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Development and Psychometric Validation of the Soft Skills Scale for Teachers (SSS-T)

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Abstract

Soft skills support individuals emotionally, cognitively, and behaviorally. Teachers are one of the professional groups whose soft skill levels are expected to develop. This is because teachers not only improve their own soft skills but also help the development of soft skills among students. To this end, we aimed to develop a valid and reliable scale to assess teachers' soft skills. The validity and reliability of the Soft Skills Scale for Teachers were established through four separate studies. In Study I, EFA revealed that the scale consists of thirty-seven items and five factors (n = 402). Study II, through CFA, demonstrated that the scale's fit indices indicate a good fit (n = 248). In Study III, Cronbach's alpha was calculated as .91 and CR was calculated as .92; convergent validity results indicate moderate correlations (n = 122). Finally, Study IV involved a test-retest procedure, and the results indicated that the first and second administrations were highly correlated and found no significant differences between two administrations (n = 57). Collectively, these findings ensure that the scale is a valid and reliable scale for measuring the soft skills of teachers. The Soft Skills Scale for Teachers is highly important because identifying and developing the soft skills of teachers is not only an educational necessity but also a social need. Additionally, the Soft Skills Scale for Teachers offers benefits for groups such as educational institutions, educational policymakers, and teacher training institutions, which are crucial for fostering teaching quality and ensuring students' soft skills development.

Keywords:

Soft Skills, Teachers, Psychometric Properties

Introduction

Education plays an important role in raising individuals who are equipped, knowledgeable, and skilled to meet the needs of countries. Therefore, our expectations from education in the current era have changed compared to previous centuries. The search for an individual who can get high grades or make good calculations, both in professional and personal life (Rani et al., 2010), has been replaced by the search for an individual who can solve problems in business life, work independently, and take social responsibility and initiative. This is because these skills contribute to the development of innovation and

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economic performance capacity (Hendarman & Cantner, 2017; Martino & Bartolone, 2011). In other words, they increase productivity at work. These developments in the business world have contributed to setting new standards for teacher qualifications at the international level (Espina-Romero et al., 2023). In the twenty-first century, teachers are expected not only to possess technical knowledge and skills but also to foster the development of students' non-cognitive competencies such as communication, empathy, and collaboration (Tuomi, 2022; van Werven et al., 2021). This expectation highlights the importance of teachers' soft skills in supporting students' holistic development.

Soft skills are multidimensional skills encompassing individuals' cognitive, social, emotional, and behavioral competencies, such as communication, conflict resolution, leadership, empathy, problem solving, collaboration, time management, flexibility, and ethical decision-making (Heckman & Kautz, 2012). These skills are understood to contribute to individuals' effective and productive functioning in their professional and social lives.

In the educational context, soft skills are viewed as learning outcomes that support students' interpersonal skills, emotional control, and cognitive skills. For teachers, soft skills encompass the competencies of empathic communication in classroom management, creating a positive learning climate, and supporting students' social-emotional development (Jennings & Greenberg, 2009; İnce et al., 2025). Therefore, soft skills are considered a fundamental component of effective teaching and learning in education. Soft skills support individuals emotionally, cognitively, and behaviorally (Melser, 2019). While an individual's development of soft skills is a personal situation, the role of the individuals with whom he/she interacts at the soft skill level is a social situation. In this context, the teacher, who guides his students on a new path to social life, is one of the professional groups whose soft skill level is expected to develop (Shawer, 2017). Teachers who have developed soft skills can help the development of soft skills in students as well (Ju et al., 2025). Teachers are responsible for encouraging positive peer relationships among children, providing different learning experiences, and leading students (Moussaoui et al., 2025; Snoek et al., 2019). An effective teacher fulfills this responsibility by being a model for his students. It is possible for the teacher to be a model for the students by first developing awareness of his/her own soft skills. The quality of teachers directly affects the education and training process (Fernandes et al., 2021). The qualifications of the teacher include ethics, morality, different knowledge structures, interpersonal communication, problem-solving and critical thinking skills, leadership qualities, emotional control, and skills to increase academic success. When teacher qualifications are evaluated from the perspective of Shulman's (1987) Pedagogical Content Knowledge theory, it becomes evident that an effective teacher must integrate subject matter knowledge with pedagogical awareness and professional ethics. According to Goleman's (1995) Emotional Intelligence theory, a teacher's ability to manage emotions and show empathy toward students positively influences the learning environment. When these qualities are considered within the framework of Leithwood and Jantzi's (2006) Transformational Leadership approach, it is understood that teachers are expected to transform students not only academically but also socially and emotionally. Furthermore, the OECD's (2021) report, Teachers as Knowledge Professionals, emphasizes that qualified teachers are professionals who integrate cognitive, emotional, and social competencies to prepare students for the future. Taken together, these theoretical frameworks suggest that teacher qualifications represent an effective integration of personal and professional competencies. Based on this information, we understand that the development of the teacher's soft skills has an impact not only on his relationship with children but also on his teaching performance.

