of the literature review and to make recommendations for potential curricular improvements aimed at developing complex thinking by integrating fieldwork.

Research Questions

RQ1. What areas of competence can fieldwork develop?

Fieldwork starts with observation, which is the first step in thinking operations. The collected results need to be organized, recorded, and analyzed, which requires the student to be able to think in systems (Blázquez-Salom & Blanco-Romero, 2020; Brinitzer & Benson, 2022; Petersen et al., 2020; Vasconcelos & Orion, 2021; Walsh et al., 2021).

Environmental attitude is essential for critical thinking, as well as for experiencing the joy of exploration, while exploration is also dominant in the use of fieldwork (Janoušková et al., 2023; Maison et al., 2020). Critical thinking, analytical thinking, problem solving, and decision making skills are also important for the development of critical thinking and fieldwork (Momsen et al., 2022; Panthalookaran, 2022 Ramírez-Montoya et al., 2022). In all these processes, the individual learns that complex systems are formed by the interaction of elements and that these complex systems are also embedded in each other (Alsarayreh, 2021; Putri & Prodjosantoso, 2020). The thinking process is about finding connections, and complex, systemic, scientific, and innovative thinking, as well as problem solving skills, have been given a cardinal role in the critical thinking process and fieldwork activities (Akben, 2020; Aktoprak & Hursen, 2022; Calma & Davies, 2021; Guo et al., 2022; Moneva et al., 2020; Rini & Aldila, 2023).

Fieldwork is research-based and therefore necessarily develops critical thinking, problem solving, interpersonal skills, and affective skills (Praskievicz, 2023). As students need to be able to evaluate processes in the environment, primary school science teaching should provide children with hands-on activities. This requires developing students' cognitive abilities, providing activities for cognitive processes, and providing tasks for students to do in a way that helps them to experience creative activities. Fieldwork is interdisciplinary. Therefore, it enables the development of systemic thinking, since to interpret the processes and changes taking place in the field, on the one hand, scientific concepts have to be interpreted and then applied actively, but this also requires competences such as the competence of innovation and creative work. As fieldwork can arouse interest in interpreting phenomena in the living and non-living environment, it can vigorously develop learning competences, and field observations reveal unique phenomena for which, in addition to qualitative changes, the interpretation of quantitative changes is essential, thus developing mathematical and thinking competences.

RQ2. How can fieldwork be linked to primary education and curricula?

Scientific subjects should be strongly linked to the environment in the learning process (Maison et al., 2020) and, therefore, also to the curriculum. In our review process, we found no primary school field experience knowledge sharing over the past five years, mostly articles from higher education and secondary school experiences (Brinitzer & Benson, 2022; Brevik et al., 2022; Emery et al., 2021; Ghail & Standing, 2020; Horota et al., 2023; Ocak et al., 2023; Petersen et al., 2020; Wasieleski et al., 2021). It can develop competences in students that help them to see the connections between the systems of Earth and enable them to approach their own role in the complex whole in a reflective way (Vasconcelos & Orion, 2021), which also contributes to the development of spatial skills and higher-level thinking skills (McNeal & Petcovic, 2020; Oxenswärdh & Persson-Fischier, 2020; Siponen & Klaavuniemi, 2021). These skills can already be developed in primary school students, and as curiosity and the joy of discovery are age-specific, they can be linked to active activities in primary school.

They are also time-consuming for the teacher, but guided outdoor activities are an excellent way to motivate children. There is a close relationship between scientific and mathematical thinking and skills, which are closely associated with problem solving, observation, interpretation, analysis, synthesis, and evaluation of scientific processes. However, all this requires the systematic development of critical thinking, analytical thinking, reflective thinking, problem solving, and decision making skills (Calma & Davies, 2021; Guo et al., 2022; Janoušková et al., 2023; Maison et al., 2020; Momsen et al., 2022; Ramírez-Montoya et al., 2022; Walsh et al., 2021 Wasieleski et al., 2021). The curriculum should allow the teacher to ensure that the outcomes are met through methodological freedom in the form of extracurricular activities. This can only be achieved if the curriculum is flexible. The delivery of the curriculum can be validated through outdoor activities.

Table 2 provides a summary of the literature. The evaluation has been structured into three thematic groups according to the professional content, which allows us to link fieldwork and complex thinking.

Presentation of the data from the pilot sample in terms of learning outcomes

The following is an analysis of the diagrams of the average age of the species in each quadrat, which can mobilize the digital skills of students by allowing them to create the diagrams. The explicit development of mathematical skills is a direct objective, as they need to understand how to represent data and the need to use descriptive statistics (e.g., mean, standard deviation).

The average age can be approximated using the work of Radó. Using the average circumference of the plant individuals found in the quadrats, the age can be obtained from Radó's table according to the values given. In calculating the average age, we have plotted individuals that reached a height of 150 cm, so that their circumference could be measured in this plane, and individuals below this height are not represented in these average age diagrams. Of course, students can also record seedlings or individuals that have not reached 150 cm in height, thus obtaining a complete picture of biocoenosis.

Table 2.

Literature links between complex thinking and fieldwork

Summary aspects of professional trends in the literature	Literature linking the professional areas	
	Literature related to fieldwork	Literature related to complex thinking
System thinking requires basic analytical and systematic skills from learners, such as critical thinking, the joy of discovery, problem solving and decision-making skills, which are linked in the relevant literature. Students need to see that systems and elements are organized through interactions.	Blázquez-Salom & Blanco-Romero, 2020; Brinitzer & Benson, 2022; Petersen et al., 2020; Vasconcelos & Orion, 2021; Walsh et al., 2021; Janoušková et al., 2023; Maison et al., 2020; Momsen et al., 2022; Panthalookaran, 2022; Ramírez-Montoya et al., 2022; Alsarayreh, 2021; Putri & Prodjosantoso; 2020 Akben, 2020; Aktoprak & Hursen, 2022; Calma & Davies, 2021; Guo et al., 2022; Moneva et al., 2020; Rini & Aldila, 2023	Maison et al., 2020; Calma & Davies, 2021; Guo et al., 2022; Janoušková et al., 2023; Maison et al., 2020; Momsen et al., 2022; Ramírez-Montoya et al., 2022; Walsh et al., 2021; Wasieleski et al., 2021
Fieldwork is a research-based activity, so the development of interpersonal and emotional areas is an essential aspect of content development.	Praskievicz, 2023	McNeal & Petcovic, 2020; Oxenswärdh & Persson-Fischier, 2020; Siponen & Klaavuniemi, 2021
The demand for scientific thinking implies a complex vision through discovery, with active learning through action being of paramount importance. The mechanisms of scientific reasoning are also closely linked to analytical thinking.	Blázquez-Salom & Blanco-Romero, 2020; Brinitzer & Benson, 2022; Petersen et al., 2020; Vasconcelos & Orion, 2021; Walsh et al., 2021	Brinitzer & Benson, 2022; Brevik et al., 2022; Emery et al., 2021; Ghail & Standing, 2020; Horota et al., 2023; Ocak et al., 2023; Petersen et al., 2020; Wasieleski et al., 2021; Vasconcelos & Orion, 2021

Figure 4

Results representation of the pilot method with process tracing (1-4 quadrats)

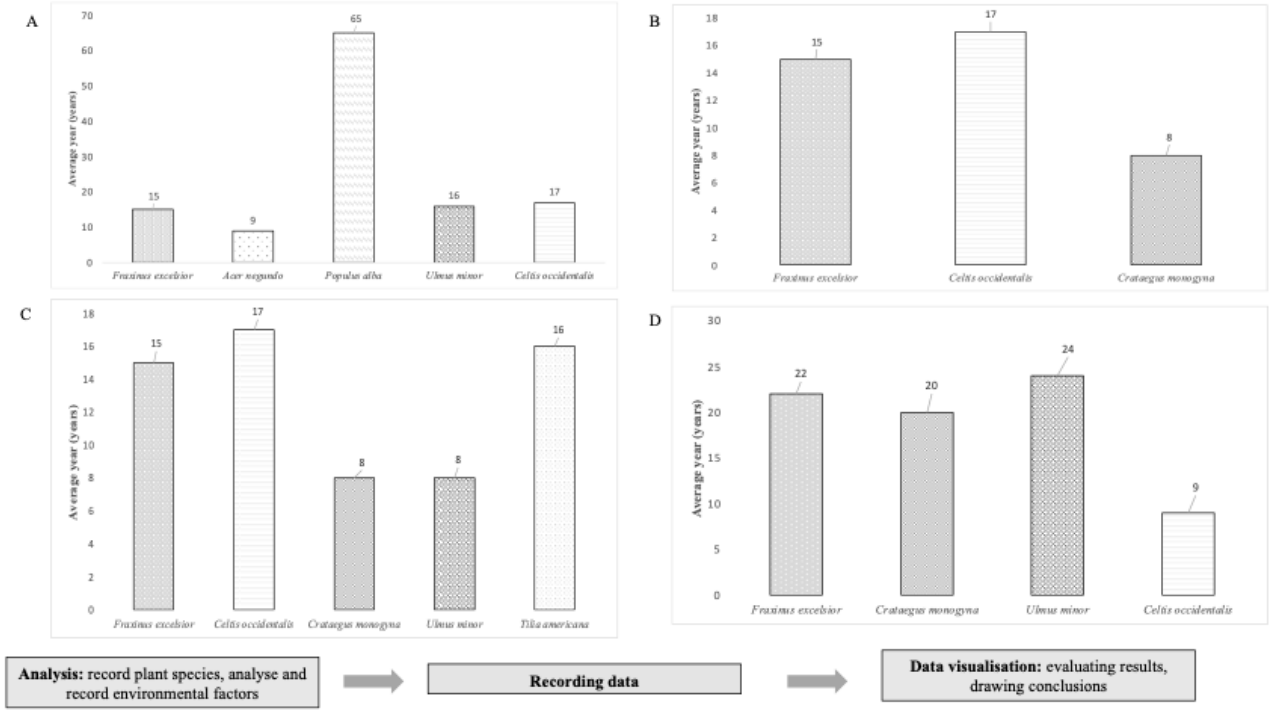


Figure 4 shows the average age of the tree species in the four quadrats. In Figure 4 A, the white poplar is the oldest species in the quadrat studied. This species is also a typical tree of lowland forests. The green maple is the latest species to establish itself. This plant has been established in the Hungarian Great Plains since the 1960s, mainly in floodplain forests and acacia plantations, which can provide children with important information to develop a sense of responsibility for the environment. Figure 4 B shows that Crataegus monogyna (Jacq.) is the youngest plant species (children did not use the Latin names of the species), with older individuals that can be measured by quadratic metrics and have an average age. Analyzing the quadrats makes it possible to develop a habitat profile of the plant species. Tree species of similar age represent themselves in each community with a different appearance, which can mobilize children's explorative qualities.

When we look at communities in network theory, we distinguish between weak and strong connections. A network link is called weak if its removal or addition does not significantly affect a characteristic property of the network. Therefore, we can say that a network link is strong if the opposite is true. Another way of putting this is that a relationship is stronger the more likely it is that two elements that are related to each other are related to other elements that are not. Weak links play an important role in the life of networks. While strong links create small groups of closely connected elements, islands, weak links connect these islands together as a bridge. Thus, we can say that weak links hold the network together, stabilizing it (Molnár et al., 2023). Therefore, their role is essential if we want to create a functioning network. This is an exciting aspect that can be explored with the students, using the elements of quadrat four as a starting point (Figure 4 D). To what extent can the removal of certain individuals modify complexity, for example, if we consider the removal of a floodplain plant? Can environmental conditions change if an older species with a larger canopy is removed from the system? The students estimated the cover of a given plant species with and without seedlings in their quadrat, and this relationship helped them understand the relationship between cover and temperature and cover and soil moisture, among other things.

Curricular adaptation of field exercises in relation to the habitat under study

In the objective of this work, the necessity to implement field practice as a method is formulated; therefore, the following matrix summarizes the curricular units around which fieldwork and thus the experiential learning model can be fitted. In Table 2, we reviewed the curricular requirements of the 5th-6th grade science subject in primary schools in Hungary, and we have indicated where and with which curricular content it would be possible to apply field practice and with what content. We have tried to find a link between the Next Generation Science Standards for States, By States, and the curriculum we have developed. The links were provided by themes and complex thinking. When organizing the curriculum, it can be concluded that fieldwork can be implemented. The fieldwork can be applied according to the curriculum developed.

Knowledge transfer, which involves the need for the student to apply the acquired conceptual structure in a general way, plays a key role in this process. The first element of generalization, and later analogy, is comprehension, i.e., the student looks for systematic analogies, i.e., common elements or differences between concepts. The resulting concepts will be an overall pattern of experiences that interact with each other. It can be said that scientific concepts are general and abstract and can be linked to other general concepts and learned deductively. The complex nature of science also emerges, not only mathematical and biological thinking is developed, but also geographical, as the student must perceive the structure and type of soil, meteorological knowledge, and the use of spatial skills. The study is also of great value in that it enables children to interpret the study unit, but seeing the whole unit requires critical thinking since other conditions are already true for the entire structure of the biocoenosis. Logical operations using "if-then" statements are required to interpret the data as a complex unit.

We have also developed a more in-depth curriculum option, to provide a recommendation on how to implement fieldwork as a concrete curricular option. Table 4 shows the resources, student and teacher activities required and the standards to be achieved. The thematic areas of Table 3 can be linked to the recommendations presented in Table 4, which can be aligned with the pedagogical content of Table 2, as it underlines the close link between fieldwork and the possibility of developing complex thinking.

Table 3.

Specific curricular opportunities for fieldwork in relation to the Natural science subject according to the topics covered in the Hungarian curriculum. In the developed curriculum, the topics and content of the curriculum are adapted to the requirements in Hungary, and we have developed the possibility of adapting the fieldwork to these requirements to develop complex thinking. The complexity stems from the realisation that science itself is an umbrella term for a complex of disciplines with a complex knowledge base covering many areas. Scientific and mathematical skills and abilities are part of its domain of understanding, as solving problems requires a systems approach that allows for the ability to see and correctly interpret the interrelationships, i.e., to create causal unity. The aim of the curriculum developed is to provide the possibility of integrating fieldwork into the teaching of science subjects in primary school, the curriculum is adapted to the age-specific needs of students aged 10-12. In the table, we have tried to find a link between the Next Generation Science Standards (NGSS) for States, By States, and the curriculum developed in this work. NGSS also aims to provide local teachers with a flexible platform to motivate their students, which is a key objective of the pilot curriculum. The links can be interesting, as the Hungarian curriculum is mainly feeder type, while the NGSS is framework type, the didactic links that we have developed provide more scope for increasing students' activity.

Grades	Elements of the curriculum according to Hungarian legislation			Links between the Next Generation Science Standards for States, By States, and the Hungarian curriculum
	Study materials	Study contents	Didactical links to fieldwork depending on our experiments	
5th grade	Materials and their properties	The scope of the unit is to learn about the materials in the immediate environment, the composition of natural and man-made materials, their uses, and changes in composition. From the point of view of fieldwork, the main content is that the student learns about the properties of soil, its role in living systems (e.g., its role in communities), soil structure, soil formation, and soil degradation. Find the links between air, water, and soil to develop complex thinking.	Children: - recognize and identify the living/non-living properties of soil; - carry out soil tests, learn about natural processes of composting; - identify woody and herbaceous plants of the forest using simple adverbs; - carry out simple experiments to determine soil properties (color, texture, lime content, organic matter content), record findings in drawings and/or in writing, also in relation to plants and animals, use microscope to determine soil structure, living structure. As the students continuously observe the characteristics of the soil and living nature through experiential learning and understand the connections through analysis, complex thinking can be supported by fieldwork.	5-LS2-1 Ecosystems: Interactions, Energy, and Dynamics, the ability to understand the processes of matter-energy transformation also aims to develop complex thinking, including by requiring students to use model-building to interpret the movement of matter between plants-animals-environment. Communicating the mechanisms of natural events through a scientific approach is a support for complex thinking.
5th grade	Measurements, units of measurement, measuring instruments	The main knowledge content of the unit is that students learn about the measurable properties of living and non-living matter and can use different measuring instruments (e.g., length, volume, mass). Learn how to measure weather elements, record data, and plot them on graphs. Introduce the concepts of temperature, heat waves, weather, and climate.	Children: - observe living and non-living substances in the environment and classify them according to given or independently invented criteria; - can make estimates, for example, of the size and age of deciduous trees in a forest, while enriching their knowledge of species, measuring circumference, and converting units of measurement during fieldwork. Analytical and critical thinking should be applied to the field exercises, if they are linked to measurement, the results should be evaluated to draw adequate conclusions, so that the learning unit can support the development of complex thinking.	5-ESS2-2 Earth's Systems the link between the Hungarian system can be built based on measurement and mathematical standards. The students should provide evidence of the quantitative presence of freshwater and saltwater. The link can be made by developing a measurement toolkit to discuss the relationship between mass and volume. For this, even in the case of the Hungarian system, the use of mathematical and computational competence is necessary, which could also aim at developing complex thinking.

Table 3. *Continue*

5th grade	Observing, experimenting, experiencing	The focus of this teaching unit is on the living conditions of plants, the process of precipitation formation, and the understanding of the basic processes of weather. The unit is an experiential unit primary.	Children: - recognize and observe living and non-living materials in the environment, grouping them according to given or independently invented criteria, making independent estimates, for example, of the age and size of tree species; - use photo books and smartphone applications to identify tree species and herbaceous plants; - learn about the living conditions of forest plants and the role of forests. By observing in the field, identifying plant species, and then placing them in the environment, analytical and reflective thinking is required, as well as decision making thinking skills, so that complex thinking can be developed.	5-ESS2-1 Earth's Systems can be linked to the Hungarian theme. The student, in an observational role, models the relationships between the geosphere, biosphere, hydrosphere, and atmosphere, and fieldwork can be used as an experiential learning unit, as biocoenosis treats the Earth's spheres as a unit. Models are intended to be tools for thinking, making predictions, and interpreting experiences, in some ways tools for thinking, making predictions, and interpreting experience. Conceptual models, which are the subject of this section, are, by contrast, explicit representations that are, in some ways, analogous to the phenomena they represent. In addition to theoretical model building, the fieldwork presented can turn theoretical model building into practical empirical model building.
5th grade	Basic cartographic skills, Topographical knowledge	In the teaching-learning unit, the student acquires knowledge about the characteristics of topography and its actual and relative position.	Children: - determine the direction in real space; - understand the relationship between the map and reality; - will be able to draw a thematic map of the forest, based on landmarks, and use it to orient themselves; - use a map or compass, use a smartphone to find directions, and take photographs of landmarks to locate them in real space. Identifying the actual situation, studying the habitat under study, using cartographic and topographical knowledge, and using spatial skills can support the development of complex thinking.	MS-ESS1-3 Earth's Place in the Universe is presented at the Middle School level. The interpretive potential associated with field practice can be seen at the scale level. Data can be derived from statistical information, drawings, photographs, models and linked to topographic features during the field exercise.
6th grade	The body structure of plants, The body structure of animals	In this unit, the student will acquire knowledge about the body structure of herbaceous and woody plants, learn Identify plants' life cycles, and be able to classify known plants according to given criteria. The student will also learn about animal physiology, the relationship between animal parts, and their functions. The student will identify the distinctive markings of vertebrates and invertebrates.	Children: - understand living organisms and their communities as a complex system; - is aware of the relationship between living conditions and body structure; - is aware that interference with living systems can have harmful effects, using concrete examples; - to distinguish the leaf shape of different plant species and draw a drawing of it and make an impression of the trunk of a tree species. As living organisms and environmental conditions form an inseparable unit, fieldwork supports complex thinking and the exploration of systemic relationships in the child's mind as part of the process of building knowledge.	MS-LS1-6 From Molecules to Organisms: Structures and Processes: In this unit, students will gather science-based evidence for the role of photosynthesis and the cycles of matter and energy. Based on their K-5 experiences, students can collect evidence of ecosystem processes, matter, and energy transitions during fieldwork and experience that forests are the result of cyclical changes.

Table 3. *Continue*

6th grade	Forest community and natural-environmental problems	In this unit, the students learn about the role of living and non-living factors in forest formation. The students recognize the links between vegetation and environmental needs. The students can group forest plants, to establish food webs in relation to the forest. Children observe the effects of pollution on local communities.	Children: - observe the main features of the forest communities of our country; - interpret the forest as a community of life; - recognize and explain the habitat-biota-body structure relationships in forest communities; - construct food chains and food webs based on the species of forest plants and animals encountered; - find animal tracks in the forest, take photos of them using a smartphone, share them, and make plaster casts of animal footprints. Observations in the field (plants, animals and their interactions with their environment), making food webs, already require the student to recognize the biocoenosis in a unified way, which supports systemic and complex thinking.	In MS-LS2-1 Ecosystems: Interactions, Energy, and Dynamics, the students seek evidence of how and in what ways resources are available to living things. With a focus on the causal links between the growth of individual organisms and the number of organisms in ecosystems in times of abundant and scarce resources, the opportunity to develop complex thinking can be supported by fieldwork. Collecting and interpreting data on a coenological basis supports the idea that living organisms are determined by environmental conditions MS-LS2-3 Ecosystems: Interactions, Energy, and Dynamics is a unit designed to collect evidence for interpreting the relationship between matter-energy flows between living and non-living things by describing phenomena. Fieldwork can support the description of the phenomena, which is a key to understand the matter-energy transport processes. MS-LS2-4 Ecosystems: Interactions, Energy, and Dynamics, through this unit, students will experience through fieldwork how changes in the physical or biological components of an ecosystem affect populations. Learn that ecosystems are dynamic in nature; their characteristics can change over time. MS-LS2-5 Ecosystems: Interactions, Energy, and Dynamics, the students evaluate competing design solutions to maintain biodiversity and ecosystem services, understanding forest ecosystem services and their role in maintaining biodiversity through field-based solutions.
6th grade	Earth's external and internal forces and processes	To develop the present complex thinking and the knowledge related to the field exercise, the students will be aware of the processes of soil formation, the processes and problems of soil degradation. Teaching the relationship between climate and hydrology is also a key point of the content unit.	Children: - conduct simple experiments to determine soil properties (color, texture, lime content, organic matter content), recording their findings in drawings and/or writing, the need to record, and the ability to document data; - understand the composting process and the organisms involved and their role; - be able to place soil formation processes in the natural cycle of the forest; - can be familiar with the process of soil degradation and the role of forests in reducing soil degradation. Empirical exploration of the properties of soil and the connections between the living things that inhabit it create opportunities to develop complex thinking.	In MS-ESS2-2 Earth's Systems, students seek evidence-based explanations of how Earth science processes have affected the surface of the fold. This unit of study covers the Hungarian context as well, as the focus is on the external and internal forces of the Earth, and the interpretation of temporal scales is also covered.

Table 3. *Continue*

6th grade	Basic atmospheric phenomena and processes	Students learn about the elements of climate and the characteristics of climate zones. Children learn about the relationship between weather pictograms and weather reports.	Children: - can name the elements of the climate and the seasons; - can name the climate elements and describe the changes in the climate; - carry out weather observation tasks in the forest (measuring rainfall, humidity, temperature) and record their findings in writing, on graphs, or in drawings; - observe changes in animal behavior as the weather changes, recording their experiences. By observing specific weather factors in the field and recognizing their impact on a given habitat, students engage in analytical, problem-solving, and critical thinking; while collecting data in the field, they also experience the joy of discovery, the harmonious presence of which supports the development of complex thinking in natural science.	In MS-ESS2-5 Earth's Systems, students collect data on climate and weather changes. They can interpret changes in the parameters that determine weather: temperature, pressure, humidity, precipitation, and wind. Students can examine weather diagrams and maps and adapt them to local conditions through fieldwork.

Table 4

Possibility of concrete pedagogical recommendations for the development of field practice and complex thinking. For the development of practical exercises and solutions, Table 2 can provide an overview of the pedagogical background for practitioners.

Pedagogical and methodological recommendation			
Learning about the forest as a community of life through fieldwork, implementation plan			
For children aged 10-12			
For classroom activities before fieldwork			
1.	Human resources:		Time required for classroom activities before fieldwork
		1 Science Teacher	135 min (3x45 min)
		Fifth or sixth grade students, 24 students in total	
2.	Materials for classroom activities:		
		Theoretical basis of the context of the forest as a community: deciduous trees of the forest, with particular reference to the tree species in the forest under study, insects in the forest, birds in the forest canopy, the role of shrubs in the forest community, large game in the forest, rodents and predators in the forest.	45 min needed to learn about deciduous trees in the forest, to understand the leveling of the forest, to understand the downward flow of material, the Radó's table is presented.
		The Radó table is presented, using the average trunk circumference values of the given tree species to calculate the possible age of the species.	45 min needed for an overview of the forest insects and birds. 45 min needed to learn about the mammals of the forest, students can use the Radó's table to find out the possible age of each tree species.
Students who demonstrate understanding can:			
Understand the processes of matter-energy conversion in the context of biocenosis. Ability to identify that living and non-living environmental elements (soil, water, air) and environmental factors (solar radiation, temperature, precipitation) are interrelated in a mutually determining way. Clarification: Students should be able to think in a process, recognize the main plant species from a picture, identify a plant by its leaves, bark and flowers, recognize animal species from a picture and be able to form food webs. Note: Children do not need to know or explain molecular processes.			

Table 4. *Continue*

For fieldwork activities			
			Time required for fieldwork activities
1.	Human resources:		135 min (3x45 min)
		2 Science Teacher Fifth or sixth grade students, if working in 8 groups, 4 students per group, 24 students in total.	
2.	Materials for outdoor activities:		
		Measuring tape (200 cm long), four marker columns per quadrat to indicate the quadrat, a record of observations and data (trunk circumference can be recorded), writing instruments, plant identification books with photos.	The time is needed to get to the forest with the children, to be able to select, measure and mark the quadrats, to identify the tree species with the help of the plant identifiers, to record the seedling and non seedling individuals and to record the data by measuring the trunk diameter of the tree species.
Students who demonstrate understanding can:			
Ability to make simple estimates under field conditions. Understands that the community of life functions as a complex unit. Ability to model and interpret forest functioning and processes. Understand that the forest changes along the dimension of time. Ability to determine the age of individual tree species. Have a complex approach to understanding processes in nature. Clarification: students should be able to work in a disciplined way, experience natural processes, and ecological services.			
For classroom activities after fieldwork			
			Time required for classroom activities after fieldwork
1.	Human resources:		135 min (3x45 min)
		1 Science Teacher Fifth or sixth grade students, 24 students in total	
2.	Materials for classroom activities:	1 computer per team with spreadsheet software (e.g., MS Excel)	45 min required to digitize the data. 45 min required to display data on graph, find the possible age of the tree species from the tree trunk circumference in the table by Rado. 45 min required to interpret the diagrams and present the data: when interpreting the data, pay attention to the oldest tree species, their role in the community, whether they are invasive species, the role of a forest in regulating microclimate, the ecological services that the community can provide (e.g. temperature buffering, water retention).
	Key outcome findings from the fieldwork:		
		Children should be able to digitize data collected in nature. Students should identify plant species and discover their role in the community. Students should be able to graph the age of the plant species found in their quadrat and present the results of the graph orally to their classmates. Students can formulate factual statements from data derived from independent exploration. For students, thinking operations (reflective thinking, analytical thinking, critical thinking) are organized in a complex way. Students make inferences about the time dynamics of the community of life.	
Students who demonstrate understanding can:			
Understand the dynamics of the community of life over time. Ability to present results through evaluative communication. Ability to construct and interpret diagrams. Ability to interpret the role of species in a community. Clarification: students should be able to digitize data, calculate the mean.			

Discussion

Human dignity as a value can only be ensured by a healthy environment, which must be made visible to children, tapping into their curiosity to explore. To maintain a state of motivation and health, we need to create optimum conditions between the natural environment and the social environment, which is also a personal need.

During evolution, terrestrial parameters enabled the formation of complex structures that are realized in living material patterns (Volvenko, 2012). However, the fact that living material patterns require abiotic and biotic conditions, and this can also be clearly traced along the lines of living communities (Cushman, 2023).

The key to understanding a system is for students to be able to understand the processes taking place in the system, the events that control and control the system on an experiential level (Molnár et al., 2023), for example, experiential learning, specifically field practice, can be a pivotal point; in this respect, we strongly recommend the use of fieldwork, which not only contributes to the development of students' competences by developing complex thinking, but also makes school work more variable. The element-system-environment cannot be separated from each other, they are closely related. In this context, it is also important to understand the functioning of biocoenoses, it is necessary to map this in the minds of the students. The complexity stems from the realization that science itself is an umbrella term for a complex of disciplines with a complex knowledge base covering many areas. Scientific attitude consists of three components: beliefs, feelings, and actions. This kind of triple unit is given in the development of complex thinking, closely linked to a scientific attitude. Feelings of pleasure in learning influence students' attitudes toward science subjects (Maison et al., 2020). In science education, it is necessary to develop scientific knowledge, critical thinking, analytical thinking, problem solving, and decision making skills (Janoušková et al., 2023), as these higher skills can be the basis for complex thinking (Panthalookaran, 2022). This is also important because complex systems, by their very nature, can be described as a power function, forming a scale-independent state (Vermeulen et al., 2020). In the teaching of complex natural sciences, this is a very important observation, because knowledge can also be built up in networks. This is, of course, also reflected in the teaching of life communities, since networks can take the form of a matter-energy flow system or even food webs (Cushman, 2023). A system is itself an entity composed of different elements; that is, it is nothing more than a total set of interrelated elements, kept in operation by the interrelationship between them (Molnár et al., 2023), an interpretation that is also true for biocoenoses, so students need to develop a mental representation that allows them to interpret the processes in living communities as a complex unit. Fieldwork can provide all of this, since outdoor activities necessarily require complex thinking, from the execution of the workflow through the execution of the tasks to the interpretation of the data.

This also requires integrative skills; for example, the development of reading skills can be combined with the development of aesthetic awareness (Alijonovna & Gozalkhan, 2022). In actual fieldwork, the student should be able to evaluate changes in the phenomena and physical processes in his/her environment. All these micro- and macro-processes can be truly learned by experiencing nature directly. What is there to observe? What needs to be measured? What should be observed next? The answers to these questions must be declared during the field exercise. There is also a significant role for data science, a rational and objective way of using the data collected (Emery et al., 2021). The logging and recording of recorded data are of cardinal importance, as Ghail & Standing (2020) point out. Critical thinking requires learners to gain experience and reflection, to actively reason by analysing and synthesising information generated or acquired, in a way that guides their actions. It can be developed from many aspects, such as through science picture books (Putri & Prodjosantoso, 2020).

The results and locations obtained should be professionally documented. It is important to plan the exercise, to prepare for the planned experiments, to check the equipment, even by making checklists. After the observations have been made, it is important to interpret and evaluate the documented results. This can be done with or without the help of preliminary questions using graphs, tables, photographs, and your own conclusions (Izatulloyevich, 2020). Another advantage of fieldwork is that it gives students a complete picture of the world, allowing them to gather knowledge holistically, whereas in the case of classroom lessons, they learn new knowledge in a subject-by-subject, lesson-by-lesson format, which they later must integrate. Although classroom learning is mostly an individual activity, fieldwork is a group activity.

During fieldwork, the teacher must play a variety of roles. These roles include specialist, teacher, and colleague. The teacher must see the children not only as students, but also as colleagues during fieldwork. Thus, participatory work, practice-based work, and context-based work are necessary for appropriate action (Islind & Norström, 2020). Taylor et al. (2021) emphasise the importance of a holistic approach in all this. Observations and results derived from the natural sciences can potentially also enhance knowledge in organizational theory (Wasieleski et al., 2021).

Technical and mathematical, digital skills and abilities are part of its domain of understanding, as solving problems requires a systems approach that allows for the ability to see and correctly interpret the interrelationships, i.e. to create a causal unity of the part-part. In their absence, processes and the forces that drive the system may become incomprehensible, and we are less likely to be able to provide relevant responses to the problems that inevitably arise. The various branches of science are also an integral part of everyday life, providing practical solutions to help individuals navigate their daily lives by understanding complexity.

As shown in the matrix presented in the results, there were many opportunities for the implementation of field sessions to satisfy the requirements of the curricula (Table 3 and Table 4).