The conceptual and methodological definition of soft skills for teachers makes it difficult to determine the level of soft skills (Fernández-Arias et al., 2021). In this context, it is understood that the focus should be on determining the soft skill level of teachers. The soft skills of teachers, who train all professional groups and contribute to the development of society, are not only an educational but also a social issue. Several cognitive ability tests and personality inventories are used to determine the soft skills of various professional groups (Raoelison et al., 2020). When the studies aiming to determine teachers' soft skill levels are examined, it is seen that there are numerous scales focusing on areas such as stress management (Cao et al., 2023; Chen et al., 2022), teachers' emotional support behaviors (Anthony and DiPerna, 2019; Frenzel et al., 2016; Granziera et al., 2022; Guo et al., 2025), emotion teaching skills (Çalık & Çapa-Aydın, 2022; Hong et al., 2016), social skills (Anthony et al., 2021; Gresham et al., 2010), emotion regulation (Heydarnejad et al., 2021), interpersonal skills (Zheng, 2022), social-emotional skills (Aldrup et al., 2020; Anthony et al., 2021; Sarısoy et al., 2021). These studies appear to focus on certain aspects of soft skills. Furthermore, there is a scale developed to assess teachers' soft skills specifically in the context of COVID-19 (Al-Sa'di et al., 2023), as well as a measurement tool designed in the form of a questionnaire (Pietro & Altomari, 2019). These studies, aimed at determining some dimensions of the soft skills of teachers, have paved the way for research on soft skills. Unlike previous studies that focused on limited dimensions of soft skills, the present study adopts a holistic approach by encompassing interpersonal relationships, problem-solving, and emotional control, as well as introducing cognitive skills and

multiculturalism, dimensions that have not been included in any prior soft skills scales. Considering the educational structure of soft skills, it can be said that current scales do not provide a holistic assessment of soft skills in teachers. In this research, unlike the scale explained above, a scale was developed to determine teachers' awareness of soft skills and their level of inclusion of these skills in practice. It is thought that determining the soft skill level of teachers will guide future studies in understanding the factors that play a role in the development of children's soft skills and in determining the source of soft skill problems experienced in schools.

The Current Study

Considering teachers' professional well-being levels, studies focus on concepts such as stress management, positive emotions, emotional regulation, resilience, teacher-student relations, and soft skills for students draw attention to the importance of soft skills. However, in studies examining teachers' opinions on teaching children's affective skills, it is understood that teachers' knowledge and skills in incorporating affective skills into the learning-teaching environment are limited (Lee & Lee, 2011). Teachers play an intermediary role among generations. Therefore, the development of teachers' soft skills plays an important role in sustainable education. Based on this information, the research aims to develop a valid and reliable scale to determine teachers' soft skill levels.

Teaching is a social action. The development of the teacher's soft skills contributes to the teacher's professional productivity (Junaidi & Rosadi, 2022). In this context, various studies have been conducted on teachers' soft skills at various levels, from preschool to higher education (Fernández-Arias et al., 2021; Lee & Lee, 2011). Although the soft skills needed by children and young people change at each age, this indicates that the experiences they have had since early childhood affect all their life processes. In this context, the study worked with a large group of participants, including preschool teachers, primary school teachers, secondary school, and high school branch teachers. Acquiring soft skills at an early age prepares children for life. This suggests that determining the soft skill level of teachers and providing awareness is important for the development of soft skills in children. This is because soft skills provide information about how people learn, think, and behave (Escolà-Gascón & Gallifa, 2022). While soft skills are an integral part of education in the twenty-first century, there are limited measurement tools that address soft skills in an educational context (Escolà-Gascón and Gallifa, 2022; Jardim et al., 2022; Phuti et al., 2023). The Soft Skills Scale for Teachers is the first constructed and validated scale in national and international literature to assess the soft skill level of teachers. For this reason, it is thought that this scale, which determines the soft skill level of teachers from different branches, will guide future research in understanding the characteristics of teachers that play a role in the development of soft skills in children and young people. Based on these, we aimed to develop a valid and reliable scale to measure teachers' soft skills. Due to this, our research question is as follows:

- Is the Soft Skills Scale for Teachers valid and reliable for measuring the soft skills level of teachers?

Method

In the development of the scale, the steps followed included defining the purpose and structure, writing the items, consulting expert opinions, conducting a pilot study, making revisions, and ensuring the validity and reliability of the scale (DeVellis, 2017). Therefore, the validity and reliability studies of the SSS-T consist of four phases. All the studies mentioned in this article adhered to scientific research and publication ethics, as approved by the Scientific Research Ethics Committee of Canakkale Onsekiz Mart University, with the decision dated 08.09.2023 and numbered 11/49.

Study I

In Study I, exploratory factor analysis (EFA) was conducted to explore the SSS-T's factor structure. In this study, the participants were administered the initial version of the scale consisting of 53 items.

Participants

Study I was conducted in the spring semester of the 2023-2024 academic year in Çanakkale.

The participants were determined using a convenience sampling technique. Teachers were contacted, informed about the purpose of the research, and invited to participate as volunteers by completing the scales. The data for the study were collected from a total of 23 schools, including two preschools (8.70%), 15 elementary schools (65.20 %), three middle schools (13.05 %), and three high schools (13.05 %). A total of 402 teachers participated in the research for EFA, consisting of 253 females (63.93%) and 149 males (37.06%). The teachers worked in pre-schools (n = 78, 19.40%), primary schools (n = 227, 56.46%), secondary schools (n = 54, 13.43%), and high schools (n = 43, 10.70%). They had professional seniority ranging from 1 to 37 years, with an average of 21.8 years.

Measures

Sociodemographic information

A personal information form was used to obtain information about the participants' gender, age, experience and school.

Soft Skills Scale-Teacher (SSS-T)

SSS-T was developed by this study. Firstly, the item pool was developed. Then, it was to ensure content validity.

Creating an Item Pool: Studies on creating an item pool first started with a literature review on the subject. As a result of the literature review 123 items aiming to measure teachers' soft skills were created. The items were written considering the interpersonal skills, cognitive skills, and emotional control dimensions of soft skills. The item pool development process was conducted once a week over six sessions, with each session lasting approximately two to three hours. At the end of the first three sessions, items that appeared to have similar characteristics were removed, reducing the number to eighty-five items. In the following three sessions, the items were reviewed again, with certain items being revised and others being completely removed. For example, the item "I set an example for my students in problem-solving" was revised to "I ensure that my students use their problem-solving skills in the face of problems." Thus, the scale item was expressed more clearly. The item "I organize activities where my students will learn to control their impulsive behavior" was completely removed from the item pool. Because there was a similar item measuring this feature, it was deleted. A consensus was reached by the research team on all fifty-nine items remaining in the item pool.