Experimental learning is of particular importance because the students must examine and individually perceive the changes that can take place in each living community; these can help to understand the complex relationships that can also be evaluated as a service of the relevant living community (Van Driel et al., 2001).

This work may provide a basis for the teaching of science and biology in other countries, as the methodology can be adapted based on the learning results. Such educational settings provide an opportunity for children to understand the complex system of natural processes and its network structure, since, for example, plant ecology (botanical surveys, plant identification) can be used to assess and monitor the internal dynamics of communities, to characterize quantitatively the changes in the state of organization under study, the spatial and temporal transition states of vegetation, i.e., the phenomena represented by the associations of living organisms, i.e., their structure, composition, living conditions, life cycles, and the environmental factors that determine them. Using the quadrat method, we can also perform vegetation and entomological analysis by marking quadrats of a certain size in the sample area and evaluating individuals in the association. The delivery of complex curricular content is difficult to support by traditional methods (Molnár et al., 2023). Biocoenoses, as systems, can be understood as complex interwoven networks, whose nodes and network relationships are governed by interconnecting functions, such as the relationships between partners involved in competition and predation (Volvenko, 2012). One of the goals of fieldwork can be to identify the initial state, the final state, and the changes that trigger the process by identifying the changes, thus enabling students to understand the dynamics of the succession sequence. Students can learn about the biotic communities of a habitat, the characteristics (physical, chemical, biological) that cause changes in the habitat, and the factors that create and maintain them (Gosset et al., 2016). Through fieldwork, students gained skills in plant identification and illustration, scientific nomenclature, and ecological research (Bowcutt & Caulkins, 2020). Fieldwork can activate and apply thinking skills and knowledge that are already present in primary school students. The curriculum developed can provide a basis for developing the building blocks of complex thinking, e.g. critical thinking, problem-solving skills, part-whole causality assessment.

Learning outcomes can also be translated into procedural skills related to field practice. This requires that the unity of theory and practice develops a coordinated knowledge of the conceptual framework network in the students (Figure 5). High levels of problem solving, and thinking are also associated with high levels of critical thinking (Moneva et al., 2020). The need for critical thinking in conjunction with the development of media literacy is emphasized by Tommasi et al. (2023).

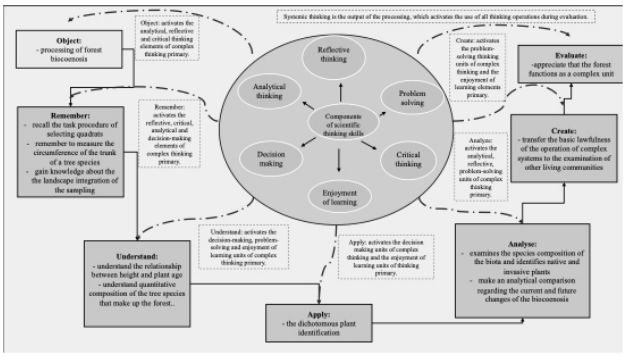


Figure 5 A scheme of complex thinking through the example of fieldwork. The figure shows the learning outcomes (in squares) in during fieldwork, which can be interpreted as a process: the initial step is object, then remember, understand, apply, analyze, create and finally evaluate processes are activated to acquire knowledge, skills and attitudes. However, the circular process also requires the application of scientific thinking skills, so the thinking skills broken down into their components are shown in the pie chart, with dashed lines indicating that scientific thinking skills need to be linked to each learning process.

Fieldwork is also significant because it can harmoniously develop the unity of theory and practice. Thinking skills associated with scientific cognition are complex skills that can be used to explain, interpret, and clarify processes, they require scientific process skills (Rini & Aldila, 2023). Natural scientific thinking is also fundamentally complicated by the need to apply the investigator's methods in the process, hence the use of quantitative methods, objectivity, and determinism. However, the system is further complicated if we approach thinking from a disciplinary perspective, because while physics, for example, investigates

idealized laws, biology thinks in terms of mechanisms (Siponen & Klaavuniemi, 2021). Oxenswärdh & Persson-Fischier (2020) refer to critical thinking and problem solving as transversal skills, as today's knowledge economies place a strong emphasis on these skills, since fieldwork is interdisciplinary, we consider it necessary to integrate it into the curricula, already in the primary school system.

If we approach a problem with a complex aspect, as well as its solution or processing, systems thinking can prevail on the way to the solution. The conditions provided by the field practice support this well, also by not immobilizing the students within the walls of the school, but by implementing effective learning in nature through action and observation.

Conclusions

The complexity of social and scientific systems can be described as specific patterns of interwoven networks (Albert & Barabási, 2000). These networks are always determined by the environment and the systems that operate within them (Albert & Barabási, 2000). In this way, basic scientific regularities can be understood, for example, ecological concepts which must necessarily be developed as a complex entity in children's minds.

The limitation of this work is, on the one hand, the need to adapt the fieldwork to the curricular requirements, and, on the other hand, the present work describes a possible methodological presentation of the study of forest communities for students aged 10-12 years. It can be of particular importance for the development of complex scientific thinking. The purpose of this paper is to present a pedagogical option that includes potentially feasible field solutions for biology and complex science teachers. In our view, real-life problems are given, and students cannot solve them through one-plane thinking, it is complex thinking that allows students to interpret multiple perspectives, but this is not always available in the classroom, and the curriculum aims to emphasize this. We wish to draw attention to the need for a methodology to teach fieldwork, field exercises, and the complex vision that can be reflected in pedagogical practice, including examples of coenology, and presenting the relevant learning outcomes that can be achieved through fieldwork in primary schools.

Disclosure statement

The authors report that there are no competing interests to declare.

References

Akben, N. (2020). Effects of the problem-posing approach on students' problem solving skills and metacognitive awareness in science education. *Research in Science Education*, 50(3), 1143-1165. https://doi.org/10.1007/s11165-018-9726-7

Alijonovna, M. & D. Gozalkhan, Y. (2022). Implementation of interdisciplinarity in the teaching of reading and natural sciences. *Galaxy International Interdisciplinary Research Journal*, 10(12), 1628-1632. https://internationaljournals.co.in/index.php/giirj/article/view/3309/3057

Aljuwaiber, A. (2022). Changing attitudes through interactive learning: The impact of teaching total quality management on students' everyday lives. *Journal of Education for Business*, 97(6), 365-375. https://doi.org/10.1080/08832323.2021.1967840.

Albert, R. & Barabasi, A. L. (2000). Topology of evolving networks: local events and universality. *Physical Review Letters*, 85(24), 5234-7. https://10.1103/PhysRevLett.85.5234.

Alsarayreh, R. S. (2021). Developing critical thinking skills towards biology course using two active learning strategies. *Kıbrıslı Eğitim Bilimleri Dergisi*, 16(1), 221-237. https://10.18844/cjes.v16i1.5521

Aktoprak, A. & Hursen, C. (2022). A bibliometric and content analysis of critical thinking in primary education. *Thinking Skills and Creativity*, 44, 101029. https://doi.org/10.1016/j.tsc.2022.101029

Amran, M. S., Zain, S. M., Jamaludin, K. A., Surat, S. (2021). Thinking About Behavior: Perspective on Meta-Behavior in Education. *Frontiers in Psychology*, 2, 727116. https://doi.org/10.3389/fpsyg.2021.727116

Ballantyne, R., & Packer, J. (2002). Nature-Based Excursions: School Students' Perceptions of Learning in Natural Environments. *International Research in Geographical and Environmental Education*, 11 (3), 218–236. https://doi.org/10.1080/10382040208667488

Blázquez-Salom, M., Blanco-Romero, A. (2020). Fieldwork in ground zero, Mallorca. A methodological fieldwork proposal for a geographical analysis of tourist areas. *Investigaciones Geográficas-Spain*, 75, 43-59. https://10.14198/INGEO2020.BB

Bowcutt, F. & Caulkins, T. (2020). Co-teaching Botany and History: An interdisciplinary model for a more inclusive curriculum. *Isis*, 111(3), 614-622. https://doi.org/10.1086/711071

Brevik, E. C., Krzic, M., Muggler, C., Field, D., Hannam, J., Uchida, Y. (2022). Soil science education: A multinational look at current perspectives. *Natural Sciences Education*, 51(1), 1-21. https://doi.org/10.1002/nse2.20077

Brinitzer, C. & Benson, E. (2022). Introduction: What Is a Field? Transformations in Fields, Fieldwork, and Field Sciences since the Mid-Twentieth Century. *Isis*, 113(1), 108-113. https://doi.org/10.1086/718147

Calma, A. & Davies M. (2021). Critical thinking in business education: current outlook and future prospects. *Studies in Higher Education*, 46(11), 2279-2295. https://doi.org/10.1080/03075079.2020.1716324

Cushman, S. A. (2023). Entropy, Ecology and Evolution: Toward a Unified Philosophy of Biology. *Entropy (Basel)*, 25(3), 405. https://doi.org/10.3390/e25030405

Doostmohammadian, M., & Rabiee, H. R. (2023). Network-based control of epidemic via flattening the infection curve: high-clustered vs. low-clustered social networks. *Social Network Analysis and Mining*, 13(1), 60. https://doi.org/10.1007/s13278-023-01070-3

Downey, R. M., Downey, K. B., Jacobs, J, Korthas, H., Melchor, G. S., Speidell, A., Waguespack, H., Mulroney, S. E., Myers, A. K. (2022). Learning design in science education: perspectives from designing a graduate-level course in evidence-based teaching of science. *Advances in Physiology Education*, 46(4), 651-657. https://doi.org/10.1152/advan.00069.2022

Emery, N. C., Crispo, E., Supp, S. R., Farrell, K. J., Kerkhoff, A. J., Bledsoe, E. K., O'Donnell, K. L., McCall, A. C., Aiello-Lammens, M. E. (2021). Data science in undergraduate life science education: A need for instructor skills training. *BioScience*, 71(21), 1274-2187. https://doi.org/10.1093/biosci/biab107

Foo, S. C. & Foo, K. K. (2022). Purposeful field trip: impact on experiential learning opportunities and critical thinking skills. *Pertanika Journal of Social Sciences and Humanities*, 30(1), 1-30. https://doi.org/10.47836/pjssh.30.1.01

Ghail, R. C. & Standing, J. R. (2020). Development of an engineering geology field trip for civil engineering students. *Quarterly Journal of Engineering Geology and Hydrogeology*, 53(1), 74-87. https:// doi.org/10.1144/qjegh2019-013

Gosset, A., Ferro, Y., Durrieu, C. (2016). Methods for evaluating the pollution impact of urban wet weather discharges on biocenosis: A review. *Water Research*, 89, 330-54. https://doi.org/10.1016/j.watres.2015.11.020

Guo, X., Hao, X., Deng, W., Ji, X., Xiang, S., Hu, W. (2022). The relationship between epistemological beliefs, reflective thinking, and science identity: a structural equation modeling analysis. *International Journal of STEM Education*, 9(1), 40. https://doi.org/10.1186/s40594-022-00355-x

Horota, R. K., Rossa P., Marques A., Gonzaga L., Senger K., Cazarin C. L., Spigolon A., Veronez M. R. (2023). An immersive virtual field experience structuring method for geoscience education. *IEEE Transactions on Learning Technologies*, 16(1), 121-132. https://doi.org/10.1109/TLT.2022.320708

Islind, A. S. & Norström L. (2020). Learning sustainable work through critical design: a case study of a hackathon to prepare the future workforce. *The Journal of Workplace Learning*, 32(8), 641-65. https://doi.org/10.1108/JWL-05-2020-0082

Izatulloyevich, O. F. (2020). Methods of teaching natural sciences to primary school pupils on the basis of a competent *PalArch's Journal of Archaeology of Egypt / Egyptology*, 17(7), 11513-11526. https://archives.palarch.nl/index.php/jae/article/view/4533

Janoušková, S., Pyskatá Rathouská, L., Žák, V., Urválková, E. S. (2023). The scientific thinking and reasoning framework and its applicability to manufacturing and services firms in natural sciences. *Research in Science & Technological Education*, 41(2), 653-674. https://doi.org/10.1080/02635143.2021.1928048

Kervinen, A., Uitto, A., Juuti K. (2020). How fieldwork-oriented biology teachers establish formal outdoor education practices, *Journal of Biological Education*, 54(2), 115-128, https://doi.org/10.1080/00219266.2018.1546762

Maison, M., Haryanto, H., Ernawati, M. D. W., Ningsih, Y., Jannah, N., Puspitasari, T. O., Putra, D. S. (2020). Comparison of student attitudes towards natural sciences. *International Journal of Evaluation and Research in Education*, 9(1), 54-61. http://doi.org/10.11591/ijere.v9i1.20394

McNeal, P. M. & Petcovic, H. L. (2020). Spatial thinking and fluid Earth science education research. *Journal of Geoscience Education*, 68(4), 289-301. https://10.1080/10899995.2020.1768007

Moneva, J. C. Miralles, R. G., Rosell, J. Z. (2020). Problem solving attitude and critical thinking ability of students. *International Journal of Research-GRANTHAALAYAH*, 8(1), 138-149. http://doi.org/10.29121/granthaalayah.v8.i1.2020.261

Molnár, Zs., Gyuris, Á., Radács, M., Nemes, P., Bátori, I., Gálfi, M. (2023). Complex natural science and the challenges of its education in the 21st century. *Cogent Education*, 10, 2. https://doi.org/10.1080/2331186X.2023.2240166

Momsen, J., Speth, E. B., Wyse, S., Long, T. (2022). Using systems and systems thinking to unify biology education. *CBE—Life Sciences Education*, 21(2), es3. https://doi.org/10.1187/cbe.21-05-0118

Ngo, S. C., Percus, A. G., Burghardt, K., Lerman, K. (2020). The transsortative structure of networks. *Proceeding of The Royal Society A Mathematical, Physical and Engineering Sciences*, 476(2237), 20190772. https://doi.org/10.1098/rspa.2019.0772

Norris, M. B., Grohs J. R., Knight D. B. (2022). Investigating student approaches to scenario-based assessments of systems thinking. *Frontiers in Education*, 7, 1055403. https://doi.org/10.3389/feduc.2022.1055403

Ocak, F., Döker, M. F., Ünsal Ö. (2023). Use of web-based GIS applications in Geography teaching-The implication from Türkiye. *Journal of the Geographical Institute Jovan Cvijic SASA*, 73(1), 65-77. https://doi.org/10.2298/IJGI23010650

Oxenswärdh A. & Persson-Fischier U. (2020). Mapping master students' processes of problem solving and learning in groups in sustainability education. *Sustainability (Switzerland)*, 12(13), 5299. https://doi.org/10.3390/su12135299

Panthalookaran, V. (2022). Beyond Bloom's taxonomy: the emergence of entrepreneurial education. *Higher Education for the Future*, 9(1), 45-61. https://doi.org/10.1177/23476311211046176

Petersen, G. B., Klingenberg, S., Mayer, R. E. Makransky, G. (2020). The virtual field trip: Investigating how to optimize immersive virtual learning in climate change education. *British Journal of Educational Technology*, 51(6), 2099-21150. https://doi.org/10.1111/bjet.12991

Pfeifer, L., Soreghan, M., Feille, K., Soreghan, G., Weissmann, G., Ibarra, R.. (2020). Activation of the multicontext model in a field-based program for traditionally underserved students. *Journal of Geoscience Education*, 69(1), 85-95. https://doi.org/10.1080/10899995.2020.1838850

Praskievicz, S. (2023). Field-based local stream research in undergraduate classes: an inquiry-based approach. *Journal of Geography in Higher Education*, 47(4), 677-684. https://doi.org/10.1080/03098265.2022.2065667

Putri, M. A. & Prodjosantoso, A. K. (2020). Improving critical thinking skills and scientific attitudes by using comics. *Psychology, Evaluation, and Technology in Educational Research*, 2(2), 69-80. https://10.33292/petier.v2i2.13

Radó, D. (1999). Bel- és külterületi fasorok EU-módszer szerinti értékelése. *Lélegzet*, 7-8., 2-12.

Ramírez-Montoya, M. S., Castillo-Martínez, I. M., Sanabria-Z, J. Miranda, J. (2022) Complex thinking in the framework of Education 4.0 and Open Innovation—A systematic literature review. *Journal of Open Innovation: Technology, Market, and Complexity*, 8(1), 4. https://doi.org/10.3390/joitmc8010004

Rini, E. F. S. & Aldila, F. T. (2023). Practicum activity: analysis of science process skills and students' critical thinking skills. *Integrated Science Education Journal*, 4(2), 54-61. https://doi.org/10.37251/isej.v4i2.322

Siponen, M. & Klaavuniemi, T. (2021). Demystifying beliefs about the natural sciences in information systems. *Journal of Information Technology*, 36(1), 56-68. https://doi.org/10.1177/0268396220901

Taylor, J., Jokela, S., Laine, M., Rajaniemi, J., Jokinen, P., Häikiö, L., Lönnqvist, A. (2021). Learning and teaching interdisciplinary skills in sustainable urban development-The case of Tampere University, Finland. *Sustainability*, 13(3), 1180. https://doi.org/10.3390/su13031180

Tommasi, F., Ceschi A., Bollarino S., Belotto S., Genero S., Sartori R. (2023). Enhancing critical thinking skills and media literacy in initial VET students: a mixed methods study on a cross-country training program. *International Journal for Research in Vocational Education and Training*, 10(2), 239-257. https://doi.org/10.13152/IJRVET.10.2.5

Ünver, G. & Yurdakul B. (2020). Developing reflective thinking through theory-practice connection; [Yansitici düsünmeyi kuram-uygulama bağlantisi yoluyla geliştirme]. *Pegem Egitim ve Ogretim Dergisi*, 10(1), 77-102. https://doi.org/10.14527/pegegog.2020.004

Van Driel, J. H., Beijaard, D., Verloop, N. (2001). Professional Development and Reform in Science Education: The Role of Teachers' Practical Knowledge. *Journal of Research in Science Teaching*, 38 (2), 137–158. https://doi.org/10.1002/1098-2736(200102)38:2<137::AID-TEA1001>3.0.CO;2-U

Vasconcelos, C. & Orion, N. (2021). Earth science education as a key component of education for sustainability. *Sustainability*, 13(3), 1316. https://doi.org/10.3390/su13031316

Vermeulen, R., Schymanski, E. L., Barabási, A. L., Miller, G. W. (2020). The exposome and health: Where chemistry meets biology. *Science*, 367(6476), 392-396. https://doi.org/10.1126/science.aay3164

Volvenko, I. V., (2012). Extremal principles and goal functions of biocenotic systems. *Biophysics*, 57, 350–362 https://doi.org/10.1134/S000635091203.

Walsh, Z., Böhme, J., Wamsler, C. (2021). Towards a relational paradigm in sustainability research, practice, and education. *Ambio*, 50, 74–84. https://doi.org/10.1007/s13280-020-01322-y

Wasieleski, D., Waddock, S., Fort, T., Guimarães-Costa, N. (2021). Natural sciences, management theory, and system transformation for sustainability. *Business & Society*, 60(1), 7-25. https://doi.org/10.1177/0007650319898384

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Investigation of Early Childhood Teacher Self-Efficacy in Terms of Various Variables

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Abstract

This study aims to examine the self-efficacy levels of early childhood teachers in terms of various variables (age, marital status, department graduated, education level, professional experience). The survey model, one of the quantitative research methods, was used in the present study. Criterion sampling; one of the methods of purposive sampling is applied. 219 early childhood teachers working as early childhood teachers in different provinces of Turkey participated in the study. The data for the study was collected using the "Teacher Self-Efficacy Scale," which was adapted to Turkish by Çapa, Çakıroğlu, and Sarıkaya (2005). The construct validity of this scale was confirmed by performing a confirmatory factor analysis for early childhood teachers. The data was analyzed using the SPSS-28 statistical program. The relevant data were subjected to the Mann-Whitney U and Kruskal Wallis H tests. Confirmatory factor analysis was performed using the Amos program, and the results indicated that the scale had acceptable fit values. In addition, the reliability level was found to be high, with the Cronbach Alpha internal consistency reliability coefficient being .97. Based on the research results, the self-efficacy of early childhood teachers varied significantly based on age group, marital status, and professional experience. However, no significant difference was observed in the self-efficacy levels of early childhood teachers based on their education level and economic status.

Keywords:

Self-Efficacy, Early Childhood Teacher, Validity

Introduction

Teaching is a profession that has been revered throughout history and is considered sacred by many. Teachers may encounter various challenging situations while practicing this revered profession. To cope with these challenges, teachers should possess some certain characteristics; among the most crucial of which are the competencies that teachers believe they have or do not have. Even though there have been numerous national and international studies on teacher competencies over the years, the number of studies conducted in accordance with today's conditions and challenges is inadequate. Teacher competencies include three main competency areas, namely "professional knowledge," "professional skills," and "attitudes and values," with a total of 65 indicators related to these areas (MEB,

2017). Professional knowledge includes mostly field knowledge, while professional skills include skills related to managing educational environments. Attitudes and values include skills related to student engagement and approaches. These competencies and indicators are set to train better and higher quality teachers. Teacher competencies are one of the most important skills teachers need to acquire to perform their profession in a qualified manner (Mohamad, Hinduja, & Siddiqui, 2023). Many studies have been conducted on the 3 main competency areas identified by MEB which are professional knowledge, professional skills and attitudes and values. Moreover,(hangi yeterlikler olduğu açıklandı) these studies have focused on sub-dimensions such as organizing educational environments, ensuring student participation, and classroom management. Organizing the educational environment is one of the things that increase students' participation, so teachers should have this competence.

Creating and managing an educational environment requires both the physical organization of the classroom and the acclimatization of students to this order. This reveals the importance of classroom management in its broadest form. One of the competencies teachers should possess for classroom management is the ability to adjust classroom arrangements and the physical environment according to lessons and activities (Alfonso, 2023). Ocakcı and Samancı (2019) revealed that teachers felt inadequate, especially regarding physical organization and working with students of different ages and characteristics. Additionally, successful teachers who provided classroom management and competencies could better cope with the challenges encountered and produce creative solutions. Because good classroom management also means a good classroom climate (O'Beid, 2023). Creating a positive classroom and school climate, supporting students' ideas, and helping students with their various needs ensures academic success with high teacher competencies (Claire, 2023). In addition to ensuring academic achievement, teacher efficacy affects the whole dynamic of school culture. This plays an important role in creating the most harmonious environment for students to learn by meeting their basic needs. (Rofiah, Kossewska, Herviani, & Sheehy, 2023).

Attitudes and values, another important competence area, namely the approach and participation of students, are among the most crucial areas that teachers should possess. The way teachers approach students directly influences student participation in the classroom. Akkuş and Doymuş (2018) found that student engagement is higher when the teacher approaches students without pressure and with the necessary time and patience. Teachers with a high degree of efficacy show more positive behavior in the classroom, are open to new ideas, and have more faith in challenging environments and students. Attitudes towards teaching improve in direct proportion to teacher self-efficacy (Hernández-Saca, Voulgarides, & Etscheidt, 2023). Teachers' possession of attitudes and values competencies depends on their belief in these competencies, that is, their self-efficacy.

The concept of self-efficacy was first coined by Bandura (1977) in the social learning theory, and consequently, Teacher self-efficacy refers to teachers' beliefs about their ability to fulfill the tasks acquired to perform their profession in accordance with the targeted success and to affect students' learning and learning environments positively (Tschannen-Moran, Hoy, & Hoy, 1998). From this point of view, Bandura (1977) suggested that the stronger a teacher's self-efficacy, the better they can cope with any problem they may face and the more determined they can be in dealing with it (Täschner, Dicke, Reinhold, & Holzberger, 2023). On the other hand, teachers with inadequate self-efficacy were found to have inadequate skills in solving problems, showing the right approach to children, inadequate classroom management skills, and stressful attitudes (Hardianto, Sari, & Hidayat, 2023). Considering all these, it is clear how vital teacher self-efficacy is. Developing these self-efficacies plays a crucial role in educational environments and children, who are the future of society. It is seen as a necessity to raise self-confident teachers who believe in themselves and can solve problems (Wray, Sharma, & Pearl, 2022).

Teachers with high levels of self-efficacy can be more comfortable and confident leaders in their classrooms. Alanoglu (2021) found that teachers with high levels of self-efficacy were more willing to direct and lead the students in their classrooms. In his study, Erdoğan (2023) found that teacher self-efficacy and teacher leadership strengthen each other in direct proportion, positively affect teachers' professional development, and thus learning outcomes are more qualified. These results show that teacher self-efficacy promotes student achievement, motivation, effectiveness, and leadership. In a classroom, the more effectively the teacher creates an effective learning environment and actively engages the students in activities and activities, the better and more effective the learning will be. Klassen and Tze (2014) suggested a strong and positive relationship between teaching effectiveness and teacher self-efficacy. In addition to the effectiveness, it is vital for teachers to be able to make practices and plans that will foster student success and motivation. The higher the students' motivation, the more positively their achievement is affected. Together, these factors increase the efficiency and quality of the learning environment (Gordon, Blundell, Mills, & Bourke, 2022). Especially the early childhood period, which is the first stage of education, has a special place. Because the quality of the learning environment and the high self-efficacy of teachers

will affect children's feelings towards school positively or negatively.

Early childhood education institutions serve as children's second homes, shaping their educational lives. The skills acquired here lay the foundation for their future development. Children's growth and acquisition of various skills enable them to become self-confident individuals (Çapa, Çakıroğlu, & Sarıkaya, 2005). Self-confident children tend to perform better in their educational pursuits. Additionally, children positively impact themselves and their surroundings through the skills obtained in early childhood (O'Reilly, Devitt, & Hayes, 2022). Teachers play a pivotal role in providing quality education and creating enriching learning environments. The self-efficacy levels of early childhood teachers are crucial in this regard (Wulandari & Suryandari, 2022). The higher the self-efficacy levels of teachers, the higher the quality of education they provide. Teacher self-efficacy is crucial for educators in all fields. Research has shown that undergraduate students with high teacher efficacy tend to be happier in their future careers and experience greater job satisfaction (Williams, Christensen, McElroy, & Rutledge, 2023). The sense of self-efficacy has allowed teachers to be more creative in enriching their teaching environments, and this has been a contributing factor to increased student academic achievement. When teachers are creative, students also become more creative and find innovative ways to solve problems (Ma, 2022). Teachers being creative and happy in their profession plays a critical role in achieving goals at all levels of education (Shu, 2022). Early childhood education institutions are where children are first introduced to school, and teachers' self-efficacy forms the basis of all levels. Therefore, when shaping the educational environment, teacher self-efficacy should be taken into consideration and developed.

Early childhood teachers' problem-solving skills and the activities they implement affect the teaching environment and children, and their self-efficacy levels are crucial in solving the problems faced in their profession. Oğuz's (2017) study illustrated a positive correlation between problem-solving skills and teacher self-efficacy. Solving classroom issues facilitates the teaching environment and aids in reaching all children. Early childhood teachers should be able to approach all children in their classrooms in an inclusive way and touch all children (D'Agostino & Horton, 2023). Due to the migration movement seen all over the world, inclusive education has become a necessity and touching every child has become even more difficult.

Especially since 2011, millions of migrants have come to our country due to the migration operation that started with Syrian migration, and today, people are migrating from different countries. When we look at the 2023 data, there are 3,222,012 migrants, and 1,006,650 of them are children between the ages of 0-9 (Directorate of Migration Management, 2023). In addition, considering the economic situation in Turkey, the number of economically disadvantaged student groups increases yearly. In early childhood classrooms, children from different cultures and financially underprivileged groups are present in a considerable number of provinces, and their numbers are increasing daily. This difference and diversity makes classroom management difficult and reduces student participation. It has been a challenge for teachers to reach children who do not know the language of instruction and who are socially deficient. (Özoruç & Dikici Sığırtmaç, 2022)

In recent years, there has been an increase in both global and local migration, driven by political and economic factors. This has led to challenges for children who find themselves in new environments with different languages and cultures. Furthermore, the financial difficulties in Turkey have had widespread effects, including on children. The early childhood years are crucial for language acquisition and overall development. Early childhood teachers play a significant role in shaping children's lives during this time. High teacher self-efficacy is essential for the well-being of both teachers and children, as well as for the future of our society.

Both student profiles and family profiles are being updated all over the world and in our country. For example, millions of immigrants have come to Turkey in the last 10 years, and working with these immigrant children requires different skills and self-efficacy. When examining national and international studies on the self-efficacy level of early childhood teachers, it is evident that such studies are scarce, and more research is required. Hence, it is crucial to assess the current self-efficacy of teachers and study the impact of different factors. Based on these findings, the Ministry of Education and school administrators can develop new initiatives to enhance teachers' self-efficacy and ability to adjust to new circumstances. Furthermore, it is essential to use a self-efficacy assessment tool with up-to-date construct validity for early childhood teachers in today's educational environment. It is believed that assessing teachers' self-efficacy, recognizing their strengths and weaknesses, and exploring the correlation between self-efficacy and demographic variables will benefit both teachers and the field.

Problem Statement

The present study addressed the following questions: "What are the levels of self-efficacy among early childhood teachers?" and "Is there a significant variance in teachers' self-efficacy levels based on demographic factors?"

Sub Problems

1. What are the self-efficacy levels of early childhood teachers?
2. Does the age variable significantly affect early childhood teachers' self-efficacy levels?
3. Does the marital status variable make a significant difference in the self-efficacy levels of early childhood teachers?
4. Does the graduated department variable make a significant difference in the self-efficacy levels of early childhood teachers?
5. Does the education level variable make a significant difference in the self-efficacy levels of early childhood teachers?
6. Does the experience variable make a significant difference in the self-efficacy levels of early childhood teachers?

Method

In this part of the study, information about the participants, research model, data collection, data collection tools, and the analysis employed are given in this section.

Research Model

In this study, the survey model, a type of quantitative research method, was employed. Survey models are used to describe past or current situations and to carefully determine specific characteristics of a group (Büyüköztürk et al., 2018).

Participants

The participants of the present study consist of early childhood teachers. The data were collected by the researcher through face-to-face and online forms with early childhood teachers. For this purpose, data were collected from a total of 230 early childhood teachers; erroneous and incomplete forms were eliminated, and as a result, data from a total of 219 early childhood teachers were evaluated. The criterion sampling method, one of the sub-headings of the purposive sampling method, was preferred in forming the sample group. In this sampling method, observation units are formed from certain events, objects, situations, or people, and those who meet the criteria determined for the sample are included (Baltacı, 2018). Three criteria were used to select participants for this study. First, participation in the study was voluntary. Second, being an early childhood teacher. Finally, having previously or currently had refugee children in the classroom. Information on the demographic characteristics of the early childhood teachers in the research group is presented below.

Table 1:

Demographic Characteristics of Participants

Variable	Group	*f*	%
Age Group	18-25 years old	44	20.1
	26-30 years old	78	35.6
	31-40 years old	52	23.7
	40 years and older	45	20.5
Marital Status	Married	115	52.5
	Single	104	47.5
Graduated Program	Early Childhood Education	184	84.0
	Child Development	35	16.0
Education Level	Associate Degree	20	9.1
	Undergraduate	159	72.6
	Postgraduate	40	18.3
Economic Level	Low	60	27.4
	Middle	146	66.7
	High	13	5.9
Work Experience	0-5 Years	104	47.5
	6-10 Years	46	21.0
	11-20 Years	45	20.5
	20 Years and above	24	11.0
Type of Institution	Practice Early Childhood Instutions	13	5.9
	Early Childhood Instutions	142	64.8
	Kindergarten	64	29.2
Total		219	100.0

In Table 1, he age distribution of the participants was as follows: 20.1% were between 18-25 years old, 35.6% were between 26-30, 23.7% were between 31-40, and 20.5% were 40 years or older. Also, the study shows that 52.5% of the early childhood teachers were single, and 47.5% were married. Moreover %84 of the participants graduated from Early childhood Education Department and %16 of participants graduated from Child Development Department. Regarding educational background, 9.1% held associate degrees, 72.6% held bachelor's degrees, and 18.3% had postgraduate qualifications. Economically, 27.4% had low, 66.7% had medium, and 5.9% had high economic status. Regarding work experience, 47.5% had 0-5 years, 21% had 6-10 years, 20.5% had 11-20 years, and 11% had over 20 years of experience. Also %84 of the participants graduated from Early childhood Education Department and %16 of participants graduated from Child Development Department. Finally, 29.2% of the early childhood teachers worked in kindergarten, 64.8% in early childhood instutions, and 5.9% in practice early childhood instutions. (Tabloya göre sıralandırıldı.)