Content Validity: Expert opinion was sought to ensure the content validity of the scale. To this end, an expert opinion form was prepared for the scale, which consisted of fifty-nine items. The field experts were from the areas of Guidance and Psychological Counseling, Primary School Education, Curriculum and Instruction, and Measurement and Evaluation in Education, and they had conducted studies on teachers' affective skills. In line with the experts' feedback, ten items were revised to ensure their suitability, clarity, and comprehensibility for the target group. Six items on which the experts did not reach a consensus regarding their effectiveness in measuring teachers' soft skills were removed from the draft item pool before it was finalized. Then, the opinion of a Turkish language expert was sought to evaluate the scale in terms of meaning and clarity, and their feedback was taken into consideration. Finally, to ensure content validity, the final fifty-three-item version of the Soft Skills Scale for Teachers (SSS-T) was presented to five teachers who had similar characteristics to the target group, prior to the actual application. After these teachers stated that the items were clear and understandable, the scale was administered to the target group. The SSS-T is composed of 53 items, each of which is rated on a 5-point Likert-type scale ranging from "Strongly Disagree" (1) to "Strongly Agree" (5). No items are reverse scored. Higher scores indicate greater levels of soft skills.

Statistical Analysis

In scale development studies, the factor analysis technique is used to test the validity of the psychometric structure. The varimax rotation technique was conducted. Varimax rotation aims to ensure that each item has a high loading value on only one factor and to maintain independence between factors (Kaiser, 1958). Thus, in developing a valid and reliable scale, the factors are made meaningful, independent and easily interpretable. The fifty-three-item scale form in the item pool was administered to 402 teachers for the first-order exploratory factor analysis. The significance level for factor loadings was accepted as .40 (Field, 2013). Accordingly, Item 44, Item 12, and Item 20 had factor loadings below .40. In addition, Item 36, Item 53, Item 40, Item 5, Item 17, and Item 43 were cross-loading items. The difference between the factor loadings of cross-loading items should be greater than .1 (Çokluk, et al., 2012). Lastly, although the factor loadings of Item 49, Item 41, Item 24, Item 15, Item 39, Item 21, and Item 45 were above .40, the number of items in a factor they were included in was less than three. A meaningful factor should contain at least three items (Şencan, 2005). In this context, Items 5, 12, 15, 17, 20, 21, 24, 36, 39, 40, 41, 43, 44, 45, 49, and 53 were removed from the dataset and the analysis was repeated. Items that loaded on two factors simultaneously but had a difference in factor loadings greater than .1 were not excluded (Çokluk et al., 2012). Accordingly, after removing 16 items, exploratory factor analysis was conducted again with the remaining 37 items. Assumptions were checked before conducting exploratory factor analysis. The Kaiser-Meyer-Olkin (KMO) measure and the Bartlett test of sphericity confirmed sampling adequacy and factorability of the data. In addition, the dataset was examined for linearity, outliers, and multicollinearity, and all indices were found to be within acceptable limits (Tabachnick & Fidell, 2007). Then, a second-order factor analysis was performed to examine whether the first-order factors reflected an overarching soft skills construct. The Kaiser-Meyer Olkin (KMO) and Bartlett Sphericity (BTS) tests were applied to determine the suitability of the data set for factor analysis.

Results

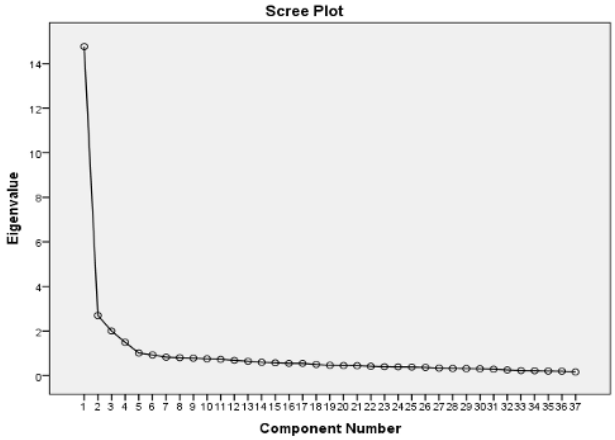
The KMO and BTS results for the second-order exploratory factor analysis are presented below. The KMO test findings are greater than .50, and the BTS is significant (χ^2 = 8349.800, *df* = 666, $p < .001$). These findings indicate that the data set is suitable for an exploratory factor analysis. Following the KMO and Bartlett tests, the eigenvalues and variances of the items were examined. The findings regarding the eigenvalue statistics are shown in Table 1.

Table 1.
The Eigenvalue Statistics and Explained Variance

		Initial Eigenvalues		Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	14.76	39.90	39.90	14.76	39.90	39.90	7.05	19.05	19.05
2	2.69	7.29	47.19	2.69	7.29	47.19	6.16	16.66	35.71
3	2.00	5.41	52.61	2.00	5.41	52.61	4.47	12.08	47.80
4	1.49	4.03	56.64	1.49	4.03	56.64	2.16	5.86	53.66
5	1.00	2.72	59.37	1.00	2.72	59.37	2.11	5.70	59.37
6	.92	2.51	61.88						
7	.82	2.23	64.11						
8	.80	2.17	66.29						
9	.78	2.11	68.40						
10	.75	2.03	70.43						
11	.72	1.96	72.40						
12	.68	1.84	74.24						
13	.64	1.74	75.99						
14	.59	1.60	77.59						
15	.57	1.54	79.14						
16	.54	1.47	80.62						
17	.54	1.47	82.09						
18	.50	1.35	83.45						
19	.46	1.24	84.70						
20	.44	1.21	85.91						
21	.44	1.19	87.10						
22	.41	1.12	88.22						
23	.39	1.07	89.30						
24	.39	1.05	90.35						
25	.38	1.03	91.39						
26	.36	.99	92.38						
27	.33	.90	93.29						
28	.31	.86	94.16						
29	.31	.84	95.00						
30	.30	.82	95.83						
31	.28	.77	96.60						
32	.25	.68	97.28						
33	.22	.61	97.89						
34	.21	.58	98.48						
35	.20	.55	99.03						
36	.19	.53	99.56						
37	.16	.43	100.00						

After the second-order exploratory factor analysis, there are thirty-seven items with eigenvalues greater than 1 and a structure with five factors. Accordingly, the first factor explains 19.05% of the total variance, the second factor explains 35.71%, the third factor explains 47.80%, the fourth factor explains 53.66% and the fifth factor explains 59.37%. Researchers can also use Scree plot graphs to determine the number of factors. A Scree Plot Graph is as shown in Figure 1.

Figure 1.
A Scree Plot Graph



As seen in Figure 1, the breaking point is between 4 and 5. In this context, it is evident that the eigenvalue statistics and the scree plot graph statistics overlap in determining the number of factors. Finally, the factor loadings of the items were examined in the study (Table 2). For this purpose, the Principal Component Analysis (PCA) method was used in the EFA, as it maximizes the total variance explained and groups a large number of items under a smaller number of components, thereby providing preliminary information about item relationships and the structure of the scale (Field, 2013).

As seen in Table 3, the analysis of the factor loadings indicated that they ranged from 0.44 to 0.80. This means that the Soft Skills Scale for Teachers consists of thirty-seven items and five factors, with factor loadings greater than .40 (Tabachnick & Fidell, 2007). After this stage, the factors were named, such as 'I organize activities that will improve my students' time management skills' under Factor 1 are Cognitive Skills; items such as 'I take care to have a trust-based relationship with my students' included under Factor 2 are Interpersonal Skills; items under Factor 3, such as 'I listen actively to understand my students', are included in Problem Solving; and under Factor 4, 'I aim for my students to acquire universal values'. Items such as 'Multiculturalism' and 'My negative emotions affect the learning environment' under Factor 5 are called Emotional control. The thirty-seven-item scale resulting from exploratory factor analysis was numbered in the new order and made suitable for confirmatory factor analysis. During the item pool studies of the measurement tool, the items were written considering the dimensions of interpersonal skills, cognitive skills and emotional control. During the exploratory factor analysis, it was seen that the items related to problem solving and multiculturalism became factors. The fact that there are four items each with factor loadings greater than .40 in the problem solving and multiculturalism factors indicates that teachers see these factors as separate dimensions. Although soft skills are theoretically defined in three dimensions, interpersonal skills, cognitive skills and emotional control, problem solving and multiculturalism are sub-concepts of soft skills, it is understood that the factorial structure that emerged in this study is compatible with literature.

Table 2.
Rotated Factor Loading Matrix

Item	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5
Item 27	.80				
Item 28	.80				
Item 26	.71				
Item 29	.69				
Item 30	.69				
Item 38	.65				
Item 33	.63				
Item 31	.59				
Item 11	.57				
Item 34	.57				
Item 35	.54				
Item 32	.52				
Item 25	.49				
Item 22	.44				
Item 3		.76			
Item 4		.75			
Item 2		.73			
Item 7		.72			
Item 8		.71			
Item 1		.70			
Item 10		.69			
Item 9		.64			
Item 6		.60			
Item 47			.70		
Item 51			.65		
Item 50			.65		
Item 48			.62		
Item 46			.58		
Item 37			.54		
Item 16				.68	
Item 18				.60	
Item 19				.60	
Item 13				.50	
Item 23					.74
Item 14					.70
Item 52					.67
Item 42					.64

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

Study II

Study II incorporates a confirmatory factor analysis (CFA) aimed at evaluating the model fit of the proposed factor structure.

Participants

Study II was conducted in the spring semester of the 2023-2024 academic year in Çanakkale. Confirmatory factor analysis was performed on new participants one month after the completion of EFA. A total of 248 teachers participated in Study II, consisting of 143 females (57.66%) and 105 males (42.33%). The participating teachers were from 12 separate schools in Çanakkale and its districts, including three preschools (n = 43, 17.33 %), five primary schools (n = 108, 45.54 %), two middle schools (n = 49, 19.75), and two high schools (n = 48, 19.35 %). The teachers had professional seniority ranging from 1 to 35 years, with an average of 19.60 years.

Measures

Sociodemographic information

A personal information form was used to obtain information about the participants' gender, age, experience and school.

SSS-T

The Soft Skills Scale for Teachers consists of 37 items and five factors: Cognitive Skills, Interpersonal Skills, Problem Solving, Multiculturalism and Emotional control. The scale is a 5-point Likert type and the items are answered as Strongly Agree", "Agree" "Neutral", "Disagree" "Strongly Disagree".

Statistical Analysis

The confirmatory factor analysis used the Maximum Likelihood (ML) estimation method, which is suitable for continuous variables and large sample sizes. This estimation method was preferred because it provides efficient and unbiased parameter estimates when multivariate normality is reasonably met (Kline, 2015). Prior to CFA, data normality, multicollinearity, and sample adequacy assumptions were examined, and all assumptions were found to be met. Then, we conducted a Confirmatory Factor Analysis (CFA) to test the model fit of the five-factor structure with 37 items obtained as a result of the Exploratory Factor Analysis (EFA). Accordingly, path analysis results were examined, and fit indices were calculated. For the exploratory factor analysis, the data were analyzed in a SPSS.24 program, while the LISREL was used for the confirmatory factor analysis.