Data Collection Tools

Data collection tools consist of a demographic information form and a teacher self-efficacy scale. Data were collected and analyzed by the researcher online and face-to-face.

Demographic Information Form

The Demographic Information Form includes questions about early childhood teachers' age, marital status, work experience, and education level. The Demographic Information Form was filled out by the early childhood teachers participating in the study.

Teacher Self-Efficacy Scale

The teacher Self-Efficacy Scale was developed by Tschannen-Moranand and Hoy (2001) to measure teachers' self-efficacy and self-efficacy beliefs and adapted into Turkish by Çapa, Çakıroğlu, and Sarıkaya (2005). The scale consists of 24 items and three sub-dimensions. The sub-dimensions are self-efficacy for instructional strategies, self-efficacy for student participation, and self-efficacy for classroom management. The summation method was used in scoring the scale, and the maximum score that can be obtained from the 5-point Likert scale is 120, while the minimum score is 24. According to the scale, high scores indicate high self-efficacy, while low scores indicate low self-efficacy. According to Cronbach's Alpha analysis, which was conducted to measure the internal consistency coefficient of the original scale, the reliability coefficient of the whole scale was obtained at .94, which is relatively high.

When analyzing the data from the scale adapted into Turkish by Çapa, Çakıroğlu, and Sarıkaya (2005), it was found that the data were collected from 628 pre-service teachers, with only 91 of them being from the early childhood teaching department. The literature on early childhood teaching does not use the words "lesson" and "student". Instead, it is widely acknowledged that children do not view school as a place for courses; instead, it is a space for children to be themselves. Teachers often use the words "child" and "activity" in their communication (Çocuk, Yanpar Yelken, Aslantürk, & Güçlü, 2021). Confirmatory factor analysis was conducted to determine the validity of the scale due to the changes made and the difference in the sample group and to understand whether the factor loadings of the original scale were valid for this research.

During the confirmatory factor analysis, the term "lesson" in the original scale was changed to "activity," and the term "student" was changed to "child" as specific to the early childhood field. In addition, the 14th item of the scale, "How much can you ensure that a student who is unsuccessful understands the lesson better?" was revised as "How much can you ensure that children with low participation in activities participate more in activities?". Other than these changes, no other changes were made. The original scale was administered to a total of 628 pre-service teachers, and only 15% of them were pre-service early childhood teachers. In this study, the data for the Early Childhood Teacher Self-Efficacy scale were collected from 219 early childhood teachers. Before the scale adaptation, permission was obtained from the scale owners. As it is known, if a scale whose construct validity has already been demonstrated is adapted to another culture and sample, it is a recommended approach to conduct confirmatory factor analysis directly without performing exploratory factor analysis again to test the construct validity of this scale (Ercan & Kan, 2004; Kahn, 2006). In addition to confirmatory factor analysis, the internal consistency reliability coefficient was also examined. Cronbach's alpha value of the scale was found to be .97, which is a very high reliability level. As a result of confirmatory factor analysis, acceptable fit values were obtained. Analyses related to construct validity and reliability are presented in this section.

Confirmatory Factor Analysis

Confirmatory factor analysis (CFA) was conducted to examine the construct validity of the Teacher Self-Efficacy Scale. The first-level correlated CFA examined the scale's 24-item and 3-factor structure.

Table 2.
Model fit values

	χ^2	*sd*	χ/sd^2	IFI	CFI	SRMR	RMSEA
Before modification	796.716	249	3,199	0.890	0.890	0.045	0.100
After modification	731.85	246	2,975	0.900	0.900	0.043	0.096
Acceptable fit values	-	-	<3	>0.90	>0.90	<0.08	<0.10

As a result of the analysis, acceptable fit values could not be reached (χ^2/sd=3,199, IFI=0,890, CFI=0,890, SRMR=0,045, RMSEA=0,100). Therefore, 3 modifications (m1-m2, m5-m15, m23-m24) were made considering the modification indices. Acceptable fit values were reached after modification. Model fit values are given in Table 2.

The item factor loadings, standard error, *t*, and *p* values after CFA are presented in Table 3. (S.S. = Student Engagement, I.S.= Instructional Strategies, C.M.= Classroom Management)

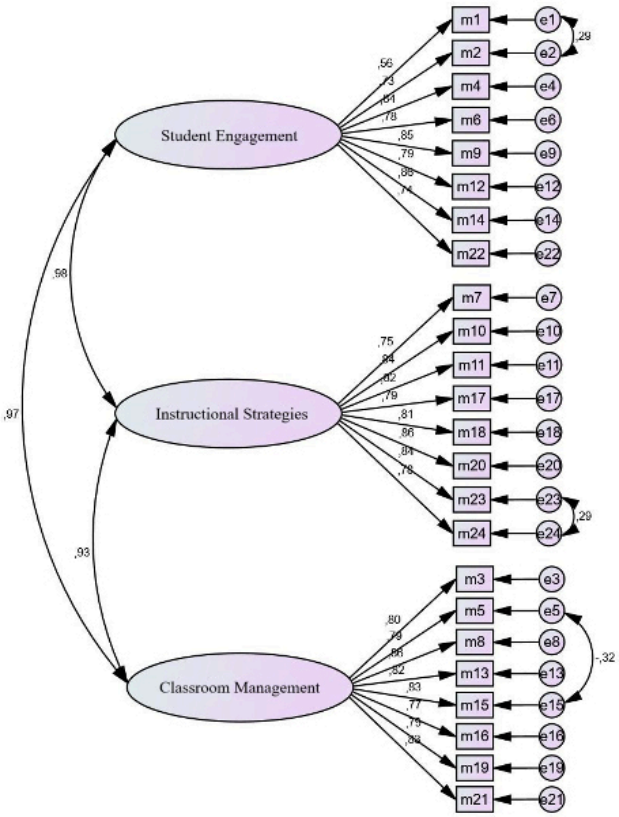
Table 3.
Item Factor Loadings, Standard Error, T and P Values

		Factor Load	S.H.	t	P
SS	m1	0.563	0.246	10.301	0.000
	m2	0.733	0.129	10.089	0.000
	m4	0.835	0.072	9.713	0.000
	m6	0.782	0.083	9.958	0.000
	m9	0.848	0.068	9.619	0.000
	m12	0.787	0.082	9.943	0.000
	m14	0.858	0.059	9.538	0.000
	m22	0.739	0.097	10.078	0.000
IS	m7	0.75	0.102	9.892	0.000
	m10	0.836	0.077	9.437	0.000
	m11	0.822	0.078	9.544	0.000
	m17	0.789	0.082	9.735	0.000
	m18	0.814	0.087	9.596	0.000
	m20	0.857	0.061	9.244	0.000
	m23	0.837	0.069	9.403	0.000
	m24	0.776	0.105	9.751	0.000
CM	m3	0.8	0.092	9.712	0.000
	m5	0.788	0.109	9.642	0.000
	m8	0.862	0.062	9.252	0.000
	m13	0.819	0.076	9.607	0.000
	m15	0.835	0.078	9.349	0.000
	m16	0.766	0.106	9.86	0.000
	m19	0.795	0.091	9.74	0.000
	m21	0.829	0.081	9.538	0.000

The factor loadings for the items ranged from 0.563 (m1) to 0.862 (m8), and all items in the scale showed statistically significant t values ($p < 0.001$). When conducting a t-test, researchers determine significance by examining the p-value. If the p-value is less than 0.001, the predetermined significance level, then the difference is considered significant (Kalaycı, 2006).

The structural model and standardized coefficients obtained after confirmatory factor analysis are presented in Figure 1.

Figure 1.
Standardized coefficients and structural model obtained after CFA



The confirmatory factor analysis confirmed the construct validity of the three-dimensional scale, which consists of 24 items. The scale was tested using the Amos program and confirmed with confirmatory factor analysis. Figure 2 shows the measurement model of the Teacher Self-Efficacy Scale.

The analysis concluded that the self-efficacy scale is a valid and reliable measurement tool.

Ethics Committee Declaration

This study was conducted with the permission of the Hacettepe University Educational Sciences Ethics Committee, whose decision is numbered E-51933218-300-00003096872, dated 24609/2023.

Findings

The purpose of this study was to assess the variation in self-efficacy among early childhood teachers based on demographic factors such as age, marital status, educational background, level of education, economic status, and teaching experience. Data was gathered from 219 teachers for this study. The collected data was analyzed using the SPSS program, and the findings were subsequently reported.

First, the f-percentage values and frequencies of the participant teachers' demographic information

were analyzed in the analyses. In addition, whether the research data met the assumption of normal distribution was examined, and as a result, skewness and kurtosis values were considered for the research data.

In the analyses conducted within the scope of the research objectives, nonparametric analysis methods were preferred. In this context, the Mann-Whitney *U* test was used in the analyses made according to variables with 2 groups, and the Kruskal Wallis *H* test was used in the analyses made according to variables with more than 2 groups. Significant differences in the Kruskal Wallis h test were analyzed using the Games-Howell test, one of the post-hoc tests.

In addition, Cronbach's alpha values were calculated to measure the reliability of the scale used in the study. The results of these analyses are reported.

Findings Regarding the Distribution of Research Data

Before analyzing the data collected for teacher self-efficacy, the distribution of the relevant data was checked. It is generally recommended that Shapiro-Wilk and Kolmogorov-Smirnov tests be used when conducting normality checks (Büyüköztürk, 2010). On the other hand, when checking normality in different sciences, especially in social sciences, skewness and kurtosis values play an important role in terms of control (Yalçıntaş, 2019). According to George and Mallery (2010), a value between -2 and +2 indicates a normal distribution.

According to Table 2, the skewness and kurtosis values of the data collected for teacher self-efficacy are not between -2 and +2. In this context, it was accepted that the research data were not normally distributed. Nonparametric methods are used to analyze studies whose data do not show normal distribution (Kul, 2014). For this reason, the research was continued with nonparametric tests.

Findings on Teacher Self-Efficacy

Within the scope of the research purpose, teacher self-efficacy was analyzed according to demographic variables. In this context, the Mann-Whitney *U* test was used to analyze variables with 2 groups, and the Kruskal Wallis *H* test was used to analyze variables with more than 2 groups. Significant differences in the Kruskal Wallis H test were analyzed using the Games-Howell test, one of the post hoc tests.

Table 4.
Normality Checks of Participant Teachers' Self-Efficacy Levels

Size	Skewness		kurtosis	
	Statistics	St. Error	Statistics	St. Error
Total	-1.39	.16	3.04	.33
SS	-1.46	.16	3.28	.33
IS	-1.34	.16	2.95	.33
CM	-1.18	.16	2.69	.33

Table 5.
Evaluation of Early Childhood Teachers' Self-Efficacy by Age

Size	Age Group	n	Rank Mean	x^2	df	p	Difference
Total	18-25 years old	44	90.45	19.75	3	.000**	4>1,2
	25-30 years old	78	94.64				
	30-40 years old	52	129.38				
	40 years and older	45	133.34				
Competence for Student Engagement	18-25 years old	44	92.50	17.57	3	.001*	4>1,2
	25-30 years old	78	94.96				
	30-40 years old	52	128.22				
	40 years and older	45	132.12				
Competence for Instructional Strategies	18-25 years old	44	90.90	19.69	3	.000**	4>1,2
	25-30 years old	78	94.67				
	30-40 years old	52	127.02				
	40 years and older	45	135.58				
Competence for Classroom Management	18-25 years old	44	92.69	13.52	3	.004*	4>1
	25-30 years old	78	98.02				
	30-40 years old	52	126.22				
	40 years and older	45	128.94				

*p<.05; **p<.001

According to Table 5, when the data on teacher self-efficacy were compared by age group, significant differences were found between the groups in total score and all sub-efficacy dimensions ($p < .05$).

Games Howell test, one of the post-hoc tests that has an important place in determining the direction of the differences in teacher self-efficacy according to age group, was conducted. Accordingly, in the total score and the dimensions of efficacy for student engagement and efficacy for instructional strategies, the scores of teachers aged 40 and over were significantly higher than those of teachers in the 18-25 and 25-30 age groups. In the dimension of competence for classroom management, the score of teachers aged 40 years and over was significantly higher than that of teachers aged 18-25.

According to Table 6, when the data on teacher self-efficacy were compared according to marital status, significant differences were found between the groups in total score and all sub-efficacy efficacy dimensions ($p<.05$). However, no significant difference was found in the dimension of efficacy for classroom management according to marital status ($p>.05$).

One of the posthoc tests, the Games Howell test, was used to determine the direction of the differences in teacher self-efficacy according to marital status. Accordingly, married teachers' scores were significantly higher than single teachers' in total scores and the dimension of efficacy for teaching strategies.

According to Table 7, when the data on teacher self-efficacy were compared according to graduation, no significant difference was found between the groups in the total score and the dimensions of efficacy for teaching strategies, efficacy for student engagement, and efficacy for classroom management ($p > .05$).

Table 6.

Evaluation of Early Childhood Teachers' Self-Efficacy According to Their Marital Status

Size	Med. Status	*n*	S.O.	x^2	df	*p*	Difference
Total	Married	115	119.95	8.36	2	.02*	1>2
	Single	102	97.65				
Competence for Student Engagement	Married	115	117.94	7.54	2	.02*	3>1,2
	Single	102	99.54				
Competence for Instructional Strategies	Married	115	121.32	10.25	2	.01*	1>2
	Single	102	96.11				
Competence for Classroom Management	Married	115	118.90	5.44	2	.07	
	Single	102	99.45				

Table 7.

Evaluation of Early Childhood Teachers' Self-Efficacy According to the Department of Graduation

Size	Graduation	n	S.O.	x^2	df	p	Difference
Total	Early Childhood Teacher.	184	106.02	4.64	2	.10	
	Child Development	35	129.89				
Competence for Student Engagement	Early Childhood Teacher.	184	105.42	6.04	2	.05	
	Child Development	35	134.33				
Competence for Instructional Strategies	Early Childhood Teacher.	184	107.11	2.78	2	.25	
	Child Development	35	123.17				
Competence for Classroom Management	Early Childhood Teacher.	184	105.90	4.91	2	.09	
	Child Development	35	130.69				

*p<.05; **p<.001

Table 8.

Evaluation of Early Childhood Teachers' Self-Efficacy by Educational Background

Size	Education Status	n	S.O.	x^2	df	p	Difference
Total	Associate Degree	20	130.38	5.24	2	.07	
	Undergraduate	159	104.08				
	Postgraduate	40	123.36				
Competence for Student Engagement	Associate Degree	20	136.80	7.81	2	.02*	1,3>2
	Undergraduate	159	102.88				
	Postgraduate	40	124.89				
Competence for Instructional Strategies	Associate Degree	20	129.57	3.61	2	.16	
	Undergraduate	159	105.27				
	Postgraduate	40	119.03				
Competence for Classroom Management	Associate Degree	20	128.63	4.68	2	.10	
	Undergraduate	159	104.38				
	Postgraduate	40	123.04				

*p<.05; **p<.001

According to Table 8, when the data on teacher self-efficacy were compared according to educational status, no significant differences were found between the groups in total score, competence for teaching strategies, and guidance for classroom management (p > .05). However, significant differences were found in the dimension of efficacy for student engagement (p < .05).

One of the posthoc tests, the Games Howell test, was used to determine the direction of the differences in teacher self-efficacy according to educational status. Accordingly, in the dimension of efficacy for student engagement, the scores of teachers with associate and postgraduate degrees were significantly higher than those of teachers with bachelor's degrees.

According to Table 9, when the data on teacher self-efficacy were compared according to experience, significant differences were found between the groups in total score, efficacy for student engagement, efficacy for instructional strategies, and efficacy for classroom management (p<.05).

Games Howell test, one of the post-hoc tests, was used to determine the direction of the differences in teacher self-efficacy according to experience. Accordingly, in the total score and the dimension of efficacy for teaching strategies, the score of teachers with 10-20 years and 20 years and more experience was significantly higher than the score of teachers with 0-5 years of experience; the score of teachers with 20 years and more experience was significantly higher than the score of teachers with 5-10 years of experience. In the dimensions of competence for student engagement and competence for classroom management, the scores of teachers with 10-20 years and 20 years or more experience were significantly higher than those with 0-5 years of experience.

Discussion, Conclusion And Recommendations

The study examined the self-efficacy of early childhood teachers using descriptive statistics for both the overall scale and its sub-dimensions. The findings indicated that early childhood teachers generally exhibit high levels of self-efficacy. Several studies support this result. For instance, Klassen and Chu (2010) found high levels of self-efficacy among early childhood teachers, particularly in the areas of classroom management and student engagement. Similar findings were also reported in previous studies by Gömleksiz and Serhatlıoğlu (2013), Ergun (2015), Semerci and Uyanık Balat (2018), Balci and Kucukoglu (2019), Karabulut (2023), Aslan et al. (2023), and Schaub and Lütolf (2024), which highlighted the high self-efficacy of early childhood teachers in classroom management and student engagement. The literature review suggests that the high self-efficacy of early childhood teachers has a significant impact on learning environments in various ways. According to the research, teachers with high levels of self-efficacy are more open-minded (O'Reilly, Devitt, & Hayes, 2022) and can produce creative solutions to the challenges encountered (Alfonso, 2023). They are able to keep up with the current and technological developments required by the age (Williams et al., 2023; Zhao & Yang, 2023), have more beliefs about the goals to be achieved, and are more self-confident teachers (Tschannen-Moran et al., 1998; Erdoğan, 2023; Zee et al., 2018). In addition, early childhood teachers with high levels of self-efficacy are able to plan inclusive activities that include all children in the classroom and ensure the participation of all children in these activities (D'Agostino & Horton, 2023). Teachers with high self-efficacy could offer creative options in classroom management and early childhood activities that play a critical role in children's development and skills (O'Reilly, Devitt, & Hayes, 2022). Furthermore, they have a higher level of job satisfaction and liking for their

Table 9.

Evaluation of Early Childhood Teachers' Self-Efficacy According to Their Experience

Size	Experience	n	S.O.	x^2	df	p	Difference
Total	0-5 Years	104	92.40	22.56	3	.000**	3,4>1 4>2
	5-10 Years	46	108.23				
	10-20 Years	45	131.34				
	20 Years and above	24	149.63				
Competence for Student Engagement	0-5 Years	104	95.02	17.18	3	.000**	3,4>1
	5-10 Years	46	106.84				
	10-20 Years	45	129.90				
	20 Years and above	24	143.67				
Competence for Instructional Strategies	0-5 Years	104	94.51	20.06	3	.000**	3,4>1 4>2
	5-10 Years	46	105.16				
	10-20 Years	45	129.96				
	20 Years and above	24	148.96				
Competence for Classroom Management	0-5 Years	104	93.24	20.76	3	.000**	3,4>1
	5-10 Years	46	108.20				
	10-20 Years	45	129.92				
	20 Years and above	24	148.73				

*p<.05; **p<.001

profession (Şenol & Ergün, 2015), and increased critical thinking skills and attitudes of both teachers and students (Arslan & Kutluca, 2021). It has emerged that the level of self-efficacy of early childhood teachers is fundamental. These studies show how vital the self-efficacy levels of early childhood teachers are.

Given the current developments, the significance of self-efficacy is increasingly evident. Therefore, it is crucial to have a self-efficacy scale that is relevant to present conditions. The research findings demonstrate that the self-efficacy scale, tailored for early childhood teachers, is reliable and valid. The study thoroughly analyzed the validity and reliability of the adapted scale, yielding positive and robust results. The findings suggest that the adapted Teacher Self-Efficacy Scale is indeed a reliable and valid tool for early childhood teachers. This adaptation is believed to hold significant value for early childhood teachers and the field of early childhood education.

When early childhood teachers' self-efficacy was evaluated according to age groups, the scores of teachers aged 40 years and over were significantly higher than those of teachers aged 18-25 years and 26-30 years in the total score and student engagement and instructional strategies sub-dimensions. In the sub-dimension of classroom management, the score of teachers aged 40 and over was significantly higher than that of teachers aged 18-25. In other words, as early childhood teachers' ages increase, their self-efficacy increases directly. In support of the results, Şenol and Ergün (2015) found that early childhood teachers aged 30 years and older had higher levels than teachers under 30. In addition, Gökmen et al. (2016) found that as the age increases, the self-efficacy levels of early childhood teachers also increase. In addition, Koç and Sak (2017) found a positive relationship between early childhood teachers' age and their self-efficacy. Sağlam (2018) presented a significant difference between the ages of early childhood teachers and their self-efficacy in his study. He concluded that as the age of early childhood teachers increased, their self-efficacy also increased. In addition, Karabulut (2023) found a directly proportional relationship between teachers' ages and their self-efficacy levels. The results of the study in terms of age were similar to most studies. It can be thought that the self-confidence brought by experience with age is the reason for the high level of self-efficacy.

When early childhood teachers' self-efficacy was evaluated according to marital status, significant differences were found between the groups in the total score and the dimensions of efficacy for student engagement and teaching strategies. However, no significant difference was found in the dimension of efficacy for classroom management according to marital status. According to the study conducted by Aslan et al. (2023), no significant difference was found between marital status and self-efficacy of early childhood teachers. Also, Mbongo (2024) found that there is no significant difference between marital status and teachers' self efficacy levels. While these support the research result in the sub-dimension of classroom management, it does not support the dimension of student engagement and teaching strategies. The difference here can be said to be that the Aslan and coworkers's sample included secondary school teachers as well as early childhood teachers. Similarly, Mbongo made his research with high school teachers.

When evaluated according to the department of graduation, which is another variable, no significant difference was found between the groups in total score and all sub-competency dimensions. Similarly, Metin and Aydoğan (2019) found no significant relationship between the department early childhood teachers graduated from and their self-efficacy. The reason for this may be that the contents of the undergraduate programs of child development and early childhood teaching departments are similar.

Another variable used in the data analysis was the early childhood teachers' education level. Accordingly, while there were no significant differences between the groups in the total score and the dimensions of competence for teaching strategies and guidance for classroom management, significant differences were found in the competence dimension for student engagement according to educational level. According to the Games Howell test, in the dimension of efficacy for student engagement, the scores of teachers with associate and postgraduate degrees were significantly higher than those of teachers with bachelor's degrees. In general, no significant relationship was found between education levels and self-efficacy. The reason for the high student participation rate may be that teachers take courses or conduct research that includes different methods for student participation in their master's or doctoral education. Similarly, Semerci and Uyanık Balat (2018) revealed that early childhood teachers with associate's degrees had higher levels of self-efficacy than teachers with graduate and undergraduate degrees. In addition, Aslan et al. (2023) According to the study conducted by the Turkish National Education Association, teachers with postgraduate degrees had more self-efficacy than teachers with undergraduate degrees. These results partially support this study. On the other hand, Sağlam (2018) did not find a significant difference between early childhood teachers' education level and their self-efficacy. The reason for this result may be that not all of the participants at the graduate level graduated from the same department.

After analyzing the data based on experience, significant differences were revealed between

the groups in total score and all sub-competency dimensions. According to the Games Howell test, teachers with 10-20 years and 20 years or more experience scored significantly higher in total score and the dimension of competence for instructional strategies than teachers with 0-5 years of experience. Additionally, teachers with 20 years or more experience scored significantly higher than those with 5-10 years of experience. In student engagement and classroom management, teachers with 10-20 years and 20 years or more experience scored significantly higher than those with 0-5 years of experience. This aligns with the findings of several studies, including Klassen and Chu (2010), Senol and Ergun (2015), Gokmen et al. (2016), Koc and Sak (2017), Saglam (2018), Cetinkaya (2019), and Aslan et al. (2023). The studies mentioned observed a strong positive correlation between early childhood teachers' experience and their self-efficacy. In addition, these results showed similar and expected results regarding the age criterion of the study, which is generally related to experience. However, there are some differing results from other studies. Gömleksiz and Serhatlıoğlu (2013) found no significant relationship between early childhood teachers' self-efficacy and their experience. This difference may be because only 10% of the participants in their study had 10 years or more of experience. Additionally, Infurna, Riter, and Schultz (2018) found no significant difference between early childhood teachers' self-efficacy and experience. This could be because their study was only conducted with teachers working in urban areas, and children in rural areas may create more challenging learning environments than children in urban areas.

This study involved 219 early childhood teachers and focused solely on data collected from this group. To improve the research, it is suggested that a broader range of early childhood teachers be included in future studies. Additionally, experimental studies on various factors that influence the self-efficacy levels of early childhood teachers are recommended. Furthermore, organizing training sessions and seminars to help teachers address current challenges is also advised. It is also recommended that qualitative research be planned to examine in depth the self-efficacy status of preschool teachers.

References

Afacan, Ş. (2008). Music Teaching Self-Efficacy Scale. *Ahi Evran University Kırşehir Faculty of Education Journal*, 1-11.

Akkuş, A., & Doymuş, K. (2018). Investigation of Science Teachers' Approach to Students in Teaching*. *Anemon Muş Alparslan University Journal of Social Sciences*, 147-153. https://doi.org/10.18506/anemon.468481

Alanoglu, M. (2021). The Role of Instructional Leadership in Increasing Teacher Self-Efficacy: A Meta-Analytic Review. *Asia Pacific Education Review, 23*, 233-244. DOI: 10.1007/s12564-021-09726-5

Alfonso, A. (2023). Professional Learning Communities (PLCs) in Selected Secondary Schools: Implementation, Challenges and Opportunities. *Asian Journal of Multidisciplinary Research & Review (AJMRR), 6*(4), 38-69. https://doi.org/10.55662/

Alisinanoğlu, F., & Buldur, A. (2020). Development of Self-Efficacy Scale for Science Education in Preschool. *Kastamonu Education Journal*, 512-520. https://doi.org/10.24106/kefdergi.3704

Arslan, A., & Kutluca, A. Y. (2021). Investigation of Pedagogical Beliefs of Preschool Teachers in Terms of Teacher Self-Efficacy and Critical Thinking. *Trakya Education Journal, 11*(2), 853-869. https://doi.org/10.24315/tred.742927

Aslan, H., Bal, A., Akbulut, S., & Çetin, B. (2023). Examining the Relationship Between Teachers' Self-Efficacy and Readiness for Change. *Scientific Educational Studies*, 1-32. https://doi.org/10.31798/ses.1270645

Ateş, Ö. (2015). Investigation of Preschool Teacher Candidates' Self-Efficacy Beliefs Towards Family Participation Studies. *Master's Thesis*. Denizli: Council of Higher Education Thesis Center.

Baltacı, A. (2018). A Conceptual Review on Sampling Methods in Qualitative Research and Sample Volume Problems. *Bitlis Eren University Journal of Institute of Social Sciences, 7*(1), 231-274.

Bandura, A. (1977). Self-Efficacy: Toward A Unifying Theory of Behavioral Change. *Psychological Review, 84*(2), 191-215. https://doi.org/10.1037/0033-295X.84.2.191

Büyüköztürk, Ş., Kılıç Çakmak, E., Akgün, Ö., Karadeniz, Ş., & Demirel, F. (2018). *Scientific Research Methods in Education.* Ankara: Pegem Akademi.

Büyüköztürk, Ş. (2010). *Handbook of Data Analysis for Social Sciences: Statistics, Research Design, SPSS Applications and Interpretation* (12th Edition). Ankara: Pegem Akademi.

Claire, H. (2023). *Expatriate Teachers' Mental Wellbeing in the Workplace - An Overview of Strategies for Improved Brain Health and Mental Wellbeing.* Tampere University of Applied Sciences.

Çapa, Y., Çakıroğlu, J., & Sarıkaya, H. (2005). Validity and Reliability Study of Turkish Adaptation of Teacher Self-Efficacy Scale. *Education and Science*, 74-81.

Çetinkaya, F. (2019). Investigation of the Relationship between Preschool Teachers' Self-Efficacy Beliefs and Teaching Attitudes. Master's Thesis: Istanbul Sabahattin Zaim University Institute of Social Sciences.

Çocuk, H. E., Yanpar Yelken, T., Aslantürk, E., & Güçlü, M. (2021). Determination of Preschool Teachers' Opinions on the Implementation of Activities Related to the Language Area of the Preschool Education Program. *The Journal of Academic Social Science Studies*, 305-320.

D'Agostino, S. R., & Horton, E. (2023). Examining Inclusive Preschool Teachers' Perspectives and Practices: A Mixed-Methods Investigation . *Journal of Early Intervention*. https://doi.org/10.1177/10538151231190627

Ercan, İ., & Kan, İ. (2004). Validity and Reliability in Scales. *Journal of Uludag University Faculty of Medicine, 30*(3), 211-216.

Erdoğan, U. (2023). Examining the Relationship Between Teacher Leadership and Self-Efficacy. *Inonu University Journal of the Graduate School of Education, 10*(20), 213-232.

George, D. & Mallery, M. (2010). *SPSS for Windows Step by Step: A Simple Guide and Reference.* Boston: Pearson.

Gökmen, A. H., Deveci, H., Bingöl, K., Bekir, H., Temel, F., & Kanat, K. (2016). Investigation of the Relationship Between Preschool Teachers' High/Scope Approach Beliefs and Self-Efficacy Beliefs. *Kastamonu Journal of Education, 24*(5), 2481-2500.

Gömleksiz, M. N., & Serhatlıoğlu, B. (2013). Preschool Teachers' Views on Self-Efficacy Beliefs. *International Periodical For the Languages, Literature and History of Turkish or Turkic, 8*(7), 201-221. http://dx.doi.org/10.7827/TurkishStudies.5336

Gözüm, A. İ., & Güneş, T. (2018). Science Teaching Self-Efficacy Scale: Validity and Reliability Study. *Mersin University Journal of Faculty of Education*, 1176-1199. https://doi.org/10.17860/mersinefd.393098

Günşen, G., & Uyanık, G. (2020). Validity and Reliability Study of Preschool Teachers' Science Education Self-Efficacy Belief Scale. *Eurasian Journal of Teacher Education*, 1-24.

Gordon, D., Blundell, C., Mills, R., & Bourke, T. (2022). Teacher Self-Efficacy and Reform: A Systematic Literature Review. *The Australian Educational Researcher, 50*, 801-821. https://doi.org/10.1007/s13384-022-00526-3

Hardianto, H., Sari, V. P., & Hidayat, H. (2023). Optimizing Teacher Self-Efficacy in Facing the New Normal: A Literature Review . *Ishlah: Jurnal Pendidikan, 15*(1). https://doi.org/10.35445/alishlah.v15i1.2835

Hernández-Saca, D. I., Voulgarides, C. K., & Etscheidt, S. L. (2023). A Critical Systematic Literature Review of Global Inclusive Education Using an Affective, Intersectional, Discursive, Emotive and Material Lens. *Education Sciences, 13*(12), 1-13. https://doi.org/10.3390/educsci13121212

Infurna, C., Riter, D., & Schultz, S. (2018). Factors that Determine Preschool Teacher Self-Efficacy in an Urban School District. *International Electronic Journal of Elementary Education*, 1-7. 10.26822/iejee.2018143929

Kahn, J. (2006). Factor Analysis in Counseling Psychology Research, Training, and Practice: Principles, Advances, and Applications. *The Counseling Psychologist*, 684-718. https://doi.org/10.1177/0011000006286347

Kalaycı, Ş. (2006). *SPSS Applied Multivariate Statistical Techniques.* Ankara: Asil Publication Distribution.

Karabulut, H. A. (2023). Determination of Teacher Candidates' Self-Efficacy Towards Inclusive Education. *Ahmet Keleşoğlu Education Faculty Journal (AKEF) Journal*, 531-542. https://doi.org/10.38151/akef.2023.68

Klassen, R. M., & Chiu, M. M. (2010). Effects on Teachers' Self-Efficacy and Job Satisfaction: Teacher Gender, Years of Experience, and Job Stress. *journal of Educational Psychology*, 741-756. https://doi.org/10.1037/a0019237

Klassen, R., & Tze, V. (2014). Teachers' Self-Efficacy, Personality, and Teaching Effectiveness: A Meta-Analysis. *Educational Research Review, 12*(4), 59-76. https://doi.org/10.1016/j.edurev.2014.06.001

Koç, F., & Sak, R. (2017). Investigation of Preschool Teachers' Self-Efficacy Beliefs Towards Activities in Preschool Education Program. *Journal of Uludağ University Faculty of Education, 30*(1), 43-71. 10.19171/uefad.323381

Koç, F., Sak, R., & Kayri, M. (2015). Validity and Reliability Analysis of Self-Efficacy Belief Scale for Activities in Preschool Education Program. *İlköğretim Online,* 1416-1427.

Kul, S. (2014). Guideline For Suitable Statistical Test Selection. *Pleura Bulletin, 8(2),* 26-29.

Ma, Y. (2022). The Effect of Teachers' Self-Efficacy and Creativity on English as a Foreign Language Learners' Academic Achievement. *Frontiers in Psychology, 13*, 1-4. https://doi.org/10.3389/fpsyg.2022.872147

Maden, A. (2020). Secondary School Students' Turkish Course Self-Efficacy Perceptions. *International Journal of Turkish Literature Culture Education (TEKE)*, 1136-1150.

Mbongo, D. (2024). Relationship Between Teachers' Self-efficacy and Age, Gender, and Marital Status Among Teachers at Rural High Schools. *International Journal of Studies in Inclusive Education , 1*(1), 93-98. https://doi.org/10.38140/ijsie.v1i1.1288

MEB. (2017). *TEDP Basic Education Support Project "Teacher Education Component" General Competencies for Teaching Profession.* General Qualifications for the Teaching Profession: Retrieved from https://oygm.meb.gov.tr/dosyalar/StPrg/Ogretmenlik_Meslegi_Genel_Yeterlikleri.pdf

Metin, Ş., & Aydoğan, Y. (2019). Investigation of Preschool Teachers' Special Field Competence and Self-Efficacy Levels. *Milli Eğitim*, 33-57.

Mohamad, R. F., Hinduja, P., & Siddiqui, S. (2023). Unveiling the Path to Sustainable Online Learning: Addressing Challenges and Proposing Solutions in Pakistan. *Sustainable Online Learning, 37*(6). https://doi.org/10.1108/IJEM-07-2023-0334

O'Beid, V. (2023). *Teacher Perception of Administration's Impact on School Climate and Overall Teacher Self-Efficacy: A Meta-Analysis of the Literature.* Major Papers.

Ocakcı, E., & Samancı, O. (2019). Investigation of Combined Classroom Teachers' Classroom Management Competencies and Their Views on Classroom Management. *Bolu Abant İzzet Baysal University Journal of Faculty of Education,* 604-620. https://doi.org/10.17240/aibuefd.2019.19.46660-473991

O'Reilly, C., Devitt, A., & Hayes, N. ´. (2022). Critical Thinking in the Preschool Classroom - A Systematic Literature Review. *Thinking Skills and Creativity*, 1-20. 10.1016/j.tsc.2022.101110

Oğuz, V. (2017). The Relationship Between Preschool Teacher Candidates' Problem Solving Skills and Teacher Self-Efficacy Perceptions. *Journal of Contemporary Management Sciences*, 20-30.

Özoruç, N., & Dikici Sığırtmaç, A. (2022). Preschool Teachers' Opinions on the Problems Faced by Refugee Children in the Education Process. *Journal of National Education, 51*(233), 237-258. https://doi.org/10.37669/milliegitim.779155

Rofiah, K., Kossewska, J., Herviani, V. K., & Sheehy, K. (2023). Postawy Nauczycieli Wobec Edukacji Wlaczzjacej. Przeglad Systsematyczny. [A Systematic Review of Teachers' Attitudes Towards Inclusive Education]. *Niepełnosprawność i Rehabilitacja, 90*(2), 69-91. 10.5604/01.3001.0053.8783

Sağlam, H. (2018). Investigation of Preschool Teachers' Self-Efficacy Beliefs Towards Activities in Preschool Education Program. Master's Thesis.

Schaub, S., & Lütolf, M. (2024). Attitudes and Self-Efficacy of Preschool Educators Towards the Inclusion of Children with Disability in Day-Care. *European Journal of Special Needs Education*, 185-200. https://doi.org/10.1080/08856257.2023.2200106

Semerci, D., & Uyanık Balat, G. (2018). Investigation of the Relationship Between Preschool Teachers' Classroom Management Skills and Self-Efficacy Perceptions. *Journal of Inonu University Faculty of Education, 19*(3), 494-519. https://doi.org/10.17679/inuefd.394585

Shu, K. (2022). Teachers' Commitment and Self-Efficacy as Predictors of Work Engagement and Well-Being . *Frontiers in Psychology*. https://doi.org/10.3389/fpsyg.2022.850204

Şenol, F. B., & Ergün, M. (2015). Comparison of Preschool Teacher Candidates' and Preschool Teachers' Self-Efficacy Beliefs Towards Teaching Profession. *Journal of Theoretical Educational Science*, 297-315.

Tabachnick, B. G. and Fidell, L. S. (2013). *Using Multivariate Statistics* (6th Edition). Boston: Pearson.

Täschner, J., Dicke, T., Reinhold, S., & Holzberger, D. (2023). *"Yes, I can!" A Systematic Review and Meta-Analysis of Intervention Studies Promoting Teacher Self-Efficacy*. https://doi.org/10.3102/00346543231221499

Tepe, D., & Demir, K. (2012). Preschool Teachers' Self-Efficacy Beliefs Scale. *Abant Izzet Baysal University Journal of Faculty of Education, 12*(2), 137-158.

Tschannen-Moran, M., Hoy, A. W., & Hoy, W. K. (1998). Teacher Efficacy: Its Meaning and Measure . *Review of Educational Research, 68*(2), 202-248. 10.3102/00346543068002202

Tuğluk, M. N., & Kürtmen, S. (2018). Teacher Competencies in Turkey. *Journal of Adıyaman University Institute of Social Sciences*, 809-841. https://doi.org/10.14520/adyusbd.480236

Yalçıntaş, M. (2019). *The Effect of Using Quantum Learning Model in Science Teaching on Primary School Fourth Grade Students' Academic Curiosity, Anxiety, Self-Efficacy and Achievement Levels* (Unpublished master's thesis). Marmara University, Institute of Educational Sciences, Istanbul.

Williams, M. K., Christensen, R., McElroy, D., & Rutledge, D. (2023). Teacher Self-Efficacy in Technology Integration as a Critical Component in Designing Technology-Infused Teacher Preparation Programs. *Contemporary Issues in Technology and Teacher Education, 23*(1), 228-259.

Yalçıntaş, M. (2019). *The Effect of Using Quantum Learning Model in Science Teaching on Primary School Fourth Grade Students' Academic Curiosity, Anxiety, Self-Efficacy and Achievement Levels* (Unpublished master's thesis). Marmara University, Institute of Educational Sciences, Istanbul

Wray, E., Sharma, U., & Pearl, S. (2022). Factors Influencing Teacher Self-Efficacy for Inclusive Education: A Systematic Literature Review. *Teaching and Teacher Education, 117*, 1-19. https://doi.org/10.1016/j.tate.2022.103800

Wulandari, A., & Suryandari, K. C. (2022). The Role of Self-Efficacy and Teacher Workload on Primary School Teacher Performance: Systematic Literature Review. *Jurnal Riset Pedagogik, 6*(3), 482-491. 10.20961/jdc.v6i3.68119

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Intrinsic and Extrinsic Motivation of Primary School Students for Mathematics and English as a Foreign Language

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Abstract

This study examines the extent to which primary school students are motivated to learn two significant academic subjects, namely mathematics and English as a foreign language (EFL). Additionally, it explores the trends in motivational levels as students advance through different grades. It is crucial to track both intrinsic and extrinsic motivation exhibited by primary school students towards specific subjects, across various subjects and grade levels, because it provides valuable insights into the dynamics of student motivation and contributes to a more comprehensive understanding of their overall learning engagement. To investigate types of motivation, a sample of 638 students from Grades 3 and 5 participated in the survey. The results indicate that primary school students are almost equally intrinsically and extrinsically motivated to learn mathematics and EFL. This suggests a balanced approach to students' overall motivation towards learning. Regarding motivational trends, the results show that in mathematics, both types of student motivation decline with increasing age, while in EFL, intrinsic motivation increases and extrinsic motivation decreases as students advance through higher grade levels. These findings underscore the necessity of implementing innovative strategies to sustain and enhance intrinsic motivation among students in the upper grades of primary school. Additionally, it highlights the importance of strategically utilizing external factors to support and promote sustained academic achievement of students of these grades.

Keywords:

Intrinsic and Extrinsic Motivation, Primary School, Age Differences, Mathematics, EFL

Introduction

Educators widely acknowledge motivation as a crucial affective factor significantly impacting student achievement across various academic subjects. Being defined as an incentive to stimulate action, or as a reason that underlies behavior (Ryan & Deci, 2017), motivation plays a crucial role in arousing students' inner drive and "directing their behavior towards learning" (Nyman & Sumpter, 2019, p. 80). Indeed, for effective learning, it is essential to

have an incentive that directs students' interest and engagement towards the learning process.

Learning incentives can appear in the form of intrinsic and extrinsic energies that stem from a student's internalized curiosity, wish, and desire for personal fulfillment and pleasure (Howard et al., 2021), as well as from the inducted interest by the external environment to succeed for being recognized and rewarded by others. Therefore, based on the self-determination theory (Ryan & Deci, 2017), there are two main types of motivation. It is intrinsic motivation, which is recognized as the process when students are engaged in a learning activity "for their own sake, or for their inherent interest and enjoyment" (Ryan & Deci, 2020, p. 3), and extrinsic motivation when students' engagement in the activity is more of an instrumental character, such as completing a task to attain some external benefits (Wallace & Leong, 2020). To understand why some students prefer certain school subjects while requiring external stimulation to engage effectively with others, it is crucial to investigate the different types of motivation that drive their learning preferences. A better understanding of students' incentives towards learning helps teachers implement research-based learning strategies that cultivate students' intrinsic and extrinsic motivation and maximize their potential to master these subjects.

As a result of an earlier perception among researchers about the difficulties in tracking the manifestation of different types of motivation in young children (Oga-Baldwin et al., 2017; Ramos et al., 2022), a priority focus was devoted to the research on students' motivation in secondary and higher education (Kum, 2022), and less attention was paid to analyzing this phenomenon in early grades (Wallace & Leong, 2020; Xia et al., 2022). However, a recent study conducted by Nyman and Sumpter (2019) with students from grade 1 to grade 3 "indicates a rather rapid change" of students' motivation in primary school and "signals the need to know more about young students' motivation" (p. 81). It is essential to track the types of motivation exhibited by students towards specific school subjects (within school subject differentiation) and across them (between school subject differentiation), as it provides "a better understanding of student motivational dynamics" (Guay et al., 2010, p. 711) towards their schooling. Moreover, even a minor reluctance to engage with specific school subjects during early education can increase students' anxiety towards these subjects in the future and, if not addressed properly, it may influence their decision to avoid related professions.

Given the critical importance of mathematics and languages in early education, this study intended to explore to what extent primary school students exhibit the main types of motivation towards learning mathematics and EFL. Poor mathematics achievement of primary school students in the international test of TIMSS 2019, which ranked Kosovo in 49th place among 58 countries (Mullis et al., 2020), is concerning and highlights the need for mobilizing all educators to increase students' desire to learn mathematics. Furthermore, the rapid development of digital technology, with English as the default language in the tech community and its use for educational purposes, necessitates the sparking of primary school students' interest in learning EFL. Among the factors that can enhance primary school students' motivation to build a solid foundation in mathematics and English are teachers. As agents of change, they can implement innovative strategies to improve the learning environment and stimulate students' curiosity and enthusiasm for learning these subjects. In the long term, this approach can help students achieve enhanced academic performance that subsequently may lead them to better career opportunities and more successful integration into the global labor market.

Literature Review

The word "motivation" originates from the word "movere", which is a Latin term that means "to move" towards achieving a goal. As a concept, motivation is understood as an internal process that induces, guides, and nurtures goal-directed behavior in humans. It can be understood as "the engine that keeps us going" (Nyman & Sumpter, 2019, p. 81), the driving force that pushes human beings to accomplish an action that has some meaning and is important to them.

Applied in education, motivation refers to students' reasons for engaging in different curricular and extra-curricular activities to attain a specific goal related to their school achievements. This implies the necessity to understand the student's motivation as a conscious activity that has to be triggered somehow (Ryan & Deci, 2017). At school, this motivation can be triggered in two ways, by stimulating students' internal needs as a natural driving force to satisfy their demands for competence, "enjoyment, and interest in doing academic tasks" (Howard et al., 2021, p. 2), and by using external prod, such as prizes and good grades, through which you tend to generate their willingness to realize certain activities (Ryan & Deci, 2020). Certainly, this does not mean that the student in the first case neglects the acknowledgment and reward that might follow the successful performance of tasks, "but these rewards are not enough to keep that person motivated" (Kum, 2022, p. 13). Consequently, two main types of students' motivation – intrinsic and extrinsic motivation – can be identified, depending on how their self-determination in completing activities during the learning process is activated. For example, students who voluntarily are engaged in solving various mathematical problems

and persist throughout the process, are intrinsically motivated towards mathematics. On the other hand, those who show no interest in solving mathematical problems unless there is an external reward following it are extrinsically motivated to learn mathematics (Rodríguez et al., 2021). Similarly, students who enjoy reading and communicating in English are intrinsically driven towards learning this language, while others, who do so mainly for the sake of getting good grades or other rewards are perceived as extrinsically driven towards learning it (Wallace & Leong, 2020). Simply put, intrinsically motivated students to learn a specific school subject are enthusiastic and show inspiration to participate in activities related to it, whereas, extrinsically motivated students' reasons "are tangential to learning" (Howard et al., 2021, p. 2) and they are usually supported with additional rewarding instigation to finish activities that are characteristic for that school subject.

Although both types of motivation are important in influencing students' academic learning and achievements (Zaccone & Pedrini, 2019), some researchers give higher credit to intrinsic motivation than to extrinsic one (Guay & Bureau, 2018; Howard et al., 2021). Indeed, stemming from a student's internal drive, intrinsic motivation fosters commitment, a positive mood, and enjoyment during the learning process. As a result, it positively impacts students' learning effectiveness and helps them achieve better grades (Rodríguez et al., 2021; Zaccone & Pedrini, 2019). To emphasize its importance, intrinsic motivation "is conceptualized as a natural catalyst for learning and achievement" (Garon-Carrier et al., 2016, p. 165). On the other hand, extrinsic motivation provides students a reason to pursue knowledge by offering the "carrot" of external rewards. Driven by external factors, learning that is motivated by the promise of external awards creates more pressure and anxiety for students to achieve the expected results (Zaccone & Pedrini, 2019). This process may initially bring students a short-term success during the mobilization period, but rarely leads to sustainable and long-lasting knowledge (Grolnick, 2023).

Although intrinsic motivation has proven to play a greater role in students' academic achievements (Guay & Bureau, 2018), teachers should not neglect the importance of nurturing extrinsic motivation to learn. More importantly, some researchers acknowledge that by carefully stimulating extrinsic motivation in students, teachers can also trigger and awaken their intrinsic motivation during the learning process, especially in students with initially low levels of it (Güvendir, 2016). Hence, students' extrinsic motivation should be seriously considered by teachers not only as a complementary tool, but also as a productive leverage "to motivate students, create a positive learning environment, and transition students towards intrinsic motivation" (Sigalingging et al., 2023, p. 1). Teachers can also motivate students to set ambitious learning goals and strive to achieve the peaks of their academic achievements by arranging school activities that spark students' inner curiosity to learn and by fairly rewarding their accomplishments.

It is important to note that most researchers have neglected the study of primary school students' motivation. This happened due to the previous belief that self-perception in early grade students is undifferentiated, meaning that "the young child simply is incapable, cognitively, of developing the verbal concept of his/her value as a person" (Harter, 2001, p. 13809). However, recent "developmental research suggests that children's ability to differentiate self-representations increases across school years (especially in Grade 3)" (Guay et al., 2010, p. 715). Given that the school environment provides children with a rich source of ideas to shape the "sense of self" by comparing their capacities and skills with others and evaluating the degree of their success based on grades and rewards they get in certain school subjects, "students' self-concept begins to differentiate and to rely more strongly on social comparison driven by feedback from teachers and parents" (Sewasew & Schroeders, 2019, p. 5). Comparisons regarding their personal and peer achievements in a certain school subject influence "the formation of students' domain-specific motivational beliefs across the childhood and adolescent years" (Wan et al., 2021, p. 2). Indeed, children are exposed to different individual and group learning experiences during primary school. This enables them to make comparisons and develop their "self-perceptions, such as self-efficacy, goal orientations, or autonomy, [which] are robust predictors of motivation and performance in school" (Furrer & Skinner, 2003, p. 148). By comparing their capabilities and skills with those of their peers, even primary school students can "accurately report on their motivational states" on their own and be "aware about their status with respect to their schoolmates in each discipline" (Guay et al., 2010, p. 715).

Being less investigated so far, there is an augmented interest in researching primary school students' motivation towards learning specific subjects. Given that mathematics is essential to foster critical and logical thinking as well as problem-solving skills, and that English, as a global language, enhances communication, comprehension, and expressive abilities, it is imperative to investigate the types of students' motivation for learning these subjects from the outset of their education.

Motivation of Primary School Students for Mathematics

It is important to note that the majority of studies report a decline in motivation, particularly intrinsic motivation for mathematics, as students age from childhood into

adolescence (Garon-Carrier et al., 2016). Although the decline in interest in learning mathematics is more pronounced as students progress from primary to secondary education (Xia et al., 2022), it is also observed among students in various grades of primary school (Blomqvist et al., 2012; Radišić et al., 2024). A study conducted with more than 11,700 primary school students from six different European countries has revealed that students' motivation is strongly associated with students' mathematical identity, and "that the grade 4 students perceived themselves less as 'math persons' than their grade 3 peers in all countries" (Radišić et al., 2024, p. 1513). Another study conducted with primary school students in Sweden shows that more grade 2 students than grade 5 students expressed a positive orientation dominated by intrinsic motivation towards mathematics, while a more negative view, often associated with extrinsic motivation for mathematics, and even stress, is more prevalent among grade 5 students (Blomqvist et al., 2012). Similarly, in a study conducted with more than 1,500 primary school students in China, Xia et al. (2022) concluded that students' "motivation and engagement decreased as their grade level increased" (p. 9).

The decrease in motivation for mathematics among primary school students as they age is a multifaceted issue affected by various cognitive, emotional, and social factors. As children's cognitive development in mathematics does not follow a linear path, and the challenge of understanding mathematical concepts and procedures shifts from concrete to abstract, some students gradually begin to struggle with solving mathematical problems (Mula & Hodnik, 2020). This struggle can lead to a continuous decline in students' interest and preference for mathematics across grades. The lack of success in solving mathematical problems can influence a poor self-concept about mathematics in many students, which consequently decreases their motivation, particularly their intrinsic motivation to learn it (Rodríguez et al., 2021). Without the support of parents, teachers, and the broader school community, these students may experience a decline in their interest in the subject matter.

Motivation of Primary School Students for EFL

Similar to mathematics, motivation is considered an essential affective factor for successful English language learning "especially in countries where English is taught as a second language" (Ramalingam & Jiar, 2022, p. 1885). It provides the primary "impetus to start, and later continue, learning a second language" (Fenyvesi, 2020, p. 691). Motivation is the driving force that nurtures students to sustain the long and exhausting EFL learning process. Therefore, it is important to study the different types of students' motivation for learning EFL and its trends from the early years of schooling.

It is interesting to note that studies conducted with primary school students show that the motivation of students to learn EFL declines through the years of primary school (Demirbulak & Zeyrek, 2022; Hu & McGeown, 2020). The same trend is not happening at other levels of education. Studies conducted with secondary and higher education students do not converge and present contrasting findings regarding their motivation to learn EFL (Fenyvesi, 2020). Some of them confirm a further decrease in students' motivation (Kum, 2022), while others indicate an increase, particularly in extrinsic motivation for learning EFL among students at these education levels (Kitjaroonchai, 2013).

Although there is a lack of studies on the motivation to learn EFL among primary school students "due to numerous constraints on the use of testing in elementary foreign language classes" (Oga-Baldwin et al., 2017, p. 141), some researchers studied this phenomenon. Among them, Carreira (2006) conducted a study with 345 students of third and sixth grades in Japan and found that "third graders have more intrinsic motivation for learning EFL than sixth graders" (p. 149). Another study conducted with 631 Chinese primary school students aged between 9 and 12 years shows a decline in students' motivation for learning EFL with increasing age (Hu & McGeown, 2020). Furthermore, Fenyvesi (2020) conducted a one-year-long study with 276 Danish 7- and 9-year-old students and found that the motivation and positive attitudes towards learning EFL of young learners "decreased significantly within one year in both age groups" (p. 19). It seems that students' high interest in singing rhythmic songs and playing games, which usually characterizes the learning of English in early grades of primary schools, becomes less enjoyable when students reach the upper grades. This, combined with the increased language requirements in the subsequent grades, may lead to a decline in their intrinsic motivation. Additionally, some authors interpret the decrease in motivation among primary school students for learning EFL from a broader perspective. They admit that this does not happen only in learning EFL, but also in other academic subjects (Chuane et al., 2023; Nyman & Sumpter, 2019) due to the increased challenges students meet and the new skills they need to develop with age. So, "a developmental decline in intrinsic motivation for studying, in general, might influence English lessons" (Chuane et al., 2023, p. 284)

Unfortunately, there is a scarcity of studies that compare types of students' motivation between two or more school disciplines. To better understand "how motivation develops during formative years" (Guay et al., 2010, p. 712) in terms of students' cognitive development and to inform teachers on how to enhance students' motivation — not only in a specific school subject, but also towards education in general

— it is important to conduct studies that examine types of students' motivation across two or more subjects and compare the results.

Methodology

Research Aim

This study explored the extent to which primary school students are motivated to learn two significant school subjects, namely mathematics and EFL. Specifically, the study sought to identify which type of motivation predominates among primary school students for learning mathematics and EFL, both within each subject and between the two of them. To better understand the possible fluctuation of types of students' motivation across grades, the study was conducted with students of Grades 3 and 5. Third graders (aged 8-9) were selected due to their cognitive ability to understand and incorporate into their judgments not only their satisfaction with learning, but also the impact of the evaluative feedback from teachers, parents, and their peers when learning a certain school subject. Fifth graders (aged 10-11), on the other hand, were selected for two reasons. First, students at this grade level are more self-confident in accurately differentiating their preferences and incentives for learning specific subjects. Second, fifth grade marks the final year for primary school students in Kosovo. The following research questions guided this research:

1. To what extent is the intrinsic and extrinsic motivation of students for learning mathematics present among Grade 3 and Grade 5 students?
2. To what extent is the intrinsic and extrinsic motivation of students for learning EFL present among Grade 3 and Grade 5 students?
3. Do students of Grade 3 and Grade 5 exhibit greater motivation to learn mathematics or EFL?

Methods

This study utilized a survey as the research method for its implementation. The survey was conducted using a questionnaire with two parts and 16 items, evenly distributed between mathematics and EFL. Out of sixteen items of the questionnaire, twelve were extracted from "the Elementary School Motivation Scale (ESMS)" (Guay et al., 2010, p. 716), who analyzed the intrinsic and extrinsic motivation of 425 French-Canadian students of primary schools (grades 1-3) for mathematics, reading, and writing. The first part of the questionnaire, which covered mathematics, contained eight items. Of these, six items (three related to intrinsic motivation and three to extrinsic motivation) were similar to the corresponding ESMS items associated with mathematics. As the target group of this study were students of higher grades (Grade 3 and Grade 5) with more capacities to differentiate their learning stimuli, it was considered important to add two other items (one per each type of motivation) to have a deeper understanding about types of students' motivation towards learning mathematics. The other eight items of the second part of the questionnaire related to English were analogue to corresponding items related to mathematics, wherein the word "mathematics" was replaced with the word "English".

The questionnaire was prepared by following the instructions and recommendations for the translation of the text, such as the procedure for translation-back-translation of items in the questionnaire from English to the Albanian language, which was the mother tongue of respondents of the study, and back to ensure the accuracy of translation. The pilot test with six randomly selected students, three from grade 3 and three from grade 5, was preliminarily conducted to ensure the questionnaire's comprehension.

Sample and Data Collection

A sample of 638 students from Grades 3 and 5 participated in the study. To ensure a better representation of the students in the study, three out of seven main municipalities located in different parts of Kosovo, namely Prishtina, Gjakova, and Gjilan, were selected. Subsequently, two schools were randomly selected from each participating municipality. The principal of each of the six selected schools randomly selected two classrooms for both Grade 3 and Grade 5 to take part in the study. All students from the same municipality completed a paper-based questionnaire on the same day, whereas the completion of all questionnaires in three municipalities was done in two weeks. The number of students disaggregated by grade and gender (M-Male and F-Female) is presented in Table 1.

Table 1.
Number of Students per Grade and Gender

		M	*F*	Total
Grade	3	144	171	315
	5	163	160	323
Total		307	331	638

Data Analysis

The main types of students' motivation towards learning mathematics and EFL were measured by asking participants to indicate their level of agreement with the corresponding items on the questionnaire, using a four-point Likert scale for frequency, ranging from 4 for "always" to 1 for "never" as presented in Table 2. Initially, participants addressed items related to mathematics and then those about English. Sample items included statements, such as "I like mathematics" and "I like English" respectively.

The data from the filled questionnaires of the study were pooled and analyzed using the Statistical Package for Social Studies (SPSS). The Cronbach's alpha for all 16 items that were part of the questionnaire was 0.855, indicating a high level of reliability. The results were analyzed separately for mathematics and English, and they were presented using the percentage frequency distribution based on the response rates for each of the 16 items. The response rates were high for both school subjects, varying from 635 to 638 for mathematics, and from 631 to 638 for English. Cross-tabulation with Pearson chi-square analysis was conducted by grade level. The measure of effect size for assessing the strength of the association between the variables was done by calculating the Cramer's V for the chi-square test.

Results

Since the statements in the items of the questionnaire that were related to students' intrinsic motivation (items 1-4) and extrinsic motivation (items 5-8) were analogous for both mathematics and EFL, the results of the study are clustered in two parts: 1) Intrinsic motivation of students for mathematics and EFL, and 2) Extrinsic motivation of students for mathematics and EFL.

Intrinsic Motivation of Students for Mathematics and EFL

The students' responses regarding items 1-4 related to their intrinsic motivation for mathematics and EFL are presented in Table 2, disaggregated by grade level (Grade 3 and Grade 5). The same table contains the percentage frequency distribution of responses to these items with chi-square (χ^2) and Cramer's V test results for mathematics and EFL in separate columns. This allows an easy comparison of students' responses in both school subjects.

According to the data in Table 2, the vast majority of respondents (around 90%) stated that they highly prefer mathematics respectively English, and are equally interested in learning both (items 1 and 2). More precisely, nearly two-thirds of all students stated that they always like and are interested in acquiring knowledge about mathematics and English, respectively. On the other hand, around one-fourth of respondents reported that they often liked and were interested in math, while one-fifth stated the same for English. Regarding engagement with mathematics and English even when not required (item 3), 34.2% of respondents reported that they always engage with mathematics even in these cases, while a slightly higher percentage, or 38.0%, reported the same for English. Interestingly, a similar pattern is observed at the other extreme, there is a lower percentage of students (4.6%) unwilling to engage with mathematics when not required, compared to those reluctant to engage with English (10.9%). Regarding the ease of learning both subjects, a higher percentage of students (85.9%) find English always or often easy to learn compared to those who think the same for mathematics (81.6%).

When analyzed by grade level, the differences in students' responses are statistically significant for the first three items related to mathematics and the first two items related to English. As for the Cramer's V results, in the case of item 3, there is a moderate association between grade level and students' readiness to engage with mathematics even when not required, while the association between grade level and students' fondness and interest in learning mathematics and English is weak (items 1 and 2).

Table 2.

Percentage of Answers to Items 1-4 About Maths and English

Item		Mathematics				English			
		All N = 638	Grade 3 n = 315	Grade 5 n = 323	Sig.	All N=638	Grade 3 n=315	Grade 5 n=323	Sig.
1. I like maths/ English	Always	65.4	71.7	59.1		67.2	63.5	70.9	
	Often	23.8	19.7	27.9	$\chi^2 = 14.6$	21.5	22.5	20.4	$\chi^2 = 8.9$
	Sometimes	10.0	8.6	11.5	$p < .05$	7.8	8.6	7.2	$p < .05$
	Never	0.8	0.0	1.5	V = .151	3.5	5.4	1.5	V= .118
2. Maths/English interests me a lot	Always	63.5	68.9	58.3		65.0	61.3	68.8	
	Often	27.8	24.1	31.5	$\chi^2 = 8.8$	22.9	21.9	23.8	$\chi^2 = 22.3$
	Sometimes	7.5	5.7	9.3	$p < .05$	8.9	14.3	3.7	$p < .001$
	Never	1.2	1.3	0.9	V = .118	3.2	2.5	3.7	V= .187
3. I do maths/ English even when I don't have to	Always	34.2	44.5	24.1		38.0	40.9	35.2	
	Often	37.6	35.3	39.9	$\chi^2 = 34.3$	28.5	26.8	30.2	ns
	Sometimes	23.6	16.7	30.3	$p < .001$	22.6	24.0	21.2	
	Never	4.6	3.5	5.7	V= .232	10.9	8.3	13.4	
4. I learn maths/ English easily	Always	40.9	43.9	37.9		58.6	57.6	59.4	
	Often	40.7	40.1	41.3	ns	27.3	26.4	28.2	ns
	Sometimes	16.4	14.6	18.0		12.1	13.4	10.8	
	Never	2.0	1.4	2.8		2.0	2.6	1.6	

The comparison of the results of students by grade level shows that younger students are more consistent in their preferences and interest in mathematics than older students (items 1 and 2). Indeed, a higher percentage of Grade 3 students compared to Grade 5 students reported that they always like mathematics (71.7% compared to 59.1%) and are always interested in it (68.9% compared to 58.3%). This decline by more than 10 percentage points between results of Grade 3 and Grade 5 students shows that a substantial number of students express lower intensity of liking and interest in mathematics as they reach upper grades of primary school. Further, there is a decline of 20 percentage points between the results of Grade 3 students (44.5%) and Grade 5 students (24.1%) regarding their readiness to do mathematics always even when not required (item 3). This indicates that fewer students in the upper grades of primary school find it important to systematically learn mathematics without being obliged to.

Even though the vast majority of students in third and fifth grades expressed their systematic wish to learn mathematics (71.7% and 59.1%, respectively), a significantly lower number of them (only 43.9% and 37.9%, respectively) stated that they always find it easy to learn it. This shows that even among primary school students who always like mathematics, there are many of them who have to work hard to learn it. Moreover, the number of these students increases in upper grades. On the other hand, a high percentage of students, around 15% in Grade 3 and 20% in Grade 5 admitted that they only sometimes or never find it easy to learn mathematics. These results indicate that a high percentage of primary school students struggle to learn mathematics, and that they can very easily lose interest and give up learning mathematics in the future, if not provided with additional support and instruction on how to face and overcome related problems.

As for intrinsic motivation for learning EFL, a detailed comparison of students' results disaggregated by grade level shows a different pattern from mathematics regarding the results across various grades. In contrast to the decrease in the percentage of Grade 5 students, who selected the "always" option for all four items about mathematics, there is an increase in the percentage of students of this grade, who chose the same option in three out of four items related to EFL. More precisely, a lower percentage of Grade 3 students compared to those of Grade 5, reported that they always like English (63.5% compared to 70.9%). The same pattern across grades is repeated concerning their interest in learning English (61.3% of third-graders compared to 68.8% of fifth-graders), and in finding it always easy to learn (57.6% compared to 59.4%). These results show that older students of primary schools are more intrinsically motivated to learn EFL than younger ones, and therefore more of them pay attention to its acquisition.

Extrinsic Motivation of Students for Mathematics and EFL

Similar to the first part, the percentage frequency distribution of results related to items 5-8 by grade level, with chi-square (χ^2) and Cramer's V test results, is presented in Table 3.