Results

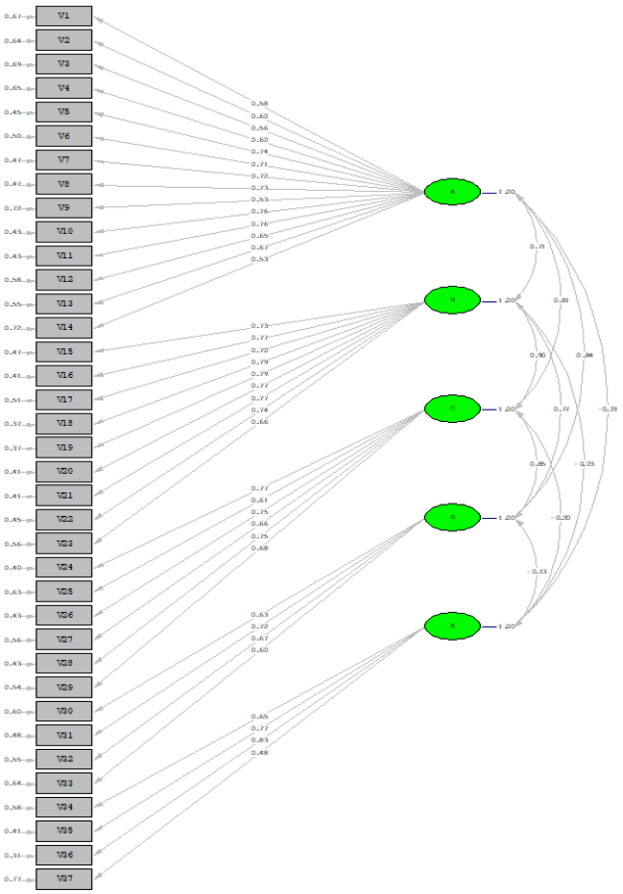
The findings of the fit indices of the scale are as shown in Table 3.

Table 3.
Fit Indices

Compliance Indices	Value	Reference
χ^2/df	2.70	2-5
RMSEA (Root Mean Square Error of Aproximation)	0.06	0-1
GFI (Goodness-of-Fit Index)	0.90	> 0.90
AGFI (Adjusted Goodness-of-Fit Index)	0.91	> 0.95
CFI (Comparative Fit Index)	0.88	> 0.90
RMR	0.06	<0.05
NFI	0.90	> 0.90
TLI	0.92	> 0.90

When the fit indices are examined, the values of the scale indicate acceptable and good fit (Tabachnick & Fidell, 2007). Following the fit indices, the path diagram of the scale was examined (Figure 2).

Figure 2.
Path Diagram



After the exploratory factor analysis, the items were renumbered. The order presented in the path analysis reflects this renumbered sequence. As seen in Figure 2, it suggests that each observed variable is related

to the latent variables. In other words, it is understood that the five-factor structure consisting of thirty-seven items was confirmed as a model.

Study III

Participants

Study III was conducted in the spring semester of the 2024-2025 academic year fall semester. The data for the study were collected from six schools, including two preschools (33.33 %), two elementary schools (33.33 %), one middle school (16.66 %), and one high school (16.66 %). A total of 122 teachers participated in the research, 68 females (55.28 %) and 54 males (44.26 %). The teachers worked in pre-schools (*n* = 36, 29.50 %), primary schools (*n* = 53, 43.45 %), secondary schools (*n* = 18, 14.75 %), and high schools (*n* = 15, 12.30 %). The teachers had professional seniority ranging from 6 months to 38 years, with an average of 22.4 years.

Measures

Sociodemographic information

A personal information form was used to obtain information about the participants' gender, age, pseudonyms, experience and school.

SSS-T

The Soft Skills Scale for Teachers consists of 37 items and five factors: Cognitive Skills, Interpersonal Skills, Problem Solving, Multiculturalism and Emotional control. The scale is a 5-point Likert type, and the items are answered as "Strongly Agree", "Agree" "Neutral", "Disagree" "Strongly Disagree".

Social-Emotional Competence Teacher Rating Scale (SEC)

SEC was adopted to Turkish by Sarısoy et al. (2021) from Tom (2012). Both the original and adapted versions of the scale consist of 25 items. The SEC includes four subscales: Student-Teacher Relationship (seven items), Emotional Regulation (six items), Interpersonal Skills (six items), and Social Awareness (six items). Items 5, 10, and 12, which are negatively worded, are reverse scored. The Cronbach's alpha internal consistency coefficients of the scale were calculated as .78, .70, .80, and .75 for the subscales, and .88 for the overall scale. The scale is a 6-point Likert type and items are answered as: "Strongly Disagree", "Disagree", "Somewhat Disagree", "Somewhat Agree", "Agree", "Strongly Agree". The tests conducted to determine the psychometric properties of the Turkish version of scale indicate that the SEC is a valid and reliable tool for measuring teachers' social-emotional competence.

Statistical Analysis

We calculated Cronbach Alpha to ensure internal consistency. Then, preliminary analyses were conducted to normality, and multicollinearity. Pearson-moment correlation coefficient was conducted to evaluate between SSS-T and SEC.