The results in Table 3 show that around two-thirds of respondents stated that they always or often learn mathematics and English to get a reward (item 5) and to please their parents or teachers (item 6). For

Table 3.
Percentage of Answers to Items 5-8 About Maths and English

Item		Mathematics				English			
		All N = 638	Grade 3 n = 315	Grade 5 n = 323	Sig.	All N = 638	Grade 3 n = 315	Grade 5 n = 323	Sig.
5. I learn maths/ English to get a reward	Always	46.8	48.9	44.7		46.1	50.0	42.2	
	Often	19.2	22.2	16.2	χ^2 = 12.8	19.0	20.7	17.4	χ^2 = 11.0
	Sometimes	17.7	17.5	18.0	p < .05	12.0	11.9	12.1	p < .05
	Never	16.3	11.4	21.1	V = .142	22.9	17.4	28.3	V= .132
6. I learn maths/ English to please my parents or my teacher	Always	52.8	60.0	45.6		50.5	57.6	43.8	
	Often	16.5	17.8	15.3	χ^2 = 26.7	16.2	19.6	12.8	χ^2 = 33.4
	Sometimes	16.7	14.6	18.8	p < .001	13.2	10.9	15.3	p < .001
	Never	14.0	7.6	20.3	V= .205	20.1	11.9	28.1	V= .230
7. I learn maths/ English to show others how good I am	Always	28.1	35.4	21.1		34.4	20.2	28.2	
	Often	24.2	25.8	22.7	χ^2 = 22.2	22.8	15.7	22.3	χ^2 = 17.7
	Sometimes	22.5	18.8	26.1	p < .001	15.9	23.4	16.1	p < .05
	Never	25.2	20.0	30.1	V= .187	26.9	40.7	33.4	V= .167
8. I learn maths/ English because it is important in life	Always	80.2	81.6	78.6		75.4	71.6	78.9	
	Often	14.7	14.5	14.9	ns	16.5	17.9	15.2	ns
	Sometimes	4.2	2.9	5.6		6.1	8.0	4.3	
	Never	0.9	1.0	0.9		2.0	2.5	1.6	

other students who selected different alternatives, in the case of mathematics, there is almost the same percentage who reported learning this subject sometimes or never to receive a reward (17.7% compared to 16.3%) or to please their significant others, such as parents or teachers (16.7% compared to 14.0%). However, this pattern is not the same for English. There is a larger gap between the percentage of students who reported sometimes or never learning English to get a reward (12.0% compared to 22.9%) or to please others (13.2% compared to 20.1%), with a greater proportion of students declaring that they never do so for these reasons.

Students were also asked about their motivation to learn mathematics and English to show off (item 7). The results reveal that more than half of them (52%-57%) always or often learn these subjects to demonstrate their success to others. However, a crucial note to be emphasized is that almost all primary school students (over 92%) reported that they always or often learn mathematics and English because they consider their learning an important element in their lives (item 8).

When disaggregated by grade level, the differences in students' results in items related to extrinsic motivation are statistically significant in three out of four items for mathematics. A comparison of students' responses by grade level indicates a decrease in students' extrinsic motivation to learn mathematics as they age. Indeed, a higher percentage of Grade 3 students compared to those of Grade 5 report being frequently motivated by external factors to learn mathematics, such as receiving rewards (71.1% compared to 60.9%), pleasing their parents or teachers (77.8% compared to 60.9%) or seeking to impress others (61.2% compared to 43.8%).

Consistent with mathematics, there is a reduction in the percentage of Grade 5 students compared to Grade 3 students who are always motivated to learn English primarily for rewards (50.0% of third-graders compared to 42.2% of fifth-graders) or to please significant others, such as parents and teachers (57.6% compared to 43.8%). In contrast to mathematics, a higher percentage of Grade 5 students compared to Grade 3 students (an 8 percentage points increase) expressed a continuous desire to learn English to impress others. These differences are statistically significant, and Cramer's V results indicate a moderate association between grade level and students' willingness to learn English to please their parents and teachers (item 6), whereas the association is weak for the other two items (items 5 and 7), which are related to students' dedication to learn English for a reward and to impress others. Finally, although the difference is not statistically significant, it is important to highlight that there is an increase in students' awareness of the importance of learning English in life (item 8) as they progress to higher grades (94.1% of fifth-graders compared to 89.5% of third-graders).

Discussion

This study investigated the extent to which the main types of motivation are exhibited among primary school students to learn two important academic subjects, such as mathematics and EFL, and the trends these motivations follow as grade levels increase. The findings from this study show both positive aspects and concerning trends. The results reveal that almost all respondents are intrinsically motivated to learn mathematics and EFL. More precisely, around 90% of students like mathematics and EFL and are interested in learning these subjects. However, despite the widespread preference for mathematics and EFL, a concerning issue is that only 71.8% of students for mathematics and 66.5% for EFL have shown a willingness to learn these subjects when they are not obliged to. The substantial reduction in the percentages of students who prefer these subjects compared to those willing to dedicate their free time to additional tasks related to them shows that a considerable portion of students do not consider it important to engage in extra work beyond school requirements for these subjects. This suggests that many students from the cohort who prefer mathematics and EFL are at risk of losing their intrinsic motivation for learning these subjects. This is possible because they consider their commitment to these subjects sufficient simply by fulfilling teachers' requirements and no longer find these subjects interesting or enjoyable enough to explore beyond what is required. This lack of engagement for their pleasure, satisfaction, and personal growth, may hinder the development of their self-efficacy and autonomy in mastering these subjects and consequently diminish their intrinsic motivation to learn them.

While students' intrinsic motivation to learn mathematics and EFL is relatively good, the situation regarding their extrinsic motivation is a bit worrying. A high percentage of students (around 66%) reported that they learn mathematics and English frequently driven by external factors, such as rewards and the need to please parents or teachers, and more than half of them (around 55%) acknowledged that they do it mainly to demonstrate to others how good they are in these subjects. Since external factors can undermine students' intrinsic motivation and usually lead to short-term success (Güvendir, 2016; Wheeler, & Cabigas, 2024), the high presence of extrinsic motivation factors among primary school students to learn mathematics and English presents a major concern. Indeed, this may be unproductive, particularly for primary school students who are building their self-awareness at this stage of development, as it can lead to a distorted perception of the true value of learning.

Analysis of the results by grade level reveals statistically significant differences in students' responses on nearly all items about mathematics. The findings indicate

that a higher percentage of third-grade students, compared to fifth-grade students, exhibit intrinsic motivation for mathematics. While around 70% of third-graders like mathematics and are consistently interested in it, this percentage decreases to 60% among fifth-graders. A wider gap is revealed in students' perpetual readiness to engage with mathematics even when not required, with Grade 3 students showing their readiness to a greater extent than those in Grade 5 (44.5% compared to 24.1%).

These findings are consistent with other research showing a decline in intrinsic motivation for mathematics in primary school students as their grade level increases (Garon-Carrier et al., 2016; Xia et al., 2022). A lower level of intrinsic motivation among older primary school students is particularly concerning, as it indicates that some students are losing their enjoyment and interest in learning mathematics with increasing age. Since an important component of "help[ing] students develop intrinsic motivation is the use of real-life themes to contextualize the use of mathematics" (Samuelsson, 2023, p. 183), this shows that some teachers do not pay enough attention to connect mathematical concepts with students' everyday situations. Some teachers may lack professional knowledge to adequately address more complex contents of mathematics in upper grades of primary school, to tailor activities based on students' needs and interests, and to "keep them engaged, [to] provide emotional support and contribute to students' IM [intrinsic motivation] to learn and perform in mathematics" (Amjad et al., 2023, p. 111).

Likely, students' motivation to learn will not last endlessly if their engagement and work are guided only by intrinsic motivation incentives. Students need feedback or recognition about their work to understand that they are doing well and following the right direction to succeed and progress. However, these external factors must be used carefully and intertwined with internal ones to foster students' interest and desire to learn. Otherwise, they may undermine students' intrinsic motivation. Although fewer Grade 5 students are extrinsically motivated to learn mathematics compared to Grade 3 students, indicating thus an increased awareness among older students about effective learning versus short-term rewards, there is still a high percentage of them (60%) who learn mathematics to get a reward or to please others. It should be the teachers' and parents' responsibility to explain to their students respectively their children the importance of learning to succeed in life and not to be satisfied with learning only to get a simple reward, such as a good grade, or to please others. One of the findings from the study that may be promising for changing the situation in favor of sustainable learning and long-term success is the high percentage (over 93%) of students of both grades who declared that learning mathematics is important in life. This perception mainly being driven by external factors, such as the rewards and benefits that successful people who know mathematics achieve or by being stimulated by parents, teachers, or other people, can be very beneficial if teachers know how to tackle many mathematical problems and activities within real-life contexts and integrate them during the learning process (Samuelsson, 2023), which may ultimately increase students' intrinsic motivation for learning mathematics.

Unlike mathematics, the disaggregation of results by grade reveals that students' intrinsic motivation for learning English increases with age, so more students of Grade 5 continuously prefer English (70.9%) compared to students of Grade 3 (63.5%), and that older students are more interested in learning it (68.8% compared to 61.3%). This indicates that as students age, they increasingly recognize the significance of learning EFL and the various opportunities it offers for utilizing diverse tools for learning and communication. It is important to note that these findings are different from similar international studies showing a decline in students' intrinsic motivation for learning EFL in upper grades of primary school (Carreira, 2006; Chuane et al., 2023). Even though differences between Grade 5 and Grade 3 students' intrinsic motivation for learning EFL are small (7 percentage points), the fact that they are statistically significant imposes a necessity to conduct additional studies to explain the reasons behind this situation in Kosovo. On the other hand, similar to mathematics, older students show poorer routines in studying EFL when they are not required to. This suggests that older students believe that meeting teachers' requirements for learning EFL is enough and are hesitant to go beyond those requirements and learn for their enjoyment.

The analysis of the results of this study about students' extrinsic motivation for learning EFL reveals a similar trend to that of mathematics, indicating that fewer fifth-graders learn EFL for a reward or pleasing significant others. However, when it comes to learning EFL to show off, there is an opposite trend compared to mathematics, with a higher percentage of older students motivated by personal prestige and appearance. Finally, a high percentage of students (over 90%) of both grades who reported that learning EFL is important in their life should mobilize teachers to use various real-life situations during the teaching and learning process and through them increase students' awareness and self-motivation for learning EFL.

Conclusion and Recommendations

This study reveals that primary school students are nearly equally motivated intrinsically and extrinsically to learn mathematics and EFL, with a slightly higher preference for mathematics in both types of motivation. This suggests a comparable dynamic in

students' overall motivation for learning. Regarding motivational trends, similar to other countries students' intrinsic and extrinsic motivation for mathematics in Kosovo declines as students advance to upper grades. As for learning EFL, the situation is quite different. In contrast to other studies, students' intrinsic motivation increases with age, whereas similar to other countries, extrinsic motivation for learning EFL decreases. There is a belief that the rise in the intrinsic motivation for learning EFL stems from the students' perception of English as a global language, which unlocks opportunities to achieve their future educational and professional aspirations.

As intrinsic motivation for mathematics tends to decline as students advance to the upper grades, teachers and the school community need to create a friendly school environment to nurture this type of motivation in these grades. On the other hand, even though students' extrinsic motivation declines with age, it remains relatively high among primary school students. This poses a high risk of student instrumentalization, as this may send the wrong message that learning is solely for the sake of rewards. Although extrinsic motivation plays an important role in engaging students in the learning process, only thoughtful and selective implementation can produce a positive effect and may nurture students' intrinsic motivation. It is the intertwinement of the high intrinsic coupled with the low extrinsic motivation of students that tends to be the most effective strategy to support students in achieving the peaks of their academic achievements (Sigalingging et al., 2023; Zaccone & Pedrini, 2019).

It has to be teachers' imperative to actively support and promote students' long-term academic achievement during their early school years by fostering an engaging learning environment and strategically using external motivators. They need to use effective learning strategies to spark students' curiosity to learn and design interesting activities from real-life situations that stimulate students' intrinsic motivation and their desire to achieve (Samuelsson, 2023). Furthermore, teachers should understand the different learning styles of students and address their eventual struggles during the learning process by "providing positive feedback, listening and responding to students' questions and being empathetic to students' needs" (Hooper et al., 2019, p. 71). It is also useful to mobilize parents as important partners in supporting their children to succeed in mathematics and EFL.

As the first study to examine both types of students' motivation in primary schools in Kosovo, this research was conducted in six primary schools across three of the seven main municipalities of the country. Despite the careful distribution of the sample among municipalities and schools to secure representative data, future studies should incorporate schools from additional municipalities to ensure a further understanding of this phenomenon at this level of education and generalize the results. Additionally, this study was focused on investigating both types of students' motivation in two different school subjects and comparing the results. To analyze in more depth both types of students' motivation towards learning a certain school subject, future studies should focus on a single academic domain, and simultaneously expand to the manifestation of other types of motivation that intertwine with the main ones. There is a strong belief that further research will offer additional valuable insights into the complex nature of student motivation. This will, in turn, help educational policymakers and practitioners better plan actions that contribute to longer-term students' achievements.

Limitations

Due to the complexity and large scope of the topic, this study used only questionnaires to evaluate students' intrinsic and extrinsic motivation for mathematics and EFL in primary school by asking them to respond to the questionnaire via self-reporting. Since motivation is an affective factor related to students' perception of their learning goals, further studies should analyze this phenomenon more deeply by expanding the research and incorporating individual and focus group interviews.

Conflict of interest

The authors declare that there is no conflict of interest.

Authorship Contribution Statement

Mula: Conceptualization and design of the study, drafting manuscript, supervision, and final approval. Naka: The collection of data and technical support, data analysis/interpretation, and contributing to the final report. Sylhasi: Designing instrument, data analysis/interpretation, conducting statistical analysis, drafting of the manuscript, and writing of the final report.

References

Amjad, A. I., Habib, M., Tabbasam, U., Alvi, G. F., Tasser, N. A., & Noreen, I. (2023). The impact of brain-based learning on students' intrinsic motivation to learn and perform in mathematics: A neuroscientific study in school psychology. *International Electronic Journal of Elementary Education*, *16*(1), 111–122. doi:10.26822/iejee.2023.318

Blomqvist, A., Elamari, U., & Sumpter, L. (2012). Grade 2 and Grade 5 students' conceptions about mathematics and mathematics education. In G. H. Gunnarsdottir, F. Hreinsdottir, G. Palsdottir, M. Hannula, M. Hannula-Sormunen, E. Jablonka, U. Jankvist, A. Ryve, P. Valero & K. Wæge (Eds.). *Proceedings of NORMA 11: The Sixth Nordic Conference on Mathematics Education*, (pp. 187–196). https://bit.ly/3MPNZuN

Carreira, J. M. (2006). Motivation for learning English as a foreign language in Japanese elementary schools. *JALT Journal, 28*(2), 135–158. https://doi.org/10.37546/JALTJJ28.2-2

Chuane, Q., Shukor, S. S., Yuehong, T., & Xiaofen, Z. (2023). The relationship between motivation and English language test performance among secondary vocational schools' students in China. *Studies in English Language and Education*, *10*(1), 280–302. https://doi.org/10.24815/siele.v10i1.25741

Demirbulak, D., & Zeyrek, G. (2022). Young learners' attitudes and motivation towards learning english in terms of Dörnyei's theory of motivation. *Journal of English Teaching*, *8*(1), 156–168. https://doi.org/10.33541/jet.v8i1.3617

Fenyvesi, K. (2020). English learning motivation of young learners in Danish primary schools.*Language Teaching Research*, *24*(5), 690–713. https://doi.org/10.1177/1362168818804835

Furrer, C., & Skinner, E. (2003). Sense of relatedness as a factor in children's academic engagement and performance. *Journal of Educational Psychology*, *95*(1), 148–162. https://doi.org/10.1037/0022-0663.95.1.148

Garon-Carrier, G., Boivin, M., Dionne, G., Jean, R. S., Vitaro, F., & Tremblay, R. E. (2016). Intrinsic motivation and achievement in mathematics in elementary school : A longitudinal investigation of their association. *Child Development, 87*(1), 165–175. https://doi.org/10.1111/cdev.12458

Grolnick, W. S. (2023). Extrinsic incentives/rewards: Short-term fix that can undermine long-term motivation. In Mimi Bong, Johnmarshall Reeve, and Sung-il Kim (Eds), *Motivation Science: Controversies and Insights* (pp. 154-158). New York. Online edn, Oxford Academic. https://doi.org/10.1093/oso/9780197662359.003.0026

Guay, F., & Bureau, J. S. (2018). Motivation at school: Differentiation between and within school subjects matters in the prediction of academic achievement. *Contemporary Educational Psychology*, *54*(September), 42–54. https://doi.org/10.1016/j.cedpsych.2018.05.004

Guay, F., Chanal, J., Ratelle, C. F., Marsh, H. W., Larose, S., & Boivin, M. (2010). Intrinsic, identified, and controlled types of motivation for school subjects in young elementary school children. *British Journal of Educational Psychology*, *80*(4), 711–735. https://doi.org/10.1348/000709910X499084

Güvendir, M. A. (2016). Students' extrinsic and intrinsic motivation level and its relationship with their mathematics achievement. *International Journal for Mathematics Teaching and Learning*, *17*(1), 1–21.

Harter, S. (2001). Self-development in childhood. In N. J. Smelser & P. B. Baltes (Eds.), *International encyclopedia of the social and behavioral sciences* (Vol. 20, pp. 13807– 13812). Oxford, UK: Elsevier.

Hooper, M., Mullis, I. V. S., Martin, M. O., & Fishbein, B. (2019). *TIMSS 2019 Context questionnaire framework*. TIMSS & PIRLS International Study Center.

Howard, J. L., Bureau, J., Guay, F., Chong, J. X. Y., & Ryan, R. M. (2021). Student motivation and associated outcomes: A meta-analysis from self-determination theory. *Perspectives on Psychological Science*, *16*(6), 1300–1323. https://doi.org/10.1177/1745691620966789

Hu, X., & McGeown, S. (2020). Exploring the relationship between foreign language motivation and achievement among primary school students learning English in China. *System*, *89*, Article 102199. https://doi.org/10.1016/J.SYSTEM.2020.102199

Kitjaroonchai, N. (2013). Motivation toward English language learning of students in secondary and high schools in education service area office 4, Saraburi Province, Thailand. *International Journal of Language and Linguistics*, *1*(1), 22-33. https://doi.org/10.11648/j.ijll.20130101.14

Kum, B. A. (2022). *The effects of intrinsic and extrinsic motivation on student learning effectiveness (Case study: International students of Estonian Entrepreneurship University of Applied Sciences)*. Estonian Entrepreneurship University of Applied Sciences. Tallinn.

Mula, M., & Hodnik, T. (2020). The PGBE model for building students' mathematical knowledge about percentages. *European Journal of Educational Research*, *9*(1), 257–276. https://doi.org/10.12973/eu-jer.9.1.257

Mullis, I. V. S., Martin, M. O., Foy, P., Kelly, D. L., & Fishbein, B. (2020). *Highlights: TIMSS 2019 International results in mathematics and science*.TIMSS & PIRLS International Study Center.

Nyman, M., & Sumpter, L. (2019). The issue of 'proudliness': Primary students' motivation towards mathematics. *LUMAT: International Journal on Math, Science and Technology Education*, *7*(2), 80–96. https://doi.org/10.31129/ LUMAT.7.2.331

Oga-Baldwin, W. L. Q., Nakata, Y., Parker, P., & Ryan, R. M. (2017). Motivating young language learners: A longitudinal model of self-determined motivation in elementary school foreign language classes. *Contemporary Educational Psychology*, *49*, 140–150. https://doi.org/10.1016/J.CEDPSYCH.2017.01.010

Radišić, J., Krstić, K., Blažanin, B., & Mićić, K. (2024). Am I a math person? Linking math identity with students' motivation for mathematics and achievement. *European Journal of Psychology of Education*, *39*(2), 1513–1536. https://doi.org/10.1007/s10212-024-00811-y

Ramalingam, K., & Jiar, Y. K. (2022). Influence of intrinsic and extrinsic motivation in knowledge sharing behavior. *Central Asia And The Caucasus*, *23*(1), 1884–1893. https://doi.org/10.37178/ca-c.23.1.186

Ramos, M., De Sixte, R., Jáñez, Á., & Rosales, J. (2022). Academic motivation at early ages: Spanish validation of the Elementary School Motivation Scale (ESMS-E). *Frontiers in Psychology*, *13*. https://doi.org/10.3389/fpsyg.2022.980434

Rodríguez, S., Estevez, I., Piñeiro, I., Valle, A., Vieites, T., & Regueiro, B. (2021). Perceived competence and intrinsic motivation in mathematics: Exploring latent profiles. *Sustainability*, *13*(16), 1–12. https://doi.org/10.3390/su13168707

Ryan, R. M., & Deci, E. L. (2017). *Self-determination theory: Basic psychological needs in motivation, development, and wellness*. The Guilford Press. https://doi.org/10.1521/978.14625/28806

Ryan, R. M., & Deci, E. L. (2020). Intrinsic and extrinsic motivation from a self-determination theory perspective: Definitions, theory, practices, and future directions. *Contemporary Educational Psychology*, *61*, Article 101860. https://doi.org/10.1016/j.cedpsych.2020.101860

Samuelsson, J. (2023). Developing students' relationships with mathematics. *Educational Action Research*, *31*(2), 180–194. https://doi.org/10.1080/09650792.2021.1899012

Sewasew, D., & Schroeders, U. (2019). The developmental interplay of academic self-concept and achievement within and across domains among primary school students. *Contemporary Educational Psychology*, *58*(March), 204–212. https://doi.org/10.1016/j.cedpsych.2019.03.009

Sigalingging, R., Nababan, H., Putra, A., & Nababan, M. (2023). Enhancing learning motivation in elementary schools: The impact and role of rewards. *Jurnal Ilmu Pendidikan Dan Humaniora*, *12*(1), 1–13. https://doi.org/10.35335/jiph.v12i1.27

Wallace, M. P., & Leong, E. I. L. (2020). Exploring language learning motivation among primary EFL learners. *Journal of Language Teaching and Research*, *11*(2), 221–230. https://doi.org/10.17507/jltr.1102.10

Wan, S., Lauermann, F., Bailey, D. H., & Eccles, J. S. (2021). When do students begin to think that one has to be either a "math person" or a "language person"? A meta-analytic review. *Psychological Bulletin, 147*(9). https://doi.org/10.1037/bul0000340

Wheeler, R. S., & Cabigas, M. E. A. (2024). Pupils' focus and motivations: Their influence on mathematics performance. *International Journal of Multidisciplinary Research and Analysis*, *7*(6), 2441–2452. https://doi.org/10.47191/ijmra/v7-i06-04

Xia, Q., Yin, H., Hu, R., Li, X., & Shang, J. (2022). Motivation, engagement, and mathematics achievement: An exploratory study among Chinese primary students. *SAGE Open*, *12*(4), 1–13. https://doi.org/10.1177/21582440221134609

Zaccone, M. C., & Pedrini, M. (2019). The effects of intrinsic and extrinsic motivation on students learning effectiveness. Exploring the moderating role of gender. *International Journal of Educational Management*, *33*(6), 1381–1394. https://doi.org/10.1108/IJEM-03-2019-0099

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Resistance Behaviors of Secondary School Students: Teacher and Student Views*

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Abstract

The main purpose of this study is to examine the perceptions of secondary school teachers and students about resistance behaviors. Phenomenological design, one of the qualitative research methods, was used in the study. The participants of the study were 5 teachers working in secondary schools and 10 students studying in secondary schools. Data were collected through semi-structured interviews with teachers and focus group interviews with students. Content analysis was used to analyze the data. As a result of the analysis of the data, the following results were obtained: Teachers see the family as the source of resistance behaviors, but they resort to situations related to improving the learning and teaching process in dealing with resistance behaviors. They also pointed out the importance of teacher attitude in preventing resistance behaviors. Resistance behaviors exhibited by students are divided into two as active and passive resistance. Active resistance behaviors exhibited by students are being constantly angry and resistance to teacher authority. Passive resistance behaviors exhibited by students are reluctant compliance and disinterest during the lesson. Students pointed to teachers, friends and situations related to themselves as sources of resistance behaviors. Teachers' reactions to students' resistance behaviors were divided into two as preventive and authoritative attitudes.

Keywords:

Resistance Behaviors; Constructive Resistance; Destructive Resistance; Active Resistance; Passive Resistance

Introduction

In the educational process, both educators and learners may encounter challenges. Students might experience academic failure, develop negative attitudes towards subjects, or exhibit absenteeism due to inappropriate teaching methodologies or adverse teacher behaviors (Koyuncu, 2017). Additionally, students may face interpersonal conflicts or issues with institutional policies. Consequently, students may manifest 'resistance behaviors', a term used in literature to describe systematic negative reactions to undesirable situations such as perceived injustice or unmet educational needs (Sarı, 2018). These behaviors can impede learning and diminish teacher motivation.

It is crucial to distinguish resistance behaviors from general classroom misconduct. Sever (2012) elucidates that resistant

students are initially motivated to learn but anxious about potential failure, whereas those exhibiting general misbehavior are often disinterested in learning. Furthermore, while general misbehavior is typically spontaneous and attention-seeking, resistance behaviors are premeditated, deliberate, and persistent (Yüksel, 2003), making them more challenging to address.

Resistance behaviors can manifest as either destructive or constructive for both students and educators. Destructive behaviors may negatively impact student learning, teacher motivation, and the overall educational process. Conversely, constructive resistance behaviors can yield positive outcomes. Examples of destructive behaviors include teacher blame, disregard for instruction, academic dishonesty, and truancy. In contrast, constructive resistance behaviors may involve students offering suggestions for course improvement, engaging in independent projects, peer tutoring, or challenging inappropriate teacher conduct (Burroughs, Kearney, & Plax 1989, as cited in Sever, 2012).

When confronted with resistance behaviors, educators should adopt a scientific approach: first defining the problem, then identifying its source, and subsequently implementing appropriate measures. The origins of resistance behaviors can be diverse, potentially stemming from disparities between students' socio-cultural backgrounds and school culture, pedagogical approaches employed by teachers, or variations in student preparedness (Yüksel, 2003). Effective prevention or management of these behaviors is contingent upon teachers' ability to accurately identify their underlying causes (Tanner & Seidel, 2013).

Yıldız and Sarı (2019) observed that teachers generally perceived resistance behaviors negatively in terms of educational processes and attempted to implement preventive measures. However, teachers often overlooked the possibility that they themselves might be the source of such behaviors, instead attributing the issue to factors such as family background, environment, student characteristics, school disciplinary systems, or curriculum design. Canoğulları (2018) found that teachers reported less frequent encounters with resistance behaviors. Koyuncu's (2017) study revealed an inverse relationship between students' problem-solving skills and their exhibition of resistance behaviors, suggesting that enhancing students' problem-solving abilities could be an effective strategy for mitigating resistance behaviors.

Sullivan et al. (2014) conducted a survey among primary and secondary school teachers to assess the frequency of negative behaviors encountered. The results indicated that teachers frequently faced low-level disruptive and defiant student resistance behaviors, often struggling to address these issues effectively. This difficulty may stem from teachers' tendency to employ strategies that assume the student is the sole source of the problem, without considering underlying causes or their own potential role in the situation.

Research indicates a low incidence of aggressive and asocial behaviors. Studies aimed to demonstrate that classroom environments tailored to diverse student needs positively influence lesson participation and reduce resistance behaviors. Sever's (2012) quasi-experimental study on inquiry-based approaches in elementary science education revealed that resistant students reported increased enjoyment of experiments and expressed desire for more hands-on activities. Teachers noted positive changes in resistant students, albeit not to the extent anticipated.

Eroğlu (2012) found that university students in vocational knowledge courses exhibited passive resistance due to negative perceptions of the course and instructors, citing issues with teaching methods, instructor relationships, and academic competence. Yüksel and Şahin (2005) observed that students with negative attitudes towards courses, teachers, and assignments displayed more frequent resistance behaviors. Yüksel (2004) identified instructors' professional characteristics, classroom social dynamics, and students' future expectations as primary factors contributing to resistance behaviors among education faculty students.

Paulsel and Chory-Assad (2004) examined the relationship between professors' antisocial behavior modification techniques and students' resistance behaviors at the university level. They found that punitive measures, student guilt, negative student-teacher relationships, and perceived teacher authority correlated with increased resistance behaviors such as teacher blame, unsolicited suggestions, and appeals to higher authorities.

Since 2004, research on student resistance behaviors has been limited, with few comparative studies incorporating both teacher and student perspectives. While some studies have examined university student behaviors, research at secondary and high school levels is scarce and primarily teacher-focused. Teachers have limited influence over resistance behaviors stemming from family, environment, curriculum, or school discipline systems. However, by observing classroom behaviors and identifying student needs, teachers can potentially mitigate resistance behaviors by adjusting their practices.

Student resistance behaviors in the classroom environment pose a significant challenge to the learning-teaching process, negatively impacting not only the resistant student's academic performance

but also potentially influencing other students. Moreover, these behaviors can decrease teacher efficiency, induce feelings of inadequacy, and lead to physical exhaustion (Alpert 1991; Spaulding 2000). Therefore, addressing resistance behaviors is crucial for maintaining a productive educational environment.

Teachers should be capable of analyzing student behaviors, distinguishing between unwanted behaviors and resistance behaviors, and developing appropriate action plans (Sever, 2012; Yıldız & Sarı, 2019).

Literature review reveals limited studies on resistance behaviors, conducted both in Turkey and internationally, involving primary school teachers (Alğan, 2020; Özgök, 2021), secondary school teachers (Yıldız & Sarı, 2019; Canoğulları, 2018; Sullivan et al., 2014; Sever, 2012), high school students (Koyuncu, 2017; Yüksel & Şahin, 2005), and university students (Eroğlu, 2012; Yüksel 2004; Paulsel & Chory-Assad, 2004).

The middle school period is crucial in students' educational journey, bridging primary education and high school, where future career decisions are made. Identifying resistance behaviors during this critical phase, fostering school-teacher-parent cooperation, and providing awareness training for teachers could be beneficial in addressing these issues. With this study, it is expected to reveal how resistance behaviors are understood from the perspective of teachers and students, to determine the resistance behaviors that teachers frequently encounter and the resistance behaviors that students frequently use, to raise teachers' awareness about resistance behaviors, to make them think about the methods they follow against these behaviors and what they can do differently, and as a result, to take a step towards ensuring effective teaching in classrooms and to reveal why students show resistance based on their views. In addition, it is hoped that this study will contribute to filling the gap in the literature and shed light on other researchers who will study on this subject.

This research aims to reveal the frequency of resistance behaviors, their potential sources, possible solutions, and whether they are preventable. It seeks to raise awareness among teachers about the underlying reasons for student resistance behaviors.

The general purpose of the study is to examine the perceptions of teachers and students in secondary schools about resistance behaviors. In line with this main purpose, answers to the following questions were sought:

- What are the opinions of teachers about the resistance behaviors shown by students?
- What are the students' views on resistance behaviors?

Method

Research Model

In this study, a phenomenological design, a qualitative research methodology, was employed. Phenomenological research aims to highlight individuals' perceptions and experiences from their own perspectives (Ersoy, 2016). The rationale for selecting a phenomenological approach in the qualitative phase of this research is to uncover the experiences of both teachers and students concerning the resistance behaviors they encounter in school settings. The focal phenomenon of this research is student resistance behaviors.

Participants

Due to Covid-19 restrictions, a convenience sample of five teachers (three female, two male) with 11-17 years of experience participated in semi-structured interviews. Three taught in medium socioeconomic status (SES) schools, two in low SES schools. All of the teachers are graduates of education faculties. Additionally, two focus groups comprising 10 students identified as resilient by their teachers were conducted. These students attended a medium SES middle school, with one 5th-grader, three 6th-graders, two 7th-graders, and four 8th-graders (two female, eight male).

Data Collection Tool

For this study, semi-structured interview forms were developed for teachers, and focus group interview forms for students. To establish validity, two experts were consulted, and the forms were revised accordingly. Teachers were asked seven and students were asked six questions about resistance behaviours. Pilot interviews were conducted with one teacher and three students before the main data collection.