Results

Cronbach's alpha internal consistency coefficient was calculated to determine the reliability of the scale. The subscale coefficients were calculated as follows: Cognitive Skills (.89), Interpersonal Skills (.82), Problem Solving (.84), Multiculturalism (.88), and Emotional Control (.76). These values indicate that the subscales range between .76 and .89, while the overall scale has a reliability coefficient of .91. Additionally, Composite Reliability (CR) coefficients were calculated. CR for Cognitive Skills was found to be .91; for Interpersonal Skills was .92; for Problem Solving was .86; for Multiculturalism was .75, and for Emotional Control was .78; the overall composite reliability (CR) coefficient of the scale was .92, Since all coefficients were above the recommended threshold of .70, it was concluded that internal consistency was sufficient for all sub-dimensions of the scale. Subsequently, the Pearson correlation coefficient was calculated to examine the relationship between the Soft Skills Scale for Teachers and Social-Emotional Competence scales (Table 4).

Table 4.
Correlations Between SSS-T and SEC

		SSS-T	SEC
SSS-T	Pearson Correlation	1	.562**
	Sig. (2-tailed)		.000
	N	122	122
SEC	Pearson Correlation	.562**	1
	Sig. (2-tailed)	.000	
	N	122	122

**. Correlation is significant at the 0.01 level (2-tailed).

As seen in Table 4, the Pearson correlation coefficient was calculated as .562, $p < .001$, between the SSS-T and SEC. In other words, the mean scores of the SSS-T and SEC are moderately correlated. This finding provides evidence for the convergent validity of the SEC, indicating that it is appropriately aligned with a related construct.

Study IV

Participants

Study IV was conducted with the same teachers at the schools that participated in Study III. The participants in the test–retest reliability study responded to the SSS-T twice in a 1-month interval. Thus, 122 teachers who participated in Study 3 were re-contacted. However, the pseudonyms of 57 teachers overlapped between

Studies 3 and 4. In this context, the analyses were conducted with the data of 57 teachers, including 33 females (57.89%) and 24 males (42.10%). Among the teachers participating in Study 4, 12 work in preschools (21.05 %), 28 in elementary schools (42.10 %), 9 in middle schools (15.80 %), and 8 in high schools (14.05 %). The teachers had professional seniority ranging from 1 year to 38 years, with an average of 22.2 years.

Measures

Sociodemographic information

A personal information form was used to obtain information about the participants' gender, age, nicknames, experience and school.

SSS-T

The Soft Skills Scale for Teachers consists of 37 items and five factors: Cognitive Skills, Interpersonal Skills, Problem Solving, Multiculturalism and Emotional control. The scale is a 5-point Likert type, and the items are answered as "Strongly Agree", "Agree" "Neutral", "Disagree" "Strongly Disagree".

Statistical Analysis

To determine the correlation between the first and second administrations of the SSS-T, we examined the test-retest reliability. Additionally, a paired-samples t test was conducted to determine whether there was any change in the mean scores of soft skills over a 1-month time interval.

Results

Pearson correlation between test and retest, the mean of the SSS-T in the first administration was 4.17, the mean in the second administration was 4.26, $r = .718$, $p < .001$. This indicates that test and retest administrations are highly correlated (Table 5).

Table 5.
Paired Sample T-Test for Test-Retest Reliability

Measure	*N*	Mean	*sd*	*df*	*t*	*p*
Test	57	4.1782	.31140	56	1.227	.228
Retest	57	4.2600	.26568			
	N	Correlation				p
Test & Retest	57	.718				.000

The results of the paired samples t-test indicated that there were no significant difference in mean SSS-T scores between the two time points, $t(1.227) = .228$, $p > .05$. This suggests that the scale's reliability is supported. Consequently, the validity and reliability tests applied to determine the psychometric properties of the Soft Skills Scale for Teachers show that the scale is structured to assess the soft skills level of teachers.

Discussion and Conclusion

The aim of the research was to develop a scale that would provide both valid and reliable measurements for determining teachers' soft skills levels. This aim stemmed from the fact that no scale was found that directly measures the soft skills of teachers. As far as we know, the Soft Skills Scale for Teachers is the first scale available for measuring teachers' soft skills in an educational context. The measurement of teachers' soft skills is crucial for improving the quality of student-teacher interactions in educational processes. This is because teachers' affective skills can directly influence students' classroom experiences and academic success. According to Goleman's (1995) Emotional Intelligence Theory, teachers who possess strong soft skills—such as empathy, emotional awareness, and interpersonal sensitivity—create supportive learning environments built on strong classroom relationships. In Jennings and Greenberg's (2009) Prosocial Classroom Model, teachers with well-developed soft skills serve as role models in empathy, self-regulation, and constructive interaction, thereby supporting students' social, emotional, and academic development. These theoretical and empirical perspectives indicate that teachers' soft skills directly influence the social, emotional, and academic climate of the classroom. Teachers need to be passionate about learning, take the initiative, adapt to changing conditions, and diversify the learning environment. Moreover, they must be innovative, creative, and emotionally stable. Therefore, accurately determining teachers' soft skill levels and fostering the development of these skills is a critical step in enhancing students' affective development. Measuring teachers' soft skill levels with a valid and reliable tool will contribute to the development of studies on soft skills in the field of education. Therefore, four studies were conducted in this research to ensure validity and reliability.

We first order exploratory factor analysis to confirm the construct validity of the scale. The first-order EFA was applied to the preliminary version of the scale, which consisted of 53 items. According to the results of the first-order EFA, three items were excluded because their factor loadings were below .40; six items were removed because they had similar loading values on two different factors; and seven items were excluded because, although their factor loadings were above .40, they did not show a clear factor structure (Çokluk et al., 2012; Şencan, 2005). Thus, the second-order EFA was conducted again for the remaining 37 items and five factors. Scree plot and Kaiser criterion results consistently supported the retention of the five-factor structure. Eigenvalue statistics indicate that each additional factor significantly contributes to the explained variance, reaching 59.37% of the total variance. This demonstrates that the soft skills concept consists of a multifactorial structure, with each

factor representing a different, yet interconnected, component of this structure. Furthermore, the five-factor structure aligns with the theoretical framework and previous research in the field of soft skills (İnce et al, 2025; Kalaimani, and Stephen, 2022; Maren et al., 2021). Therefore, although no parallel analysis was conducted, the five-factor model appears to be statistically and theoretically appropriate and conceptually consistent (Tabachnick & Fidell, 2007). Accordingly, considering previous literature, these factors were called cognitive skills, interpersonal skills, problem solving, multiculturalism and emotional control, respectively. These dimensions show that soft skills are discussed comprehensively and a structure compatible with the theoretical frameworks in literature. The first factor is the cognitive skills factor. Cognitive skills refer to teachers' competencies in the teaching process. These skills include skills such as developing thinking skills, time management, lesson planning, material development, using teaching methods and techniques, measurement and evaluation. Research shows that if teachers' cognitive skills are high, students show higher academic performance (Krieglstein et al, 2024; Kunter et al., 2013). When the research findings are examined theoretically, they reveal results consistent with Bandura's (1977) Social Learning Theory and Vygotsky's (1978) Sociocultural Theory. According to Bandura, students can observe their teachers and model or imitate their cognitive and metacognitive performances. In line with Vygotsky's perspective, teachers can provide students with rich cognitive experiences through social interaction and cognitive scaffolding. Similarly, Darling-Hammond et al. (2020) found that cognitively competent teachers support students' cognitive skills such as critical thinking, adaptability, and self-reflection. These theoretical and empirical perspectives together demonstrate that teachers' cognitive skills play a transformative role in the development of students' soft skills. Therefore, the importance of teachers' cognitive skills in terms of soft skills should be emphasized. The second one is the interpersonal skills factor. The interpersonal skills factor includes teachers' abilities to communicate effectively, show empathy, cooperate, and to act respectfully with students, parents, colleagues, and other stakeholders. Healthy relationships increase students' commitment to school and academic success (Epstein & Sheldon, 2006; Roorda et al., 2017). In this respect, it can be said that teachers' interpersonal skills affect students' social-emotional development as well as their academic success. The third one is the problem-solving factor. Teachers inevitably face various problems in their daily lives. Today, the problems teachers face include not only academic but also social and emotional issues. In such cases, teachers are expected to demonstrate skills such as analytical thinking, creative problem solving, adaptation and flexibility in solving problems. In cases where standard solutions do not work, producing creative and innovative solutions and finding the most suitable solutions for students' needs are the skills expected from teachers (Bellanca & Fogarty, 2012; Darling-Hammond et al., 2017; Roorda et al., 2017). It is important for teachers to act flexibly and adaptably, adapting to changing conditions and unexpected situations, and to organize educational plans according to the needs of students. In addition, problem-solving skills help teachers effectively handle discipline problems and student behavior they encounter during classroom management. Teachers' ability to overcome classroom problems increases classroom interaction, the quality of the learning environment, and student participation. This indicates that problem-solving skills are an important professional skill that a teacher should possess in the context of soft skills. The fourth is the multiculturalism factor. Multiculturalism includes teachers' respect for cultural diversity, their understanding of the needs of students from different cultures, and their ability to effectively manage a multicultural classroom environment. Developing teachers' multicultural skills helps students accept their cultural differences and understand each other. A teacher who is soft to multiculturalism should deal with each student individually and, at the same time, be soft to the group and cultural affiliations of each student. Otherwise, if a situation occurs, situations such as disappointment, misunderstandings and intercultural conflict become more likely to occur in the classroom (Griner & Stewart, 2013; Schachner et al., 2021). As a result of all this, teachers' development of their skills in this factor will help support cultural diversity, strengthen students' cultural identities and create an effective learning environment. The last one is emotional control. Today, teachers face many challenges such as constantly increasing academic expectations, student diversity, lack of resources, parental pressure and rapid changes in the educational system. These difficulties can negatively affect teachers' mental health by causing negative emotions such as stress, burnout, anxiety and anger. The way teachers manage their own emotions, cope with stress, and react to negative emotions directly affects both their own health and the learning experiences of their students. Teachers with good emotional control can provide emotional guidance to their students and maintain their emotional balance in difficult situations, thanks to their emotional awareness and regulation skills (Schwab & Elias, 2015). Emotional control increases teachers' abilities to establish and maintain authority in the classroom and thereby contributes to an orderly and productive learning environment. As a result, we concluded that the five-factor structure obtained through EFA encompasses the teacher's soft skills in an educational context.

As the second step, we conducted a CFA to test the validity of the structure obtained through EFA as a