Data Collection Process

Teacher interviews were conducted online via Zoom, while student focus group interviews took place in a school classroom and recorded with voice recorder All interviews were recorded with written consent. The interviews were conducted in September and October in the first semester of the 2021-2022 academic year. Teacher interviews lasted 6-17 minutes, and each student focus group session lasted approximately 13-14 minutes.

Data Analysis

Content analysis was performed using Nvivo 9 software. An independent expert analyzed the data

alongside the researcher. Themes were compared and discussed to reach consensus. Reliability was calculated using Miles and Huberman's (1994) formula, resulting in agreement rates of 87.5% for teacher interviews and 93.3% for student focus groups. Findings were organized thematically and supported by direct quotations. Five main themes were reached in teacher opinions and four main themes were reached in student opinions.

Findings

Findings Related to First Research Question

The first question of the study, was tried to be answered based on the data obtained from the interviews with teachers.

Table 1 shows the main themes obtained from the semi-structured interviews with teachers.

Table 1.

Main Themes of Teacher Opinions

Student Resistance Behaviors
Sources of Resistance
Impact of Resistance on Teachers and Students
Dealing with Resistance
Preventing Resistance

As seen in Table 1, the interviews with teachers were analyzed under the themes of student resistance behaviors, sources of resistance, effects of resistance on teachers and students, dealing with resistance and prevention of resistance. The findings obtained from the analysis of the data are explained under these main themes in the sub-sections. The themes and sub-themes were supported with direct quotations.

Student Resistance Behaviors

The findings of the question "What are the resistance behaviors your students show?", which was asked to the teachers during the interviews in order to determine what kind of student resistance behaviors they faced, are shown in Table 2.

Table 2.

Student Resistance Behaviors

Passive resistance	
Lack of equipment	
Not being active in class	
Not doing homework	
Learning disability	
Non-attendance	
Active resistance	
Non-attendance	
Being late for class	
Failure to follow the rules	
Demonstrate undesirable behaviors	

As seen in Table 2, resistance behaviors encountered by secondary school teachers are divided into two as passive and active resistance. Passive resistance behaviors encountered by teachers are students' lack of equipment, not being active in class, not doing homework, learning disability and non-attendance. On the other hand, active resistance behaviors encountered by teachers are students non-attendance, being late for class, failure to follow the rules and demonstrate undesirable behaviors. Teachers stated that among the active resistance behaviors, non-attendanca, being late for class and failure to follow the rules were the most common; among the passive resistance behaviors, lack of equipment, not being active in class and not doing homework were the most common resistance behaviors.

> *"If they don't like music class, not participating in music-related activities. If we play melodica, not playing melodica, if we sing, not singing. In that way."(S3) (Active resistance – Non -Attendance)*

> *"And being late, especially in the mornings, tardiness to class is more common." (S1) (Active resistance - Being late for class)*

> *"There can be a lack of equipment. He brings his notebook and does not bring his book, he brings his book and does not bring his notebook."(S1) (Passive Resistance - Lack of Equipment)*

> *"Since there is some anxiety in mathematics, there are behaviors such as not raising a finger or not answering the question I ask, that is, I don't want to answer whether they know or not." (S5) (Passive Resistance - Not being active in class)*

Sources of Resistance

In order to reveal what teachers think about the reasons underlying the resistance behaviors they encounter, the findings related to the question "What could be the sources of your students' resistance behaviors?" are presented in Table 3.

Table 3.

Sources of Student Resistance Behaviors

Family-related situations
Family problems
Lack of emphasis on education
Economic reasons
Student-induced situations
Interest and ability
Attracting attention
Anxiety
Private life
Situations arising from the social environment
Circle of friends
Desire to continue old behaviors

Table 3 shows the possible causes of student resistance behaviors that emerged from the interviews with teachers. According to the teachers, the sources of resistance behaviors are related to the family,

the student and the student's social environment. Teachers mentioned family-related situations the most. Student-related situations, which were cited as the cause of student resistance, ranked second.

Regarding the family problems sub-theme of the theme of family-related situations, T1 expressed the following opinion:

"There are a lot of family problems. Because there are families with separated parents in all of our classes. Students whose parents are not separated, that is, in a very small number of classes... This of course creates problems. Because there is no place where the child stays all the time. When we ask where the child is, we see that the mother has the child. Two days later he doesn't come to school. Where is the father? This naturally makes it difficult for the child to adapt to school." (T1)

S3 stated the following about interest and ability, which is the sub-theme of the theme of student-induced situations:

> *"Well, in relation to my course, the fact that he has no musical talent and when he realizes that ... he doesn't want to do it. Other than that, he doesn't like it, he absolutely doesn't like music."*

Regarding anxiety, which is the sub-theme of the theme of student-induced situations, S5 stated his views as follows:

> *"It's probably something like if you do something wrong, you know, you think you're going to be made fun of by your friends."*

Regarding the course segregation sub-theme of the theme of student-induced situations, S3 expressed his views as follows:

> *"Not putting the music lesson in the same position as other lessons. In other words, he sees music as a simple and normal lesson."*

S4 mentioned the sub-theme of the theme of situations arising from the social environment, the circle of friends, as follows:

> *"The circle of friends comes second. Students are very much influenced by each other. We talked about a student with a teacher friend. He said that he started listening to the lesson very well, he had a friend doing bad behaviors. When he went to another class, this one started listening to the lesson in the front row."*

Impact of Resistance on the Teacher

To determine the impact of resistance behaviors on teachers, the findings related to the question "How do these resistance behaviors shown by your students affect you and other students?" are given in Table 4.

Table 4.
Impacts of Resistance on Teachers and Students

Impact of Resistance on the Teacher
Affective effects
Establishing authority
Interruption of the lesson
Different methods and techniques
Impact of Resistance on the Learner
Setting an example interruption of the lesson
Staying away from class

As seen in Table 4, the impacts of student resistance behaviors on teachers can be summarized under the titles of affective effects, establishing authority, interruption of the lesson and different methods and techniques. Teachers are most affected from an affective perspective and in establishing authority. On the other hand, resistance behaviors affect students in terms of setting an example, interrupting of the lesson and staying away from class.

The affective effects of resistance behaviors on teachers, as expressed by the teachers, are as follows:

> *"It affects me, it makes me sad. I mean, because if we consider that music is in every aspect of our lives, whether my student is talented or not, he/she doesn't have to be talented, but I feel sad when he/she shows resistance in this subject."(T3)*

> *"First of all, of course, he tests our patience with this behavior. I mean, we are trying to be patient, but sometimes the smallest thing can overflow our patience."(S5)*

Teachers stated the effects of resistance behaviors on teachers' authority as follows:

> *"It does, if you don't find a solution, when they resist, it actually becomes a war. You should not confront with the students in the classroom. I mean, you should not come to that situation, so you need to set the rules from the very beginning and introduce who you are to the student from the very beginning."(S4)*

Teachers revealed how the lesson was interrupted when they encountered student resistance as follows:

> *"There can be interruptions in our lesson. For example, if this student persistently continues this behavior, naturally there is a disruption in our lesson. Because we are trying to eliminate that behavior of that child when we should be teaching at that moment. There is a disruption in our lesson."(T1)*

S1 expressed the setting an example effect of resistance on the student as follows:

> *"Now, if there is a resistance behavior of other students, for example, during the class lesson, if there is a problem of not taking notes, then there may be some comfort in other children. When the homework is incomplete, after a while, the students who complete the homework may also start to lack. Results like this occur. For example, in cases of tardiness, if a student is always late in the morning and nothing is done about it, other students start to be late as well. It is perceived as if nothing will happen."*

Dealing with Resistance

In order to understand the ways teachers use to deal with student resistance, the teachers were asked the question "What do you do to deal with the resistance behaviors you encounter in the classroom?". The findings are shown in Table 5.

Table 5.
Teachers' Ways of Dealing with Resistance Behaviors

Communication with family
Informing
Support from family
Communication and cooperation with other stakeholders
Communication with other teachers and administration
School counselling service
One-to-one communication with the student
Relating to real life
Understanding why
Situations related to improving the teaching and learning process
Considering individual differences
Different methods and techniques
Protecting authority
Gradual warning
Reinforcing the truth
Making feel valued
Ignoring

As seen in Table 5, in order to deal with student resistance, teachers resort to communication with the family, communication and cooperation with other stakeholders, one-to-one communication with the student and situations related to improving the teaching and learning process. Teachers frequently addressed situations related to improving the teaching and learning process.

T1 mentioned informing, which is the sub-theme of the theme of communication with the family, as follows:

> *"The most important point to overcome these resistance behaviors is the cooperation between the school and the family. What I do about this is that in all the classes I attend, I directly get the numbers of the families of the children in the first lesson and I tell the children that if you don't do your homework 3 times for 3 days in a row, if you get a minus, I will call your family directly and inform your family.*
>
> *If I have such a problem, if I warn someone a few times or if there is a student who does not do his homework in a row, then I really call. I call in front of everyone's eyes. Since they see that I am calling, they see that I am talking to the parents, so there is not much continuation of this behavior in the class. In other words, especially if the communication between the family and the school is realized, such a problem is not experienced much."*

Regarding the sub-theme of communication and cooperation with other stakeholders, S5 expressed his opinion about communication with other teachers and administration as follows:

> *"It is most important that we discover why he is doing this. Why is he doing this? But for example, if he is a 5th grade student, we can start a dialog with his primary school teacher. You know, why is he exhibiting such a behavior, did he have such a behavior before, why does it continue like this? We should also be in contact with other classmates, I mean for middle and high school. I mean, is he exhibiting this behavior only in our class or in all classes. This is also an important criterion. If he exhibits this behavior in all classes, maybe there is at least a problem with his general situation. But if it is only in my class, at least I try to solve the part about myself."*

Regarding the sub-theme of one-to-one communication with the student, S3 expressed the following opinion:

> *"I talk about why we should do it. For example, I try to explain why we should love music or why it is important to sing, play an instrument, take part in music lessons in some way, how important it is in our lives. I try to support these with examples from our lives." Teacher 2 exemplified considering individual differences, which is the sub-theme of the theme of situations related to improving the learning-teaching process, as follows*
>
> *"Let's say there is a gifted child and the activities in the classroom are very simple for him/her. Obviously, what I can do with such a child is to involve him/her in the transfer of lessons with me. I often ask him for his opinion. If I talk about Impressionism, he has already read something about Impressionism or has an opinion about it. I say, don't create a mystery, if Impressionism didn't exist. Because this is a question he can answer. What do you think would not have happened. For example, I expect him to say that Cubism wouldn't exist and I take him towards that question.".*

Regarding protecting the authority, the sub-theme of the theme of situations related to improving the learning- teaching process, Teacher 4 expressed her views as follows:

> *"You should not confront the child in the classroom. It should not be too long. I mean, I don't prolong it, because if the child increases resistance, you can't do anything. You have no authority. Then your control over other students will decrease and your discipline will decrease.".*

Teacher 5 expressed her views about the gradual warning, which is the sub-theme of the theme of situations related to improving the learning-teaching process, as follows:

> *"First of all, I think the first thing I do when I see these behaviors is to warn. First of all, I prefer to tell the majority, not the individual. For example, if a student is late, he takes his place. Children, let's be careful not to be late at school. Or if he/she is not writing his/her notebook at that moment, children, let's get everyone to open their notebooks. If a student did not receive the necessary warning, I call him/her by name and try to warn him/her. Or I walk around him/her for a while, I want to give the feeling that I am aware of you, I see that you are not doing it.".*

Preventing Resistance

The findings of the question "What can be done to prevent students' resistance behaviors?", which was asked to get teachers' suggestions about what can be done before resistance emerges, are listed in Table 6.

Table 6.

What can be done to prevent resistance?

Communication with family
A common solution
Source of the problem
Extracurricular activities
Teacher attitude
Classroom rules
Active learning environment
Reinforcement

As shown in Table 6, teachers' opinions on what can be done to prevent resistance are communication with the family, extracurricular activities and teacher attitude. Teachers mostly think that teacher attitude can be effective in preventing resistance.

Regarding a common solution, the sub-theme of the theme of communication with the family, Teacher1 expressed his views as follows

> *"We need to be in constant contact with the family. We need to understand the family situation, we need to know what the family situation is like, we need to know what the source of this behavior is. For example, if the child is always late in the morning, the reason for this is, of course, the family. The family doesn't get up and get ready in the morning, so the child is late. I think there will be better results if information is obtained-from the family about the reason for being late for school and if the solution is agreed upon jointly with the family."*

Teacher 4 stated the following about the classroom rules, which is the sub-theme of the teacher attitude theme:

> *"... If the teacher sets the rule clearly, if the teacher is determined, but it will be clear. What is my rule for resistance; one, she will not speak without raising her finger, two, she will not enter the class after you. If you do, you don't say, "Come on, just this once. For 1 month, he/she will try and force you. It's a mutual struggle. Whoever wins will stop resisting. I call the parents or we have such a problem for the first 1-2 months in the 5th grade, then the student already treats the teacher according to the teacher. They don't show the same resistance to everyone. We should not compromise. We need to be firm on some rules.".*

Teacher 2 stated the following about the active learning environment, which is the sub-theme of the teacher attitude theme:

> *"... Let me tell you about different paintings of the same painter, for example one we did. Picasso has periods in his art life such as his blue period and pink period. I gave a painting from one period to one group and a painting from the other period to the other group, and after the work, that is, the products, came out, I had them tell each other which period was better, which period was more productive, which period was more appreciated, and there was no one left in the class who did not participate. This kind of activities. In other words, I think it is very important that the classroom becomes a social environment to attract the child's interest. I think that's what I use the most, and I realized it when I told you about it now, making the classroom environment social. An uncreative drawing lesson, which I remember from my own student life, where you put a still life example in the middle and say, "Let's do this picture," and the whole class says, "Let's do that," can increase the resistance of students. So I try to make the environment social.".*

Regarding reinforcement, which is the sub-theme of the teacher attitude theme, Teacher 5 expressed his views as follows:

> *"In order to prevent it, for example, we can reinforce the children who do not do this behavior. Maybe, for example, if a student is late, if we do something like reinforcing the children who are not late, such as "children, for not being late" or "I am very happy, I start the lesson on time" ... I mean, if we do something like rewarding other students instead of punishing them, I think maybe we can prevent it."*

Findings Related to the Second Research Question

The second question of the study, was tried to be answered based on the data obtained from the focus group interviews with the students. Table 7 shows the main themes obtained from the focus group interviews with students.

Table 7.

Main Themes Obtained from Focus Group Discussions with Students

Resistance Behaviors
Situations Causing Student Resistance
Teacher Reactions to Resistance
Students' Suggestions for Teachers to Prevent Resistance Behaviors

As seen in Table 7, the focus group interviews with students were analyzed under the themes of resistance behaviors, situations causing student resistance, teacher reactions to resistance and students' suggestions for teachers to prevent resistance behaviors. The findings obtained from the analysis of the data are explained under these main themes in the sub-sections. The themes and sub-themes were supported with direct quotations.

Resistance Behaviors

The findings of the questions "What do you like to do most in the lessons?" and "What do you do when there are things you don't like to do in the lessons?" asked to the students to determine what kind of resistance behaviors they exhibit are shown in Table 8.

Table 8.

Student Resistance Behaviors

Active Resistance
Constant anger
Complain
Resistance to teacher authority
Speaking during class
Blaming the teacher

Passive resistance
Reluctant compliance
Extracurricular activities

As seen in Table 8, the resistance behaviors exhibited by middle school students are divided into two as active and passive resistance. Active resistance behaviors exhibited by students are being constantly angry and resistance to teacher authority. Passive resistance behaviors exhibited by students are reluctant compliance and disinterest during the lesson.

Student 7 expressed his/her opinion about the blaming the teacher behavior under the sub- theme of the active resistance theme, resistance to teacher authority, as follows:

> *"I don't know, either I don't understand or the teacher can't explain it properly. I mean, I don't know if my other friends understand, but that's what happens to me."*

Regarding the reluctant compliance behavior, which is the sub-theme of the passive resistance theme, student 3 expressed the following opinion:

> *"I try to solve the problem, and when I can't, I ask the teacher if I can take my seat. If he gives me permission, I take my seat; if not, I continue."*

Regarding the disinterest, which is the sub-theme of the passive resistance theme, students expressed their views as follows:

> *"I try to draw a picture of the professors, but I can't really resemble them." (student 3) "I look at the phone when I am bored, very little."(student 7)*

Situations that Cause Student Resistance

The findings of the question "What do you dislike doing in the lessons?", which was asked to the students in order to reveal the situations that cause the resistance behaviors of the students, are shown in Table 9.

Table 9.

Situations Causing Student Resistance

Teacher-related situations
Taking the student to the board
Location change
Writing
Situations caused by other students
Situations arising from the student himself/herself
Field of interest
Perception of failure

As can be seen in Table 9, the reasons for the resistance behaviors exhibited by the students were handled in three groups as teacher-related situations, situations caused by other students and situations arising from the students thimself/herself. Teacher-related situations include taking the student to the board, changing the location of students and writing. The reasons originating from the student himself/herself are his/her field of interest and perception of failure.

Regarding taking the student to the board, the sub-theme of the theme of teacher-induced situations, student 3 stated the following:

> *"I don't like getting up to the blackboard to solve a problem because I can't solve it and then I feel embarrassed."*

Student 2 expressed his opinion about the situations caused by other students as follows:

> *"I don't like it when people in the class keep bothering me. They want a nib, they want a pencil."*

Regarding the perception of failure, which is the sub-theme of the theme of reasons originating from the student himself/herself, student 7 expressed the following opinion:

> *"How can I put it, I'm trying to listen to the class. Last time there was a math class and an education class. I focus, but I don't understand anything. What the teacher says goes in one ear and out the other. Let me put it this way.*

Teacher Reaction to Resistance

The findings of the question "Can you explain what your teachers do about the behaviors you show when there are things you don't like in the lessons by giving examples?", which was asked to the students to determine what kind of reactions the teachers give to the resistance behaviors shown by the students, are shown in Table 10.

Table 10.

Teacher Reaction to Resistance

Preventive attitude
Taking the student to the board
Ignoring
Authoritative attitude
Low grade
Warning
Verbal Warning
Reactive Warning

As seen in Table 10, teachers' reactions to students' resistance behaviors were divided into two as preventive attitude and authoritative attitude. Preventive attitude is ignoring and taking the student to the board. Authoritative attitudes are low grades and warnings.

Regarding taking the student to the board, the sub-theme of the preventive attitude theme, student 5 stated the following:

> *"Teacher, he puts me on the blackboard to keep me quiet. He tries to make me do something on the blackboard."*

Regarding low grades, the sub-theme of the authoritative attitude theme, student 4 stated the following:

> *"My teacher is taking it out of my grade."*

Regarding the sub-theme of the authoritative attitude theme, warning, students expressed their opinions as follows:

> *"When I don't like writing in class, I go to bed and the teacher gets angry. So I always pick up where I left off." (student 8)*

> *"When I fall asleep, they wake me up like the normal teacher does, by telling my friends or other friends wake me up because the teacher gets angry."(student 7)*

> *"When I talk to my friend, they separate us and change our places." (student 6)*

Students' Suggestions for Teachers to Prrevent Resistance Behaviors

The findings of the question "What do you think your teachers can do to prevent you from showing these behaviors?", which was asked to the students in order to obtain information about the suggestions they would give to their teachers in order to prevent students' resistance behaviors, are shown in Table 11.

Table 11.
Students' Suggestions for Teachers to Prevent Resistance Behaviors

Making the lesson fun
Using different materials in the teaching process
Demonstrating affectionateness

As seen in Table 11, in order to prevent resistance behaviors, the students' suggestions to their teachers are as follows: making the lesson fun, using different materials in the teaching process and demonstrating affective closeness.

Student 10 expressed his views about making the lesson fun as follows:

> *"I mean, teachers should be more playful. Our teachers are too harsh."*

Student 2 stated the following about using different materials in the teaching process:

> *"There are tests to make the lesson fun. For example, when I open tests from Eba related to the subject, they are good."*

Regarding affectionateness, student 7 mentioned the following:

> *"I don't get bored in class when teachers ask me questions like, "What happened to your ear?" or "Do you go to a sport?" Another teacher asked me that."*

Discussion and Conclusion

The research findings indicate that educators encounter both active and passive forms of student resistance, corroborating studies by Yıldız and Sarı (2019), Gencel and Saracaloğlu (2013), Spaulding (2000), and Kearney, Plax & Burroughs (1991). Active resistance primarily manifests as non-attendance, being late for class, failure to follow the rules and demonstrating undesirable behaviours while passive resistance includes lack of equipment, not being active in class, and not doing homework, learning disability and non-attendance. Notably, teachers did not report hostile attitudes towards them. Beaman, Whelldal and Kemp's literature review (2007, as cited in Sullivan, Johnson, Owens, & Conway, 2014) suggests that frequent, albeit minor, disruptive behaviors like unsolicited talk may contribute to teacher burnout.

Analysis of focus group interviews revealed that students' resistance behaviors were categorized into active and passive forms. Teacher interviews corroborated this dichotomy, albeit with differing behavioral manifestations within each category. Teachers identified active resistance as non-attendance, being late, and failure to follow the rules, primarily challenging teacher authority. Students, however, exemplified active resistance as constant anger and complaining. Regarding passive resistance, teachers noted lack of equipment, not being active in class, and not doing homework, while students mentioned reluctant compliance and disinterest during the lesson. This classification aligns with previous studies by Yıldız and Sarı (2019), Gencel and Saracaloğlu (2013), Spaulding (2000), and Kearney, Plax and Burroughs (1991).

Students' active resistance manifests as persistent anger and defiance of teacher authority, exemplified by in-class complaints about peers and disruptive behavior, respectively. Passive resistance encompasses reluctant compliance, which may positively impact learning despite students' unwillingness, and disinterest, where students engage in unrelated activities like drawing. Resistance behaviors may stem from various factors including school environment, teacher-related issues, student characteristics, instructional context, and teacher-student communication dynamics (Kearney, Plax & Burroughs, 1991; Field & Olafson, 1999; Margonis, 2004; Hendrickson, 2012; Wells, Jones & Jones, 2014). To address resistance, teachers should first identify underlying causes (Başar, 2015). Subsequent interventions may include enhancing the learning environment, conducting motivational interviews, and fostering students' sense of belonging within the classroom and school community (Johnson et al., 1983, as cited in Osterman, 2000; Margonis, 2004; Wells, Jones & Jones, 2014).

Teachers predominantly attribute resistance behaviors to family-related factors, followed by student-specific characteristics and social environment influences. This aligns with findings from Sever (2012), while Yıldız and Sarı (2019) and Field and Olafson (1999) similarly report teachers identifying students as primary sources of resistance. Notably, teachers do not perceive themselves as potential reasons for student resistance. However, relevant literature emphasizes the significant impact of teacher attitudes and behaviors on student resistance (Hendrickson, 2012; Goodboy & Bolkan 2009; Burroughs, 2007; Margonis, 2004; Paulsel & Chory-Assad, 2004). Kearney, Plax & Smith (1986) demonstrated that teachers employing punitive strategies and maintaining distant relationships with students are more likely to encounter resistance behaviors.

Students attribute resistance behaviors to three primary sources: teacher-related situations, peer-related factors, and self-generated reasons. Contrary to teachers' perspectives, students identify teachers as significant contributors to resistance behaviors. Analyzing students' viewpoints reveals that certain classroom practices, such as being taken to the blackboard, can elevate anxiety levels. Research indicates that anxiety can lead to academic failure (Saito & Samimy, 1996; Şentürk, 2010; Dursun & Bindak, 2011; Bozkurt, 2012), potentially resulting in alienation and resistance towards the subject. Students also highlighted location change as a problematic practice. Forced relocation, particularly when paired with incompatible peers, may disrupt concentration and foster negative attitudes towards the teacher. Field and Olafson (1999) demonstrate that domineering attitudes, demanding respect, and labeling students as resisters exacerbate resistance. Teachers can foster a democratic environment by valuing students' perspectives, tolerating criticism, and encouraging active participation (Balat, Bilgin, & Unsal, 2017). Democratic practices may include involving students in setting rules (Başar, 2015) and offering choices in classroom activities, aligning with active learning principles that empower students to direct their learning processes (Kalem & Fer, 2003).

Student resistance primarily affects teachers emotionally and challenges their authority, potentially leading to feelings of inadequacy, reduced productivity, or undesirable classroom atmospheres. Goodboy and Bolkan (2009) found that negative classroom environments increase the likelihood of undesirable student behaviors, suggesting a potential cyclical effect of resistance. To mitigate this, teachers should vigilantly monitor classroom behaviors and intervene proactively to prevent the escalation of unwanted behaviors into resistance. This approach may help maintain a positive learning environment and minimize the negative impacts of resistance on both teachers and students.

Teachers perceive resistance behaviors as affecting students through exemplification, lesson disruption, and disengagement. Özdemir (2019) classifies classroom management factors as in-class and out-of-class, with peer relationships being a crucial out-of-class social factor. Adolescent peer influence significantly shapes behavior (Demir, Görgün Baran, & Ulusoy, 2005; Medikoğlu & Dalaman, 2018), potentially propagating resistance behaviors among students.

To address resistance, teachers primarily focus on enhancing the learning and teaching process, followed by family communication. This suggests teachers' self-reflection on their role in student resistance and their efforts to implement changes. The diverse coping strategies employed by teachers indicate an awareness of students' individual differences.

Teachers should promptly collaborate with students, colleagues, and parents to identify and resolve the underlying causes of resistance before interventions become challenging. This proactive approach may help mitigate the spread of resistance behaviors and maintain a positive learning environment. Alpert's (1991) study reveals that student resistance behaviors are prevalent in classrooms where students' interests and opinions are disregarded, while effective teacher-student communication and student validation minimize resistance. However, the current study's finding that teachers primarily attribute resistance to family factors, yet prioritize self-directed interventions when addressing resistance, warrants careful consideration. This discrepancy suggests that teachers possess a fundamental awareness of student resistance and attempt to modify the learning and teaching process to align with students' interests. Nevertheless, the apparent contradiction between teachers' attribution of resistance causes and their chosen intervention strategies highlights a complex dynamic in understanding and addressing student resistance behaviors in educational settings.

Based on student perspectives, teacher responses to student resistance behaviors were categorized into preventive and authoritative approaches. Preventive strategies include engaging students by taking them to the board and forcing them to participate, while sometimes opting for non-intervention. Conversely, authoritative approaches involve verbal warnings, changing the location of students, or utilizing grade-based incentives to modify behavior. Student-reported teacher reactions diverged from those articulated by educators in interviews. Teachers indicated employing methods such as communication with family, collaboration with other stakeholders, individualized student communication, and enhancements to the teaching-learning process

to address resistance. Margonis (2004) observed that teachers who successfully mitigated resistance behaviors did so through open dialogue about students' challenges and by fostering non-hierarchical relationships. Paulsel and Chory-Assad (2004) found that punitive measures, attribution of blame, exertion of authority, and negative teacher-student dynamics exacerbated resistance behaviors. Consequently, educators should be careful when implementing authoritative strategies such as low grades or warning.

Teacher strategies for mitigating resistance encompass communication with family, extracurricular activities, and instructor attitudes. The predominant perception among educators is that their attitude plays a crucial role in resistance prevention. Goodboy and Bolkan (2004) conceptualize resistance as a student response to instructors demonstrating classroom incompetence or engaging in student humiliation. The study participants exhibited awareness of how their classroom conduct influences student behavior. Burroughs (2007) observed that positive teacher-student relationships correlate with reduced resistance behaviors. Furthermore, students' willingness to engage in lessons is associated with their cognitive and affective learning processes. This suggests that to enhance academic performance, educators may benefit from cultivating emotional connections with their students.

Recommendations

Based on the research findings, several recommendations for practice and future research can be proposed. To address student resistance behaviors, it is suggested that both pre-service and in-service teachers receive comprehensive training on active and passive resistance behaviors, as well as constructive and destructive behaviours. This training should include practical observations and strategies for prevention and management of such behaviors. Given the significant role of teacher-student relationships in mitigating resistance behaviors, seminars focusing on student developmental stages and appropriate classroom attitudes are recommended. Teachers should be encouraged to select classroom activities that align with students' readiness levels, interests, and real-life relevance, while fostering a supportive environment through positive reinforcement rather than punitive measures. A holistic approach involving school administration, colleagues, peers, and family members is advised when addressing resistance behaviors. Additionally, school counselors can contribute by conducting student training on interpersonal relationships, emotional regulation, and anger management. For future research, it is recommended to expand the study across various educational levels and geographical locations, conduct comparative studies between private and public schools, and incorporate parental perspectives to provide a more comprehensive understanding of resistance behaviors in educational settings.

References

Algan, S. (2020). *Sınıf öğretmenlerinin öğrenci direnç davranış algıları ile sınıf içi iletişim becerileri arasındaki ilişki.* [The relationship between classroom teachers' perceptions of student resistance behavior and classroom communication skills]. (Unpublished master's thesis). Çukurova University, Adana.

Alpert, B. (1991). Students' resistance in the classroom. *American Anthropological Association*, *22*(4), 350-366.

Balat, G. U., Bilgin, H., & Ünsal, F. Ö. (2017). Okul öncesi öğretmenlerinin öğretmenlik tutumları ve sınıf yönetimi arasındaki ilişkinin incelenmesi. [Examining the relationship between preschool teachers' teaching attitudes and classroom management]. *Journal of Education and Society Research*, *4*(1), 114-126.

Başar, H. (2015). İstenmeyen davranışların değiştirilmesi [Changing undesirable behaviors]. In E. Ağaoğlu (Ed.), *Sınıf Yönetimi. [Classroom Management]* (pp. 74 – 104). Eskisehir: Anadolu University Publications.

Beaman, R., Wheldall, K., & Kemp, C. (2013). Recent research on troublesome classroom behaviour. In K. Wheldall (Ed.), *Developments in Educational Psychology* (pp. 135-152). Newyork: Routledge.

Bozkurt, S. (2012). *İlköğretim ikinci kademe öğrencilerinde sınav kaygısı, matematik kaygısı, genel başarı ve matematik başarısı arasındaki ilişkilerin incelenmesi.* [Examination of the relationships between test anxiety, mathematics anxiety, general achievement and mathematics achievement in elementary school second level students]. (Unpublished master's thesis.) Istanbul University, Istanbul.

Burroughs, N. F. (2007). A reinvestigation of the relationship of teacher nonverbal immediacy and student compliance-resistance with learning. *Communication Education*, *56*(4), 453-475.

Canoğulları, E. (2018). *Öğretmenlerin okullarındaki yaşam kalitesine ve öğrenci direnç davranışlarına ilişkin algılarının incelenmesi*. [Examining teachers' perceptions of the quality of life in schools and student resistance behaviors]. (Unpublished master's thesis). Çukurova University, Adana.

Demir, N. Ö., Görgün Baran, A., & Ulusoy, D. (2005). Türkiye'de ergenlerin arkadaş akran grupları ile ilişkileri ve sapmış davranışlar-Ankara örneklemi. [Adolescents' relationships with peer groups and deviant behaviors in Turkey-Ankara sample]. *Bilig*, *32*, 83-108.

Dursun, Ş., & Bindak, R. (2011). İlköğretim 2. kademe öğrencilerinin matematik kaygılarının incelenmesi [Investigation of mathematics anxiety of elementary school 2nd level students]. *Cumhuriyet University Faculty of Arts and Sciences Journal of Social Sciences*, *35*(1), 18-21.

Eroğlu, M. (2012). *Öğretmen adaylarının öğretmenlik meslek bilgisi derslerine yönelik direnç davranışları* [Resistance behaviors of prospective teachers towards teaching professional knowledge courses]. (Unpublished master's thesis). Fırat University, Elazığ.

Ersoy, A. F. (2016). Fenomenoloji [Phenomenology]. In A. Saban & A. Ersoy (Editors), *Eğitimde Nitel Araştırma Yöntemleri [Qualitative Research Designs in Education]* (p. 55 - 65). Ankara: Anı Publishing.

Field, J. C. & Olafson, L. J. (1999). Understanding resistance in students at risk. *Canadian Journal of Education*, *24*(1), 70-75.

Gencel, İ. E., & Saracaloğlu, A. S. (2013). An investigation of resistant behaviours of the teacher candidates toward the teaching certificate courses. *Çukurova University Faculty of Education Journal*, *42*(2), 87-98.

Goodboy, A. K., & Bolkan, S. (2011). Leadership in the college classroom. *Journal Of Classroom Interaction*, *46*(2), 4-10.

Hendrickson, K. A. (2012). Student resistance to schooling: disconnections with education in rural Appalachia. *High School Journal*, *95*(4), 37-49.

Kalem, S. and Fer, S. (2003). Aktif öğrenme modeliyle oluşturulan öğrenme ortamının öğrenme, öğretme ve iletişim sürecine etkisi. [The effect of learning environment created with active learning model on learning, teaching and communication process]. *Educational Sciences in Theory and Practice*, *3*(2), 433-461.

Kearney, P., Plax, T. G., & Burroughs, N. F. (1991). *An attributional analysis of college students' resistance decisions*. Paper presented at the 41st annual meeting of the International Communication Association. Chicago, IL: University of Illinois.

Kearney, P., Plax, T. G., & Smith, V. R. (1986). *Effects of teacher immediacy and strategy type on College Student Resistance*. Paper presented at the 72nd annual meeting of the Speech Communication Association. Chicago, IL: University of Illinois.

Koyuncu, B. (2017). Lise Öğrencilerinin Problem Çözme Becerilerinin Derslere Yönelik Direnç Davranışlarının Yordanması. [Prediction of High School Students' Problem Solving Skills and Resistance Behaviors Towards Lessons]. *International Journal of Eurasia Social Sciences*, *8*(29), 1071-1090.

Margonis, F. (2004). From student resistance to educative engagement: A case study in building powerful student-teacher relationships. *Counterpoints*, *259*, 39-53.

Medikoğlu, O., & Dalaman, O. (2018). Öğretmenlerin derste karşılaştıkları istenmeyen öğrenci davranışları ve bu davranışlara yönelik çözüm stratejileriyle ilgili öğretmen görüşlerinin belirlenmesi. [Determination of teachers' opinions about the undesirable student behaviors that teachers encounter in the lesson and solution strategies for these behaviors]. *Journal of Educational Theory and Practice Research*, *4*(1), 20-32.

Osterman, K. F. (2000). Students' need for belonging in the school community. *Review of Educational Research*, *70*(3), 323-367.

Özdemir, G. (2019). Sınıf yönetimini etkileyen faktörler. [Factors affecting classroom] management. In O. Sarıgöz, R. Tösten, & M. Baş (Eds.), *Sınıf Yönetimi [Classroom Management]* (pp. 25-54). Ankara: Anı Publishing.

Özgök, A. (2021). *İlkokul dördüncü sınıf düzeyinde öğretmenlerin karşılaştığı direnç davranışlarının incelenmesi*. [Investigation of resistance behaviors encountered by teachers at the fourth-grade level of primary school]. (Unpublished doctoral dissertation). Çukurova University, Adana.

Paulsel, M. L., & Chory-Assad, R. M. (2004). The relationships among instructors' antisocial behavioral alteration techniques and student resistance. *Communication Reports*, *17*(2), 103-112.

Saito, Y. & Samimy, K. K. (1996). Foreign language anxiety and language performance: a study of learner anxiety in beginning, intermediate and advanced level of college students of Japanese. *Foreign Language Annals*, *29*(2), 239-249.

Sarı, M. (2018). Development of a teacher scale to measure presence and frequency of students' resistance behaviours. *Universal Journal of Educational Research*, *6*(2), 226- 234.

Sever, D. (2012). *İlköğretim fen ve teknoloji dersinde araştırma temelli öğrenme yaklaşımının öğrenci dirençlerine etkisi.* [The effect of research-based learning approach on student resistance in elementary science and technology course]. (Unpublished doctoral dissertation). Anadolu University, Eskişehir.

Sullivan, A. M., Johnson, B., Owens, L., & Conway, R. (2014). Punish Them or Engage Them? Teachers' Views of Unproductive Student Behaviours in the Classroom. *Australian Journal of Teacher Education*, *39*(6), 43-56.

Şentürk, B. (2010). *İlköğretim beşinci sınıf öğrencilerinin genel başarıları, matematik başarıları, matematik dersine yönelik tutumları ve matematik kaygıları arasındaki ilişki.* [The relationship between primary school fifth grade students' general achievement, mathematics achievement, attitudes towards mathematics course and mathematics anxiety]. (Unpublished master's thesis). Afyon Kocatepe University, Afyon.

Tanner, K. D., & Seidel, S. B. (2013). "What if students revolt?"-Considering student resistance: Origins, options and opportunities for investigation. *CBE-Life Sciences Education*, *12*, 586-595.

Wells, H., Jones, A., & Jones, S. C. (2014). Teaching reluctant students: using the principles and techniques of motivational interviewing to foster better student-teacher interactions. *Innovations In Education and Teaching International*, *51*(2), 175-184.

Yıldız, E., & Sarı, M. (2019). Öğretmen gözünden öğrenci direncine bakış: Görüşleri, stratejileri ve önerileri. [A teacher's perspective on student resistance: Opinions, strategies and suggestions]. *SDU International Journal of Educational Studies*, *6*(2), 128- 149.

Yüksel, S. (2003). Öğrencilerin öğretme-öğrenme sürecine yönelik direnç davranışları. [Students' resistance behaviors towards teaching-learning process]. *Journal of Uludağ University Faculty of Education*, *17*(1), 235-251.

Yüksel, S. (2004). Eğitim Fakültesi öğrencilerinin öğretme-öğrenme süreçlerine yönelik direnç davranışları. [Faculty of Education students' resistance behaviors towards teaching-learning processes]. *Turkish Journal of Educational Sciences*, *2*(3), 341-354.

Yüksel, S., & Şahin, E. (2005). Alt sosyo-ekonomik düzeyden gelen lise öğrencilerinin öğrenme-öğretme faaliyetlerine ilişkin direnç davranışları. [Resistance behaviors of high school students from lower socio-economic levels regarding learning-teaching activities]. *Journal of Education and Science*, *30*(138), 52-66.

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Strategies to Enhance Eco-Friendly Culture and Environmental Awareness by Green Curriculum Integration in Indonesian Elementary Science Classroom

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Abstract

This study aimed to develop and assess strategies for integrating a green curriculum into Indonesian elementary science education to improve environmental awareness and eco-friendly culture among students. Utilizing research development design, the research began with a needs analysis from five elementary schools, followed by a quasi-experiment in one selected school. Environmental awareness and eco-friendly culture were measured at the end of the learning period in both control and experimental groups, with a t-test revealing significant differences. The experimental group showed higher environmental awareness and eco-friendly culture scores than the control group than the control group ($p < .05$). These results confirmed that integrating environmental responsibility into student activities in science education, such as caring for plants or animals, significantly enhances their environmental stewardship. This study provides practical and theoretical insights into green curriculum integration, especially in developing countries, and highlights the importance of incorporating ecological responsibility projects in education to promote sustainable behaviors. The findings can inform educational practices, curriculum development, and policymaking in sustainable education.

Keywords:

Eco-Friendly Culture, Environmental Awareness, Green Curriculum, Integration Model, Science Education

Introduction

Environmental awareness and an eco-friendly culture ensure our planet's sustainability and future generations' wellbeing (Bhandari & Abe, 2000; Kudlas, 1984; Parker & Prabawa-Sear, 2019a). In Indonesia, environmental awareness and eco-friendly is still relatively low, as evidenced by various environmental issues such as deforestation, air and water pollution, and plastic waste accumulation (Nurkaidah et al., 2024; Viteri & Pazmiño, 2023). Instilling environmental awareness and an eco-friendly culture early is crucial, especially among elementary school students (Bootrach et al., 2015). Instilling these values helps to shape

a generation that is conscientious and responsible for environmental preservation (Lowan-Trudeau, 2023).

Research on environmental awareness among elementary school students has become a key focus in environmental education studies globally, particularly in (Husamah et al., 2022; Komariah & Sa'ud, 2024). This concern is supported by evidence of the low levels of environmental awareness and eco-friendly practices among elementary school students (Ardoin & Bowers, 2020; Masalimova et al., 2023). A study conducted by Sadikin et al., (2024), which measured environmental awareness among fifth-grade students in an Indonesian elementary school, revealed that only 37.38% of students could distinguish between organic and inorganic waste, and 45.27% were familiar with the 3R concept (Reduce, Reuse, Recycle). Similarly, Rindawati et al., (2020) assessed the environmental knowledge of 10-year-old elementary students in an Indonesian urban area and found that merely 10% of students understood solid, liquid, and industrial waste. These findings highlight the urgent need for curriculum development and more structured environmental education strategies at the elementary school level (Rindawati et al., 2020; Sadikin et al., 2024).

Elementary school is a critical period during which values and habits can be firmly established through systematic learning approaches (Aningsih et al., 2022; Fekih Zguir et al., 2021). This aligns with research by Errica & Mulyadi (2022), which compared environmental education curricula in Indonesia and Japan. Their findings revealed that Japan's practical approach at the elementary school level promoted greater environmental awareness and pro-environmental behavior compared to Indonesia's predominantly theoretical methods. Therefore, research focusing on structured and practical environmental education is urgently needed to bridge the gaps in sustainable practices among elementary school students in Indonesia (Gavilan Tatin et al., 2024; Gunansyah et al., 2021; Parker & Prabawa-Sear, 2019a).

In Indonesia, since 2006, environmental education has been integrated into school environmental management through the Adiwiyata program (The Ministry of Environment and Forestry Republic Indonesian, 2006). This program encourages students to participate in maintaining the school environment beyond regular class hours (Parker, 2018; Parker & Prabawa-Sear, 2019a). However, studies indicate that the implementation of the Adiwiyata program has not fully succeeded in fostering environmentally friendly behavior among students (Tompodung et al., 2018). Despite its significant potential, research findings reveal that a lack of active participation and deep understanding of environmental issues among students often hinders its effectiveness (Desfandi M. et al., 2019), and it is also context-dependent on individual schools (Syahrial et al., 2020). This condition highlights the need for structured and practical development of environmental education within the learning process (Gavilan Tatin et al., 2024; Gunansyah et al., 2021; Parker & Prabawa-Sear, 2019a). A green curriculum serves as a framework for integrated environmental education through various learning practices to foster environmental awareness and promote sustainable practices (Corpuz, 2022; Louw, 2013; Ni et al., 2024).

The green curriculum refers to an educational approach that integrates environmental issues into learning, effectively promoting sustainable actions among students (Louw, 2013; Ni et al., 2024). Its implementation aims to equip students with the skills to analyze and address environmental challenges caused by human activities, reflecting the reciprocal relationship between humans and nature (Ni et al., 2024). However, its implementation often encountered challenges in adapting to local contexts, necessitating strategies that were tailored to the specific educational and cultural needs of each community to ensure effective integration and impact (Fekih Zguir et al., 2021; Olsen et al., 2024; Sterling, 2024; Wals, 2015). Integrating environmental education into elementary science curricula enhances its potential by aligning with science's focus on understanding nature, the environment, and human-ecosystem interactions (Nation & Feldman, 2021). Although the urgency of environmental education has been widely acknowledged, the systematic implementation of a green curriculum within formal education, particularly in science subjects at the elementary level in Indonesia, remains unrealized (Parker et al., 2018; Parker & Prabawa-Sear, 2019b). Presently, environmental education efforts in Indonesia are largely confined to extracurricular activities or project-based initiatives outside the classroom, highlighting a substantial gap in its integration into the core curriculum (Syahrial et al., 2020; Tompodung et al., 2018). This study aimed to address this gap by developing strategies for implementing a green curriculum integrated into science education, with the goal of fostering an environmentally friendly culture and enhancing students' in-depth awareness of environmental issues.

Theoretical Framework

Green Curriculum

The green curriculum refers to an educational framework that incorporates environmental topics into the learning process, fostering sustainable behaviors among students (Louw, 2013; Ni et al., 2024). Its goal is to develop students' abilities to analyze and tackle environmental problems resulting from human activities, highlighting the interdependent relationship between humans and the natural world (Ni et al., 2024). The green curriculum incorporates several key components to foster environmental

awareness and sustainable behaviors among students effectively (Louw, 2013; Ni et al., 2024; Şahin, 2008). First, the green curriculum integrates environmental issues such as pollution and climate change into core subjects like science, fostering awareness and sustainable practices. Second, it emphasizes project-based learning through activities like waste management and energy audits, linking theory with practical applications to enhance critical thinking and eco-friendly habits (Parker et al., 2018; Parker & Prabawa-Sear, 2019b). Finally, it focuses on character development by encouraging responsibility and ethical attitudes through activities such as plant care and community clean-ups, promoting environmental stewardship (Aningsih et al., 2022).

Integrating environmental education into science classes provides students with practical experiences that enhance their understanding of sustainability and environmental issues (Kumar,et al., 2023; Shulla et al., 2020). Cultivating a garden during lessons on plant biology allows students to observe plant growth, understand photosynthesis, and recognize the environmental conditions necessary for sustainable ecosystems (Aningsih et al., 2022; Louw, 2013). The integration of the green curriculum into science education bridges theoretical concepts with practical applications, enhancing students' understanding of ecological systems and fostering sustainable practices (Ni et al., 2024; Tuncer et al., 2007; Viteri & Pazmiño, 2023). Outdoor experiential activities, such as observing local ecosystems or participating in community cleanup initiatives, provide students with a deeper appreciation for biodiversity and the interconnectedness of life, fostering environmental responsibility and eco-friendly behaviors (Aurélio et al., 2022; Dillon & Scott, 2002). By embedding these activities into the science curriculum, students develop skills needed to address real-world environmental challenges effectively (Olsen et al., 2024; Viteri & Pazmiño, 2023).

Student's Environmental Awareness And Eco-Friendly Culture

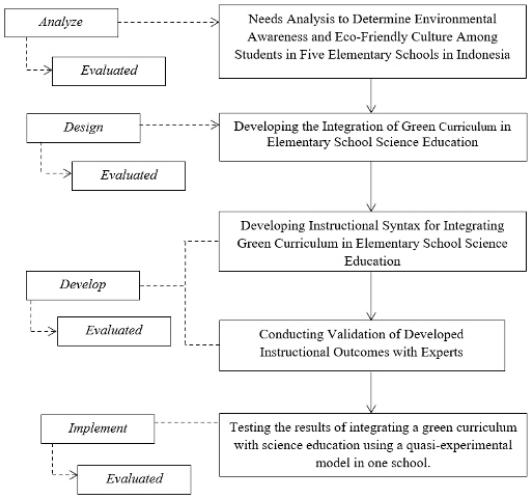
Student environmental awareness refers to the understanding, attitudes, and behaviors that students develop toward environmental issues and the necessity for sustainable practices (Ni et al., 2024; Özden, 2008). Cultivating environmental awareness among students is essential for shaping a generation capable of addressing ecological challenges (Moody-Marshall, 2023). Individuals need to possess environmental care attitudes before recognizing their social and environmental responsibilities, which ultimately enhance their intention to adopt eco-friendly practices (Ha et al., 2023). These attitudes encompass five aspects are receiving, which refers to sensitivity to environmental issues; responding, which involves actions to address environmental problems; valuing, which reflects the belief that actions to protect the environment can minimize damage; organization, which entails encouraging others to take collective action in preserving the environment; and characterization, which represents a consistent disposition to maintain cleanliness and avoid environmentally destructive behaviors (Yu, T.-Y., & Yu, 2017).

Eco-friendly culture refers to a set of integrated practices, behaviors, and values that minimize environmental harm and promote sustainability (Gobena & Kant, 2022; Ullman et al., 2008). Key components include green planning and design, which focuses on creating sustainable infrastructures; green energy, emphasizing renewable energy sources to reduce carbon emissions; and waste management, targeting waste reduction, recycling, and composting to prevent environmental degradation (Bradley, 2009; Wals, 2015). Additionally, water conservation and green transportation are central, ensuring the efficient use of natural resources and reducing pollution through eco-friendly mobility solutions. These interconnected elements aim to foster a society that prioritizes sustainable development and ecological balance (Jorgenson et al., 2019; Parker, 2018; Shulla et al., 2020). By integrating these principles, eco-friendly culture serves as a foundation for addressing global environmental challenges while supporting long-term sustainability (Fekih Zguir et al., 2021; Prabawani & Hanika, 2017).

Method

This study employed a research and development (R&D) model adapted from the ADDIE model, which stands for Analyze, Design, Develop, Implement, and Evaluate (Branch, 2009). The research process conducted using this development model is described in Figure 1 below.

Figure 1.
Research Flowchart of The Development Model.



Problem Analyze Phase

In the first stage, the problems in the environmental education process were identified through observations and questionnaires distributed to five elementary schools in East Java Province. The schools participants in this study were selected from five elementary schools in East Java through purposive sampling based on several criteria, including the availability of environmentally focused programs, diversity in school types encompassing public, private, and faith-based institutions, the presence of supporting infrastructure, and fifth-grade students aged 10–11 years who are at the concrete operational cognitive development stage, making them suitable for project-based learning and understanding environmental issues. This selection ensured a comprehensive understanding of the environmental education challenges across various school settings (see Table 1 for a description of participants).

The problem analysis was conducted through direct field observations and a review of supporting curriculum documents, including semester-long lesson plans, school teaching schedules, and school supervision records. This comprehensive approach aimed to evaluate both the on-ground implementation and the structural alignment of the environmentally-based curriculum for fifth-grade students across five schools. The indicators for assessing the achievement level of the environmentally-based curriculum were adapted from Şahin, (2008), as detailed in Table 2.

The needs analysis data from the identification process were analyzed using descriptive statistics to evaluate the environmental-based curriculum implementation level in the five participating schools. This analysis aimed to measure the extent to which environmental programs have been implemented to support the development of students' environmental care character. The evaluation focused on the frequency and quality of environmental programs, student participation, and the alignment of educational implementation across the five schools involved in this needs analysis.

Design and Develop Phase

The green curriculum integration model for science education was designed and developed in this phase based on the issues identified during the problem analysis phase. The primary objective of this phase was to create a comprehensive model that effectively integrates environmental education into the science curriculum, promoting environmental awareness and eco-friendly culture among students.

Content Validity was assessed using expert reviews. A panel of five environmental education specialists, curriculum developers, and experienced teachers evaluated the curriculum to confirm that it addressed all necessary environmental topics and adhered to best practices in sustainability education. The content validity of the curriculum was determined by calculating the Content Validity Index (CVI) for each item and the overall model. The formula for content validity index (CVI):

$$CVI = \frac{N}{A}$$

Where:
A = the number of experts who rated the item as relevant.
N = the total number of experts.
A CVI score of 0.8 or higher was considered acceptable, indicating strong content validity.

The expert review results are summarized in Table 4, showing the CVI scores for each curriculum component. The experts rated the curriculum's alignment with environmental education standards,

Table 1.
Description of Participants.

No.	Origin School	Total Number of students	Grades	Male	Female	Age (Yo)
1.	Public Elementary School Malang	102	5th	46	56	10-11
2.	Islamic Elementary School Malang	113	5th	48	65	10-11
3.	Islamic Elementary School Pasuruan	98	5th	48	60	10-11
4.	Public Elementary School Pasuruan	80	5th	32	48	10-11
5.	Privat Elementary School Sidoarjo	88	5th	47	41	10-11

Table 2.
Indicators for the Achievement Level of the Environmentally-Based Curriculum

No.	Indicator
1.	The school's vision reflects the development of students' environmental awareness character.
2.	The mission provides direction for the goals of the green school program.
3.	Environmental programs are evident in the school's vision and mission.
4.	There are specific routine activities for environmental management.
5.	Additional learning time is provided to support environmental management activities and the development of students' environmental awareness character.
6.	Promotion criteria include achievements in environmental programs.
7.	Environmental management activities and campaigns involve parents.
8.	Activities are conducted to develop students' environmental awareness character.
9.	There is a dedicated supervision program for environmental initiatives.

Adapted from Şahin, (2008).

content relevance, and comprehensiveness using a Likert scale (1 = Strongly Disagree, 2 = Disagree, 3 = Agree, 4 = Strongly Agree). The mean CVI score for each component was calculated to ensure that all critical aspects of the curriculum met the required validity threshold. The result of the expert review for content validity is in Table 3. Below.

Multiple methods were employed to assess the reliability of the green curriculum integration in science learning. First, Cronbach's alpha was calculated for the environmental awareness and eco-friendly culture questionnaires used to measure students' attitudes and behaviors. The internal consistency of the instruments yielded high Cronbach's alpha coefficients of 0.85 for the environmental awareness scale and 0.87 for the eco-friendly culture scale, indicating strong reliability of the instruments. Next, inter-rater reliability was assessed by having six trained teachers independently assess students' environmental projects using a common rubric. Cohen's Kappa coefficient was calculated to measure the level of agreement among the raters, resulting in a coefficient of 0.82, indicating substantial agreement. Finally, test-retest reliability was evaluated by administering the same questionnaires to a subset of 50 students at two different time points, with a 4-week interval. The Pearson correlation coefficient for the test-retest reliability was 0.91, confirming the stability of the instruments over time. The iterative design, development, and validation process ensured that the green curriculum integration model was theoretically sound and practically applicable. Feedback from the pilot phase provided critical insights incorporated into the final version.

Implementation Phase

in the final stage, a quasi-experiment testing process was carried out with two classes (a control class and an experimental class) in an elementary school in BAIPAS Islamic Elementary School Malang, East Java. The selection of students for this stage was different from those who participated in the analysis phase. The selection was based on purposive sampling, where participants were specifically chosen to ensure they met the criteria for the study's objectives. The school was selected based on its willingness to participate in the research and its suitability for implementing both traditional and integrated green curriculum methods within its existing science curriculum. Additionally, the school was located in an area with varied socio-economic backgrounds, providing a more comprehensive context for testing the green curriculum's impact on students' environmental attitudes and behaviors. The participants in this stage consisted of 80 students from five grades, aged 10-11 years (Description of quasi-experiment participants in Table 4).

In this quasi-experimental study, the control group received Problem-Based Learning (PBL) in science instruction. In this approach, students worked collaboratively to address and find solutions to various environmental problems presented by the teacher. The goal was to engage students in active problem-solving related to real-world environmental issues, fostering critical thinking, teamwork, and a deeper understanding of environmental challenges. In contrast, the experimental group received science instruction integrated with a green curriculum, where environmental issues were embedded within the science content. The green curriculum aimed to raise environmental awareness and promote sustainable practices among students, incorporating hands-on activities and projects aligned with sustainability principles and ecological responsibility.

At this stage, environmental awareness and eco-friendly culture values were measured using a paper-

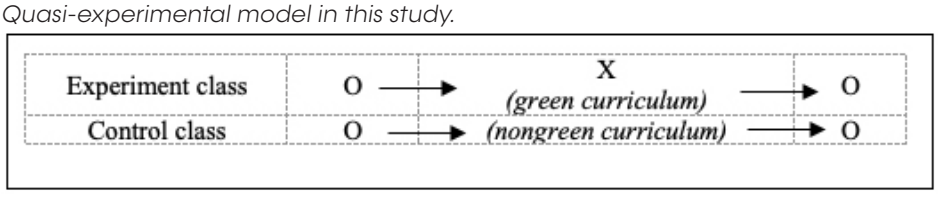
Table 3.
Results of Expert Review for Content Validity

No.	Component	Expert Rating (1-4)	Number of expert ratings (agree/all)	CVI Score	Mean CVI Score
1.	Environmental Topics	3.9	4/5	0.8	0.88
2.	Pedagogical Approach	4.0	5/5	1.0	1.00
3.	Assessment Tools	3.8	4/5	0.8	0.85

Table 4.
Description of Quasi Experiment Participant.

No.	Class	Grades	Male	Female	Age (Yo)
1.	Control	5th	17	23	10-11
2.	Experiment		15	25	

Figure 2.
Quasi-experimental model in this study.



based self-assessment Likert scale questionnaire, distributed in paper form and filled out directly by the students after the science lessons in their classrooms. The questionnaires were designed to align with the study's objectives by measuring specific aspects, ensuring the data collected supported the evaluation of the green curriculum's effectiveness. The environmental awareness indicators were adapted from Yu, T.-Y., & Yu, (2017), as shown in Table 2, and the eco-friendly culture indicators were adapted from Wals, (2015), as presented in Table 3 below.

Cronbach's alpha was calculated to determine the internal consistency of the environmental awareness and eco-friendly culture questionnaires to assess the reliability of the instruments used to measure students' environmental awareness and eco-friendly behavior. The Cronbach's alpha coefficient for the environmental awareness scale was 0.85. For the eco-friendly culture scale, it was 0.87, indicating a high internal consistency and reliability of the instruments for measuring these constructs (self-assessment questionnaire based on indicators Table 5 and 6 in Appendix 1 and 2).

The data were analyzed using independent samples t-tests in SPSS 26. The t-test compared the mean scores of the experimental group (students taught using the green curriculum) and the control group (students taught using the conventional curriculum). This analysis determined whether the green curriculum significantly improved students' environmental attitudes and behaviors. A significance level of ($p \leq 0.05$) was used to interpret the results.

Result

This study aimed to explore and assess strategies integrated into a green curriculum in Indonesian elementary science education to improve students' environmental awareness and eco-friendly culture. A green curriculum integration model for science education was developed, and the results were described through a series of ADDIE phases.

Table 5.

Indicators of Environmental Awareness

No.	Indicators	Description
1.	Receiving	External stimuli include problems and symptoms in the students' environment.
2.	Responding	Actions that students must take to address the problems in their environment.
3.	Valuing	A belief that actions taken to address ecosystem or environmental issues can minimize environmental damage.
4.	Organization	Effort to encourage others to take action to preserve and maintain the surrounding environment for the common good.
5.	Characterization	Having an attitude and traits that are sensitive to environmental maintenance.

Adapted from Yu, T.-Y., & Yu, (2017)

Table 6.

Indicators of Eco-Friendly Culture.

No.	Assessment indicators of an environmentally friendly culture	Description
1	Habituation in Mapping the Potential and Condition of the Environment	Students' habits in mapping local environmental conditions, including identifying natural resources, environmental issues, and conservation efforts.
2	Habituation in Waste Management	Students' habits in managing waste effectively, including reduction, separation, recycling, and environmentally friendly disposal.
3	Habituation in Energy Use	Students' habits in using energy efficiently, including reducing energy consumption, switching to renewable energy, and optimizing electricity use in schools.
4	Habituation in Water Conservation and Management	Students' habits in conserving water include reducing water wastage, utilizing rainwater, and using water-saving technologies.
5	Habituation in Soil Management and Prevention of Chemical Contamination	Students' habits in understanding and applying proper soil management and preventing chemical contamination
6	Habituation in Being Sensitive to School Facilities and Infrastructure	Students' awareness of and care for environmentally friendly school facilities and infrastructure, including cleanliness and long-term sustainability.
7	Habituation in Orderliness and Environmental Sustainability Around the School	Students' habits include maintaining orderliness and cleanliness around the school environment.
8	Habituation in Campaigning for Environmental Sustainability	Students' involvement in supporting and promoting environmental sustainability campaigns.

Adapted from Wals, (2015).

Problem Analysis Phase

In this problem analysis phase, the achievement level of the Environmentally-Based Curriculum was identified for fifth-grade students across five elementary schools. The results of this analysis will serve as the foundation for the subsequent development stages. The findings regarding the curriculum achievements in environmental education across the five schools are presented in Figure 2 below.

The graph in Figure 2. illustrates variations in the achievement levels of the environmentally based curriculum indicators across five elementary schools. Indicators with high achievement percentages, such as students' activities in building environmental awareness and environmental activities, indicated that these schools had integrated environmental values into certain aspects of education. Furthermore, indicators like promotion criteria and environmental programs reflected in the school's vision and mission revealed gaps between school policies and the practical implementation of environmental education. These results highlighted the need for a more structured, environmentally based curriculum directly connected to classroom learning to foster students' environmental awareness and eco-friendly behavior more effectively.

Design and Developing Phase

The design and developing phase focused on creating a green curriculum integration model that embedded environmental issues and responsibilities into science learning to enhance students' environmental awareness and foster eco-friendly behaviors. The core structure of this model is visually represented in Figure 3, illustrating how the curriculum components and learning activities align to achieve the intended educational goals.

Figure 2.
Graph of the Achievement Levels of the Environmentally-Based Curriculum

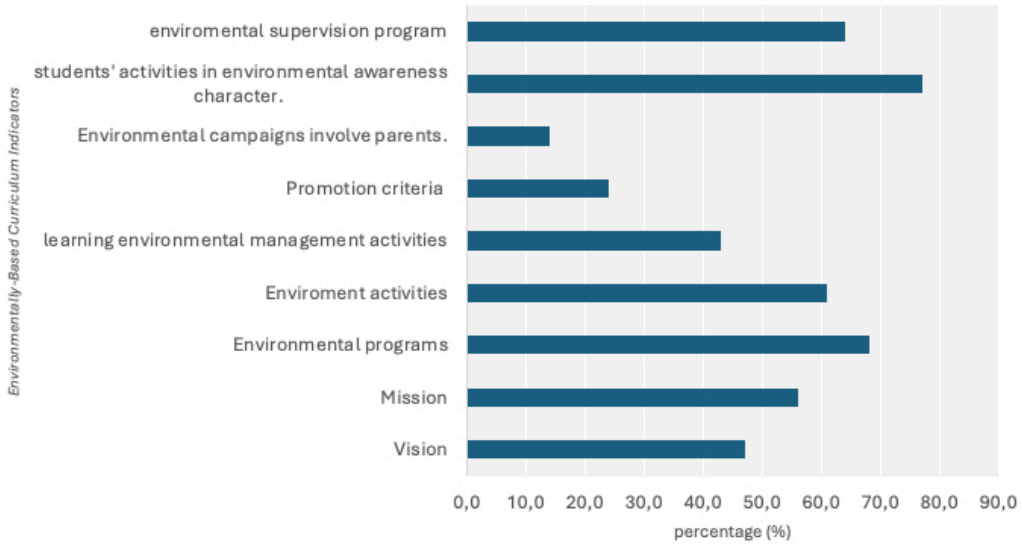
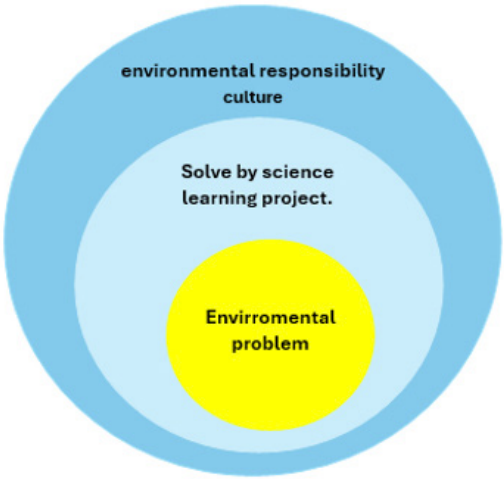


Figure 3.
Illustration of The Integration Green Curriculum in Science Learning.



The most appropriate integrated model is inserting green curriculum aspects in the form of environmental problems and responsibilities in science learning in the classroom. Students solved environmental issues through science learning projects. Meanwhile, the habit of environmental responsibility is formed at the beginning of the learning process, such as responsibility for plants or animals that need to be cared for. Integrating responsibility and projects to resolve environmental problems with repeated reinforcement learning fostered awareness of the environment and eco-friendly culture. This can be explained in the learning syntax in Table 7.

Integrating a green curriculum into science education significantly transforms the learning experience by fostering a deeper connection between students and their natural surroundings. These outdoor experiences are carefully designed to align with and reinforce the science concepts covered in the classroom. For example, while learning about photosynthesis, students might cultivate a garden, observing firsthand how plants grow and respond to different environmental conditions (see Figure 4). In addition to these immediate educational benefits, students are assigned projects focusing on environmental preservation. These projects require them to devise and implement strategies for conserving local ecosystems, including planting trees, creating habitats for pollinators, or organising clean-up drives. To amplify the impact of their work, students also engage in environmental campaigns, using various media to raise awareness about ecological issues and promote sustainable practices within their community.

Figure 4.

Documentation of Students Engaging in Outdoor Experiences During Science Lessons with The Integration of The Green Curriculum

Through these initiatives, students learn about ecosystems theoretically and develop a profound appreciation for the complexity and fragility of the natural world. They are taught the importance of biodiversity and the interdependence of different species, including humans. This holistic educational approach instils in them a sense of stewardship and a commitment to environmental sustainability that they carry into adulthood. Ultimately, integrating a green curriculum into science education in elementary schools will produce environmentally conscious individuals with the knowledge, skills, and values necessary to contribute positively to preserving and enhancing their local and global environments.

Results of The Quasi-Experimental Study

A more in-depth evaluation was subsequently conducted as part of a quasi-experimental test during the implementation phase following the development

Table 7.

Learning Activity Process of Integration Green Curriculum and Science Education.

Learning Activity	Student activities	Teacher activity
Animal or plant care activities	Students manage plants and animals, which is their responsibility, from seedlings to harvest.	Teachers help students get into the habit of managing the plants and animals they are responsible for, from seed to harvest
Explore environmental problems with questions	Students observe environmental problems they encounter by asking questions	The teacher facilitates students in finding questions about environmental problems.
Product design by watching video.	Students watch videos on YouTube uploaded by the teacher regarding the steps for working on the project	The teacher demonstrates the steps for working on the project directly or uploads a video via YouTube
Create a schedule.	Students determine the project implementation schedule as a group	The teacher facilitates students in preparing project implementation schedules in groups
Implement the plan with group	Students work on projects in groups	The teacher facilitates student activities in the project stages and ensures that all group members are involved in project implementation activities
Implement plate independently.	Students implement the project stages in groups	Teachers support students in activities independently
Monitor of the project	Students observe the progress of the project implementation from the potential to the obstacles encountered	The teacher facilitates students in project activities and provides direction to resolve the obstacles encountered
Integrating materials with project activities with presentations	Students relate the projects they are working on to the environmental problems that they have encountered	The teacher facilitates students with several questions related to the relevance of learning material to environmental problems and the projects that they are working on
Campaign to friends about being environmentally friendly	Students campaign for activities related to environmental management	Teachers encourage students to tell or teach their learning experiences to friends or family.

of the green curriculum integration in science learning. This step analyzed environmental awareness and eco-friendly aspects based on specific indicators. Based on the measurements of environmental awareness and eco-friendly behavior conducted after implementing the green curriculum integration in the experimental science class and problem-based learning without green curriculum integration in the control class, it was found that the experimental class had a higher average score compared to the control class. The descriptive analysis of these two variables is presented in Figures 5 and 6.

The graph indicates that the environmental awareness scores of students in the experimental class are significantly higher than those in the control class despite the average score differences for each indicator ranging from 10 to 20 points. This trend is also evident in the environmental concern scores assessed through observer evaluations. As depicted in Figure 6. below, the results further substantiate these findings.

The results of the quasi-experimental test showed that environmental awareness and eco-friendly cultural value increased in the control and experimental

Figure 5.
Graphic Result of Environmental Awareness Value.

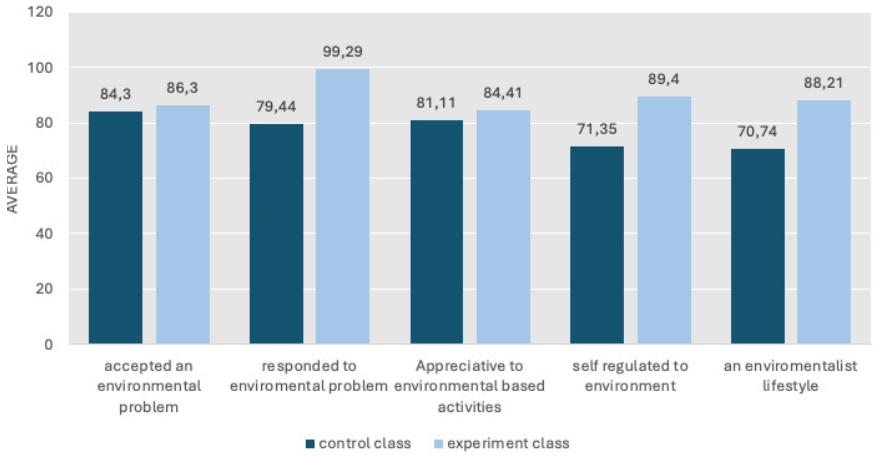
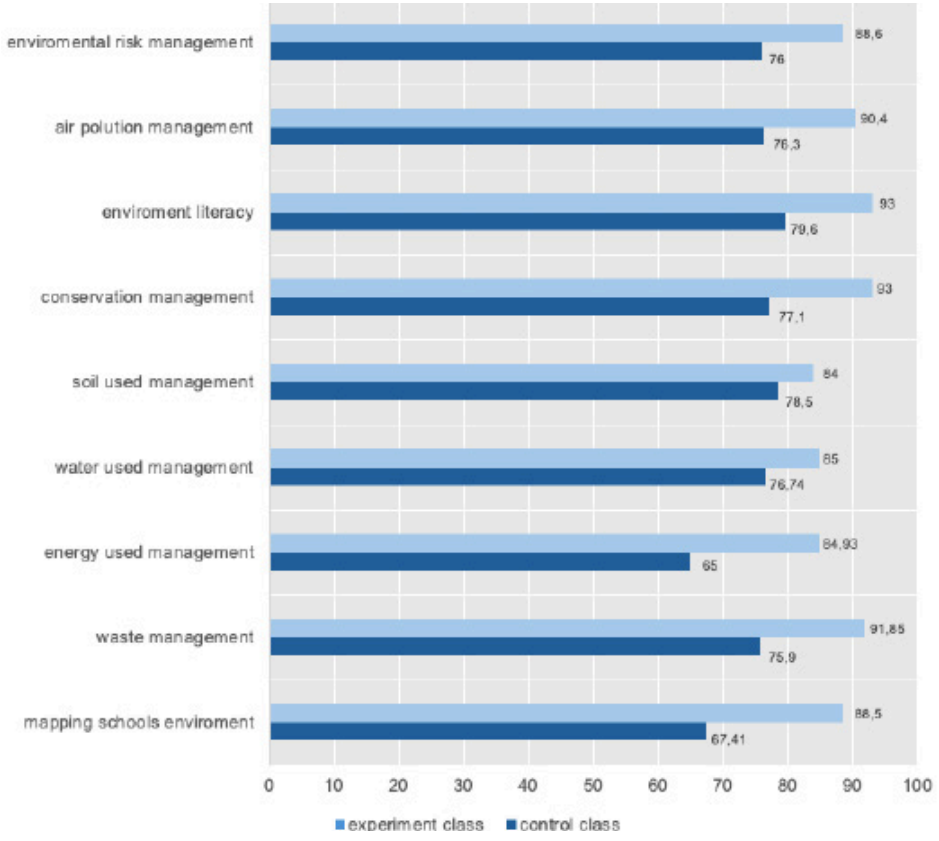


Figure 6.
Graphic of Eco-Friendly Culture Value.



classes. The average difference in the eco-friendly culture score was 12.3-23.6 points higher than in the control class (see Figures 5 & 6). Upon analyzing the overall averages of both the environmental awareness and eco-friendly culture values, the results are comprehensively summarised in Table 8 below. These findings provide a clear comparison between the experimental and control groups, highlighting the effectiveness of the implemented intervention in fostering environmental awareness and promoting an eco-friendly culture among students.

Table 8.
Average Scores of Environmental Awareness and Eco-Friendly Culture

Class	Scores with Green Curriculum (Experimental Class)		Scores with Non-Green Curriculum (Control Class)	
	EA	EFC	EA	EFC
	87,69	88,45	77.93	79.15

EA (environmental awareness), EFC (Eco-Friendly culture)

These results were then tested for inferential statistics using the different *t*-tests to analyze the differences in the values of the two aspects in the control and experimental classes. (see Table 9).

Table 9.
T-test Result of Environmental Awareness and Eco-Friendly Culture.

No.	Aspect	Sign. (2-tailed)	Mean different.
1.	Environmental awareness	0.000	9.3
2.	Eco-friendly culture	0.000	8.7

The hypothesis test results confirm that there is an effect on increasing students' environmental awareness and environmentally friendly culture after the learning process. Based on the data analysis, it was found that the significance was $p = 0.000 \leq \alpha$ (0.05). Learning success can be seen from the corrected mean difference between the experimental and control classes. The corrected mean value for the experimental class is greater than that of the control class. The growth and development of an environmentally friendly culture are due to integrating the green curriculum in science learning with repeated reinforcement. These results prove that integrating the green curriculum model in science learning effectively implements environmental education.

The results of these quantitative measurements are consistent and supported by evidence based on observations of an environmentally friendly culture. It was found that children understand science concepts inductively. They know how the ecosystem concepts around them are formed from specific observations or experiences in their surrounding environment during learning. This is evidenced by the findings of students' questions about science concepts during vegetable cultivation activities at the beginning of the learning process. After the lesson, students consistently ensure that the classroom is in optimal condition. This includes turning off unnecessary lights when the room is adequately lit, opening windows for proper ventilation, unplugging unused electrical outlets, and maintaining a clean and comfortable learning environment. Integrating environmental awareness and consciousness into the science curriculum fosters these good habits, encouraging students to take responsibility for the sustainability of their environment. Through the green curriculum, this approach instills in students a lasting sense of stewardship and proactive behavior toward environmental conservation.

Discussions

This study has developed the integration of a green curriculum model in science learning, addressing key challenges identified during the problem analysis phase. The integration of this curriculum supports the simultaneous development of environmental awareness and an eco-friendly culture among students. By emphasizing direct, experiential learning, the model allowed students to develop competencies in exploring and understanding environmental concepts through hands-on activities (Komariah & Sa'ud, 2024; Ni et al., 2024). The integration process included clear objectives, tailored content and learning materials, and structured learning activities aligned with sustainable education goals (Aurélio et al., 2022; Dillon & Scott, 2002).

This study demonstrated that cultivating environmental awareness is most effectively achieved by assigning students responsibility for caring for animals or plants as part of their learning projects. This approach deepened students' connection with the environment and fostered attitudes of care and accountability, confirming findings from previous studies (Sadikin et al., 2024; Torre Gibney et al., 2017). While elementary students may possess foundational knowledge of environmental issues, the study underscored the need to translate such theoretical knowledge into actionable behaviors through direct, practical actions, a critical aspect of environmental education (Viteri & Pazmiño, 2023).

Furthermore, an eco-friendly culture emerged from environmental projects and campaigns embedded within the curriculum. These activities promoted collaboration, inquiry, and reflective practices, fostering environmental responsibility and ecological sensitivity (Daher, 2022; Shulla et al., 2020). Students also engaged in using environmentally friendly products, such as reusable water bottles and food containers, cultivating habits that foster sustainable practices into adulthood (Komariah & Sa'ud, 2024; Parker, 2018).

The findings that integrating a green curriculum in science education enhances students' environmental

awareness and eco-friendly culture align with studies by Torre Gibney et al., (2017) and Tuncer et al., (2007), which emphasises the importance of responsibility in shaping students' environmental attitudes. Gibney et al. found that a deep project-based learning approach encourages students to be more actively involved in environmental activities. At the same time, highlighted the importance of theoretical knowledge in building a solid understanding of environmental issues. Although both approaches are practical, they show differences in teaching methods and outcomes (Li et al., 2021).

Additionally, challenges such as economic constraints and resource limitations in Indonesia highlighted the need for community-based approaches and cost-effective strategies, as suggested by Parker et al., (2018; 2019a) tailored strategies, including culturally relevant and context-specific methods, were found to be essential for addressing these challenges and achieving sustainable outcomes (Bhandari & Abe, 2000; Lowan-Trudeau, 2023). These results provide a robust framework for integrating green curricula into science education, offering practical and theoretical insights for advancing environmental education in diverse socio-economic and cultural contexts. Moreover, limited institutional support can significantly hinder the success of such programs, particularly in developing countries like Indonesia (Parker & Prabawa-Sear, 2019a). Using environmentally friendly products in developing countries like Indonesia is very expensive. Buying some environmentally friendly products is more costly than regular products (Parker et al., 2018; Parker & Prabawa-Sear, 2019a). This causes environmental education to not only be invested in one or two specific periods, such as workshops or non-learning programs (Knamiller, 1983; Nomura et al., 2003). Modern industrial technology, the capitalist economic system, economic growth, and an affluent consumer society are determining aspects of the level of environmental awareness of citizens (Stevenson, 2007). This means that environmental education tends to have different effects in different countries.

The differences in implementing the green curriculum may be due to variations in access to learning materials, teacher training, and community participation (Bhandari & Abe, 2000; Parker & Prabawa-Sear, 2019a). Discussing these differences can provide further insights into how environmental education programs can be tailored to local needs. For example, more straightforward and community-based approaches may be more effective in countries with limited resources than methods requiring extensive resources. By understanding the specific contexts and challenges in each location, educators and policymakers can design more adaptive and responsive environmental education programs that better meet local needs, thereby achieving better outcomes in enhancing students' environmental awareness and eco-friendly behavior.

The implications of these findings for environmental education policy in Indonesia are significant. The government and education stakeholders must consider a more comprehensive integration of the green curriculum within the educational system. More incredible support is needed by providing resources, teacher training, and establishing policies that encourage using environmentally friendly products. Moreover, environmental education programs must be tailored to local conditions, considering existing economic and social challenges. Community-based approaches involving students and the community may offer practical solutions to overcome resource limitations and achieve better environmental education goals. Thus, environmental education policy in Indonesia can become more adaptive and sustainable and positively impact the enhancement of environmental awareness and eco-friendly behavior among students.

Limitation Of Study

This study identified several limitations that need further discussion. A key limitation is the lack of specialized teacher training, which may have impacted the quality of instruction and students' comprehension of the green curriculum. Additionally, demographic factors such as socio-economic status, culture, and geographic location created variability in student participation. Economic barriers limited resource access for disadvantaged students, while geographic and cultural differences affected engagement with project-based activities.

To address these issues, the study proposed strategies such as cost-effective projects utilizing local resources, adaptable activities for diverse settings, and culturally relevant content. Engaging parents and communities and offering targeted support for underserved students were also emphasized to enhance participation. Future research should explore these approaches further, focusing on teacher training, community involvement, and longitudinal studies to evaluate the curriculum's long-term impact across varied contexts.

Conclusions

The integration of a green curriculum into elementary science education demonstrated its effectiveness in enhancing students' environmental awareness and fostering an eco-friendly culture. This study employed the ADDIE model to systematically design, develop, and implement a green curriculum that incorporated environmental issues and responsibilities into science learning. The findings from the quasi-experimental test revealed a significant improvement in environmental awareness and eco-friendly cultural

values among students in the experimental group compared to those in the control group. These results indicated that integrating project-based activities, cultivating responsibility, and reinforcing environmental behaviors effectively nurtured sustainable practices. This study highlighted the importance of embedding environmental education into core curricula to promote sustainable behaviors and ecological responsibility from an early age. Future research should focus on scaling this model across diverse socio-economic and cultural contexts and exploring its long-term impacts on students' environmental stewardship. The integration of a green curriculum provided a promising framework for achieving sustainable education goals, particularly in developing regions.

Reference

Aningsih, Zulela, M. S., Neolaka, A., Iasha, V., & Setiawan, B. (2022). How is the Education Character Implemented? The Case Study in Indonesian Elementary School. *Journal of Educational and Social Research*, *12*(1), 371–380. https://doi.org/10.36941/jesr-2022-0029

Ardoin, N. M., & Bowers, A. W. (2020). Early childhood environmental education: A systematic review of the research literature. *Educational Research Review*, *31*, 100353. https://doi.org/https://doi.org/10.1016/j.edurev.2020.100353

Aurélio, L., Sequeira, V., França, S., Amoroso, S., Boaventura, D., Cardoso, I., Amorim, A., & Cabral, H. N. (2022). Bridging the gap between formal and non-formal science education: traditional fish markets as a tool to promote ocean literacy. *Applied Environmental Education & Communication*, *21*(3), 238–253. https://doi.org/10.1080/1533015X.2022.2043207

Bhandari, B., & Abe, O. (2000). *Enviromental education in asia pasific region: some problems and prospect*. *1*(1), 57–77.

Bootrach, P., Thiengkamol, N., & Thiengkamol, T. K. (2015). Environmental Education Strategy. *Applied Environmental Education & Communication*, *14*(4), 200–212. https://doi.org/10.1080/1533015X.2015.1096223

Bradley, K. (2009). Planning for eco-friendly living in diverse societies. *Local Environment*, *14*(4), 347–363. https://doi.org/10.1080/13549830902764738

Branch, R. M. (2009). *Instructional Design The ADDIE Approach*. Springer.

Corpuz, A. M. (2022). *Integration of Environmental Education (Ee) in Teacher Education Programs : Toward*. *7864*(Cc).

Daher, W. (2022). Elementary school students' perceptions of democratic practices in the project-based science classroom. *International Journal of Mathematical Education in Science and Technology*, 1–16. https://doi.org/10.1080/0020739X.2022.2039793

Desfandi M., Maryani E., & Disman. (2019). Implementation Of Adiwiyata Program In The Effort To Create Environmental Cultured School In Banda Aceh. *Sumatra Journal of Disaster, Geography and Geography Education*, *3*(2), 1–8. https://doi.org/10.24036/sjdgge.v3i2.205

Dillon, J., & Scott, W. (2002). Perspectives on environmental education-related research in science education. *International Journal of Science Education*, *24*(11), 1111–1117. https://doi.org/10.1080/09500690210137737

Errica, L., & Mulyadi, B. (2022). Differences in Environmental Education at the Elementary School Level in Japan and Indonesia. *E3S Web of Conferences*, *359*. https://doi.org/10.1051/e3sconf/202235902007

Fekih Zguir, M., Dubis, S., & Koç, M. (2021). Embedding Education for Sustainable Development (ESD) and SDGs values in curriculum: A comparative review on Qatar, Singapore and New Zealand. *Journal of Cleaner Production*, *319*, 128534. https://doi.org/https://doi.org/10.1016/j.jclepro.2021.128534

Forestry, I. M. of E. and. (2006). *Adiwiyata*. Adiwiyata Schools.

Gavilan Tatin, I. A., Triyono, S., Jacobs, G. M., Trett, S., Soeta Bangsa, A. A., & Zhu, C. (2024). An Analysis of Environmental Education in Indonesian EFL Elementary School Textbooks. *International Journal of Education and Literacy Studies*, *12*(3), 3–16. https://doi.org/10.7575/aiac.ijels.v.12n.3p.3

Gobena, A. E., & Kant, S. (2022). Assessing the Effect of Endogenous Culture, Local Resources, Eco-Friendly Environment and Modern Strategy Development on Entrepreneurial Development. *Journal of Entrepreneurship, Management, and Innovation*, *4*(1), 118–135. https://doi.org/10.52633/jemi.v4i1.153

Gunansyah, G., Zuhdi, U., Suprayitno, S., & Aisy, M. R. (2021). Sustainable development education practices in elementary schools. *Journal of Education and Learning (EduLearn)*, *15*(2), 178–187. https://doi.org/10.11591/edulearn.v15i2.17091

Ha, J. W., Jeon, E.-C., & Park, S. K. (2023). Status of environmental awareness and participation in Seoul, Korea and factors that motivate a green lifestyle to mitigate climate change. *Current Research in Environmental Sustainability*, *5*, 100211. https://doi.org/https://doi.org/10.1016/j.crsust.2023.100211

Hernández-Pérez, M., Pérez-Sirvent, C., Martínez Sánchez, M. J., & Jordán González, E. (2023). Visualizing climate change through LIFE-AMDRYC4: a VR mobile-based video game to educate adult audiences on sustainable agricultural practices. *Applied Environmental Education and Communication*, *22*(2), 91–106. https://doi.org/10.1080/1533015X.2023.2236623

Husamah, H., Suwono, H., Nur, H., & Dharmawan, A. (2022). Environmental education research in Indonesian Scopus indexed journal: A systematic literature review. *JPBI (Jurnal Pendidikan Biologi Indonesia)*, *8*(2), 105–120. https://doi.org/10.22219/jpbi.v8i2.21041

Jorgenson, S. N., Stephens, J. C., & White, B. (2019). Environmental education in transition: A critical review of recent research on climate change and energy education. *Journal of Environmental Education*, *50*(3), 160–171. https://doi.org/10.1080/00958964.2019.1604478

Knamiller, G. (1983). Environmental education for relevance in developing countries. *The Environmentalist*, *3*(3), 173–179. https://doi.org/10.1007/BF02240106

Komariah, M., & Sa'ud, U. S. (2024). *Integration Education for Sustainable Development (ESD) into the Learning Process in Elementary School: A Systematic Literature Review BT - New Technology in Education and Training* (J.-C. Hong (ed.); pp. 217–229). Springer Nature Singapore.

Kudlas, J. (1984). Environmental Awareness. *Journal of Physical Education, Recreation & Dance*, *55*(4), 10–14. https://doi.org/10.1080/07303084.1984.10629714

Kumar, K. ., Nabhan Almaawali , Z. M. ., Sulaiman Alomrani, N. M. . ., & Sharma, K. C. . (2023). Framework for implementation of sustainable Green Information Technology in library digitalization. *Journal of Energy Engineering and Thermodynamics*, *3*(01), 31–37. https://doi.org/10.55529/jeet.31.31.37

Li, C. J., Monroe, M. C., Oxarart, A., & Ritchie, T. (2021). Building teachers' self-efficacy in teaching about climate change through educative curriculum and professional development. *Applied Environmental Education and Communication*, *20*(1), 34–48. https://doi.org/10.1080/1533015X.2019.1617806

Louw, W. (2013). Green curriculum : Sustainable learning at a higher education institution. *International Review of Research in Open and Distance Learning*, *14*(1), 1–15. https://doi.org/10.19173/irrodl.v14i1.1310

Lowan-Trudeau, G. (2023). Digital technologies and environmental education. *The Journal of Environmental Education*, *54*(1), 1–7. https://doi.org/10.1080/00958964.2022.2152413

Masalimova, A. R., Krokhina, J. A., Sokolova, N. L., Melnik, M. V., Kutepova, O. S., & Duran, M. (2023). Trends in environmental education: A systematic review. *Eurasia Journal of Mathematics, Science and Technology Education*, *19*(2). https://doi.org/10.29333/ejmste/12952

Moody-Marshall, R. (2023). An investigation of environmental awareness and practice among a sample of undergraduate students in Belize. *Environmental Education Research*, *29*(7), 911–928. https://doi.org/10.1080/13504622.2022.2079613

Nation, M. T., & Feldman, A. (2021). Environmental Education in the Secondary Science Classroom: How Teachers' Beliefs Influence Their Instruction of Climate Change. *Journal of Science Teacher Education*, *32*(5), 481–499. https://doi.org/10.1080/1046560X.2020.1854968

Ni, L., Fayaz Ahmad, S., Alsanie, G., Lan, N., Irshad, M., Bin Saeed, R. H., Bani Ahmad, A., & Khan, Y. (2024). Investigating the role of green curriculum in shaping pro-environmental behaviors and environmental values orientation for sustainability. *International Journal of Sustainability in Higher Education*, 1537–1557. https://doi.org/10.1108/IJSHE-05-2023-0207

Nomura, K., Hendarti, L., & Abe, O. (2003). NGO Environmental Education Centers in Developing Countries: Role, Significance and Keys to Success, from a "Change Agent" Perspective. *International Review for Environmental Strategies*, *4*(2), 165–182.

Nurkaidah, Anas, A., & Baharuddin, T. (2024). Implementation of environmental policies on the development of a new capital city in Indonesia. *Cogent Social Sciences*, *10*(1), 2297764. https://doi.org/10.1080/23311886.2023.2297764

Olsen, E. K., Lawson, D. F., McClain, L. R., & Plummer, J. D. (2024). Heads, hearts, and hands: a systematic review of empirical studies about eco/climate anxiety and environmental education. *Environmental Education Research*, *0*(0), 1–28. https://doi.org/10.1080/13504622.2024.2315572

Özden, M. (2008). Environmental awareness and attitudes of student teachers: An empirical research. *International Research in Geographical and Environmental Education*, *17*(1), 40–55. https://doi.org/10.2167/irgee227.0

Parker, L. (2018). Environmentalism and education for sustainability in Indonesia. *Indonesia and the Malay World*, *46*(136), 235–240. https://doi.org/10.1080/13639811.2018.1519994

Parker, L., & Prabawa-Sear, K. (2019a). Enviromental Education in Indonesia. In *Environmental Education in Indonesia*. https://doi.org/10.4324/9780429397981-4

Parker, L., & Prabawa-Sear, K. (2019b). Environmental education in Indonesia: Creating responsible citizens in the global South? In *Environmental Education in Indonesia: Creating Responsible Citizens in the Global South?* (Issue September). https://doi.org/10.4324/9780429397981

Parker, L., Prabawa-Sear, K., & Kustiningsih, W. (2018). How Young People in Indonesia see themselves as Environmentalists. *Indonesia and the Malay World*, *46*(136), 263–282. https://doi.org/10.1080/13639811.2018.1496630

Prabawani, B., & Hanika, I. M. (2017). Primary schools eco-friendly education in the frame of education for sustainable development. *International Journal of Environmental and Science Education*, *12*(4), 607–616.

Rindawati, Sulistinah, & Widodo, B. S. (2020). *Elementary School Students Understanding of Environmental Concepts in the City of Surabaya*. *473*(Icss), 304–308. https://doi.org/10.2991/assehr.k.201014.065

Sadikin, D. N., Athiyyah, L. A., Purnomo, W. D., Restyalino, I. L., & Alpian, Y. (2024). Analisis perilaku Peduli Lingkungan pada Siswa Sekolah Dasar. *Jurnal Pendidikan Tambusai*, *8*(1), 2885–2890.

Şahin, E. (2008). *an Examination of Indications for a Green Curriculum* (Issue November). The Graduate School of Natural And Applied Sciences 0f Middle East Technical University.

Shulla, K., Filho, W. L., Lardjane, S., Sommer, J. H., & Borgemeister, C. (2020). Sustainable development education in the context of the 2030 Agenda for sustainable development. *International Journal of Sustainable Development and World Ecology*, *27*(5), 458–468. https://doi.org/10.1080/13504509.2020.1721378

Sterling, S. (2024). Transformative Learning and Sustainability: *Learning and Sustainability in Dangerous Times*, *January 2011*, 149–162. https://doi.org/10.2307/jj.1347649.14

Stevenson, R. B. (2007). Schooling and environmental education: contradictions in purpose and practice. *Environmental Education Research*, *13*(2), 139–153. https://doi.org/10.1080/13504620701295726

Syahrial, S., Asrial, A., Sabil, H., & Arsil, A. (2020). Effectiveness of Adiwiyata in the Character of Caring. *Humanities & Social Sciences Reviews*, *8*(2), 109–115.

Tompodung, T. C. G., Rushayati, S. B., & Aidi, M. N. (2018). Efektivitas Program Adiwiyata Terhadap Perilaku Ramah Lingkungan Warga Sekolah Di Kota Depok. *Jurnal Pengelolaan Sumberdaya Alam Dan Lingkungan (Journal of Natural Resources and Environmental Management)*, *8*(2), 170–177. https://doi.org/10.29244/jpsl.8.2.170-177

Torre Gibney, D., Preston, C., Drake, T. A., Goldring, E., & Cannata, M. (2017). Bringing Student Responsibility to Life: Avenues to Personalizing High Schools for Student Success. *Journal of Education for Students Placed at Risk*, *22*(3), 129–145. https://doi.org/10.1080/10824669.2017.1337518

Tuncer, G., Sungur, S., Tekkaya, C., & Ertepinar, H. (2007). A comparative study on pre-service teachers' and elementary students' attitudes towards the environment. *International Research in Geographical and Environmental Education*, *16*(2), 188–198. https://doi.org/10.2167/irgee217.0

Ullman, E., Rowe, D., & Eisenberg, L. (2008). Eco-friendly education. *Community College Journal*, *79*(2), 14.

Viteri, F., & Pazmiño, M. (2023). Climate change curriculum for children–generative learning across multiple intelligences. *Applied Environmental Education and Communication*, *0*(0), 1–14. https://doi.org/10.1080/1533015X.2023.2282462

Wals, A. E. J. (2015). Beyond unreasonable doubt. Education and learning for socio-ecological sustainability in the anthropocene. In *Wagening University* (Issue December). https://library.wur.nl/WebQuery/wurpubs/fulltext/365312

Yu, T.-Y., & Yu, T.-K. (2017). The Moderating Effects of Students' Personality Traits on Pro-Environmental Behavioral Intentions in Response to Climate Change. *International Journal of Environmental Research and Public Health, 14*(12), 1472. https://doi.org/https://doi.org/10.3390/ijerph14121472

Appendix 1

Self-Assessment Quisioner of Environmental Awareness.

No.	Statements for self-assessment of environmental awareness	Indicators
1	I will follow the rules about maintaining the school environment.	Receiving
2	I am happy to come to school early because I can see the clean and green school.	Receiving
3	I wouldn't say I like participating in school cleaning activities because it is tiring to follow the exercises.	Responding
4	I enjoy studying at this school because of the green school program, which makes the school beautiful and comfortable.	Valuing
5	I do not need to conserve water because there is plenty of it.	Characterization
6	Wastewater from the school bathrooms needs to be treated with clean water.	Receiving
7	I will turn on the lights during the day even though the classroom is well-lit because it is a school facility.	Characterization
8	If there are many leaves scattered around the house, I will make compost to clean the yard.	Responding
9	I enjoy seeing the plants at school.	Receiving
10	I will burn the scattered trash so it doesn't dirty the school environment.	Characterization
11	I will ignore friends who litter.	Characterization
12	I will invite my brother, mother, and father at home to make hand sanitizer and soap from plants.	Valuing
13	I enjoy participating in communal work with my siblings, father, and mother to clean the village.	Responding
14	If I become a class leader, I will invite my friends to play rather than invite them to clean and take care of the school environment.	Organization
15	I don't care if my friends brush their teeth after lunch because it's not my teeth that will decay.	Characterization
16	I will use bombs to catch fish to get more fish.	Characterization
17	I prefer using air conditioning over utilizing natural ventilation.	Characterization
18	I feel sad when I see people littering.	Receiving
19	I will continue to plant vegetables and raise animals to prevent extinction.	Valuing
20	I enjoy sorting trash by separating paper, plastic, hazardous waste, organic, and residue.	Responding

Appendix 2

Self-Assessment Quisioner of Eco-friendly Culture.

No.	Statements for self-assessment of eco-friendly culture	Indicators
1	I am used to identifying natural resources in the school environment.	Habituation in Mapping the Potential and Condition of the Environment
2	I can recognize environmental issues around me.	
3	I participate in mapping environmental potentials to support conservation efforts.	
4	I separate waste based on its type (organic, plastic, residual).	Habituation in Waste Management
5	I take part in recycling activities at school or home.	
6	I reduce the use of disposable items to minimize waste.	
7	I always turn off lights and electronic devices when not in use.	Habituation in Energy Use
8	I support the use of renewable energy at school (e.g., solar panels).	
9	I prefer using natural ventilation over air conditioning.	
10	I save water by turning off the tap when not in use.	Habituation in Water Conservation and Management
11	I utilize rainwater for certain activities, such as watering plants.	
12	I support the use of water-saving technologies in school.	
13	I avoid excessive use of chemical fertilizers in farming or gardening activities.	Habituation in Soil Management and Prevention of Chemical Contamination
14	I use organic waste to create compost.	
15	I support reforestation efforts to prevent soil erosion.	
16	I keep school facilities such as classrooms, toilets, and gardens clean.	Habituation in Being Sensitive to School Facilities and Infrastructure
17	I report any damage to school facilities so they can be fixed promptly.	
18	I support the provision of environmentally friendly facilities in schools	
19	I regularly clean the school surroundings to maintain tidiness.	Habituation in Orderliness and Environmental Sustainability Around the School
20	I always dispose of trash in the designated bins.	
21	I support school programs focused on environmental preservation.	
22	I actively participate in campaigns to raise environmental awareness.	Habituation in Campaigning for Environmental Sustainability
23	I encourage my friends to keep the school environment clean and beautiful.	
24	I help spread information about the importance of environmental preservation through social media or posters.	