model. The model fit indices were calculated as $\chi 2/df$ = 2.70, RMSEA = 0.06, GFI = 0.90, AGFI = 0.91, CFI = 0.88, RMR = 0.06, NFI = 0.90, and TLI = 0.92. In the confirmatory factor analysis, the model fit indices were examined separately for each reference value. The χ^2/df (Chi-square/degree of freedom) ratio examined to assess the model's fit to the data indicates excellent fit when it is less than 3 for large samples and less than 2 for small samples (Tabachnick & Fidell, 2007). In this study, the obtained χ^2/df = 2.70 value suggests that the model fits the data well. In evaluating the model's fit to the data, another index, RMSEA, is examined. An RMSEA value less than 0.08 indicates good fit, and a value less than 0.05 indicates excellent fit (Hooper, et al., 2008; Schumacker & Lomax, 2010). In this context, the RMSEA value of 0.06 for the The GFI, which examines the overall fit of the model, and the AGFI, which considers the model's complexity, are considered to indicate good fit when their values are greater than 0.90 and excellent fit when greater than 0.95 (Hooper, et al., 2008; Hu & Bentler, 1999; Schumacker & Lomax, 2010). In this context, it can be concluded that the GFI and AGFI values in this study show good fit. The CFI value, which provides reliable results for both large and small samples, indicates good fit when it is greater than 0.90 and excellent fit when it is greater than 0.95 (Hu & Bentler, 1999; Schumacker & Lomax, 2010). The CFI value of 0.88 calculated for the SSS-T indicates an acceptable fit. The fact that the lower limit of the CFI value is below .90 may be related to the sample size obtained in CFA; however, the chi-square test is not an index that is sensitive to sample size (Schermelleh-Engel et al., 2003). In other words, it works even with small samples. In this context, the use of both CFI and chi-square together in this study and the fact that the chi-square showed good fit indicates that the CFI value is acceptable. Both NFI and TLI evaluate the model's fit to the data, but TLI provides a more reliable fit assessment by considering the degrees of freedom. A value greater than 0.90 for both indicates good fit, and a value greater than 0.95 indicates excellent fit (Hu & Bentler, 1999; Schumacker & Lomax, 2010; Tabachnick & Fidell, 2007). It can be concluded that all indices, except for CFI, indicate good fit. However, when the model is evaluated overall with all indices, it is understood that the SSS-T has been validated as a model.

In a subsequent study, further evidence for the reliability of the scale was obtained through the calculation of Cronbach's alpha coefficients and a convergent validity analysis conducted with the SEC scale, which theoretically measures related constructs. The reliability coefficients for the subscales were as follows: Cognitive Skills (.89; .91), Interpersonal Skills (.82; .92), Problem Solving (.84; .86), Multiculturalism (.88; .75), and Emotional Control (.76; .78). These results indicate that the reliability values of the subscale ranged from .76 to .89, while the overall scale yielded a Cronbach's alpha coefficient of .91 and composite reliability (CR) coefficient of the scale was .92, A Cronbach's alpha and composite reliability value exceeding .70 is generally considered to demonstrate high internal consistency and an acceptable level of reliability (Tabachnick & Fidell, 2007). Moreover, a significant positive correlation was found between the SSS-T and the SEC scale ($r = .562$, $p < .001$), providing evidence for the convergent validity of the developed scale. In convergent validity studies, moderate correlations are expected when two measures assess conceptually related but non-identical constructs, indicating theoretical overlap without redundancy (Hair et al., 2020). A teacher's social-emotional competence refers to the development of their social, emotional, and partially cognitive competencies (Li & Qian, 2025). Given these characteristics, social-emotional competence overlaps with teachers' soft skills, particularly in areas such as relationship-building and empathy (CASEL, 2020). Accordingly, we decided to use the SEC to assess convergent validity.

Finally, the results obtained from administering the scale twice at different time points were examined using the test-retest technique. Test-retest reliability is crucial as it provides evidence for the stability and consistency of the scale over time (Cohen & Swerdlik, 2018). The findings indicated a strong correlation between the data obtained from the two administrations of the SSS-T, $r = .718$, $p < .001$. The expected correlation level in test-retest applications is generally .70 or higher (Tabachnick & Fidell, 2007). Additionally, to assess whether there was a significant difference between the two administrations, a paired-sample t-test was conducted (Field, 2013). The results from Study 4 suggest that the SSS-T is reliable, showing no significant difference between the measurements taken four weeks apart, $t(1.227) = .228$, $p > .05$. The results from the two separate tests in Study 4 provide strong evidence for the reliability of the scale (Creswell, 2014).

The results obtained from these four separate studies, conducted to determine the psychometric properties of the SSS-T, indicate that the scale is both valid and reliable. Difficulties in determining the psychometric structure of soft skills reflect the complexity of defining and measuring this concept. In the field of education in particular, the limitation of valid and reliable measurement tools that measure soft skills prevents in-depth research in this field. Developing a valid and reliable scale to measure teachers' soft skills levels for the first time in literature with this research will provide a more comprehensive understanding of teachers' soft skills in future studies. Although soft skills are a concept that is becoming increasingly important in today's world, it is a critical issue for both education and society that teachers who train all professional groups in society have these skills (Scheerens et al., 2020). Examining teachers' soft skills in detail in these

studies will enable the determination of teachers' strengths and areas that need to be improved in terms of soft skills and the development of training and intervention programs in the areas needed. Therefore, teachers' personal and professional development will be supported, and, as a result, students' academic, social and emotional learning will be positively supported. On the other hand, skills such as life/work skills, leadership, cultural competence, and emotional awareness enable teachers to contribute to the soft skills development of students, be soft to different cultures, and to perform classroom management effectively.

Limitations and Implications

This study has some limitations. The first is about the samples of each phase. A review of the literature suggests that a sample size of 300–400 is recommended for the exploratory factor analysis in Study I (Comrey & Lee, 1992), 100–200 for the confirmatory factor analysis in Study II (Kline, 2015), and approximately 100-200 participants for the convergent validity conducted in Studies III (Kline, 2015) and 30-50 participant for the test retest conducted in Study IV (Cohen & Swerdlik, 2018). In this study, the sample sizes obtained were close to the lower boundaries of these recommended ranges, which limits the generalizability of the findings to the broader field of education. To address this limitation, future research should aim to include larger and more diverse samples of teachers across different regions and educational contexts. This would enhance the generalizability of the findings and provide a more robust validation of the scale.

The second limitation of the study concerns the acceptable and good levels of model fit indices obtained during the confirmatory factor analysis. Although these indices suggest that the model fits the development sample well, they do not guarantee that the same level of fit will be achieved in different populations. This raises concerns regarding the generalizability of the scale. Therefore, it is recommended that the scale be validated on independent samples to ensure its stability and robustness across different groups (DeVellis, 2017).

Future research should also examine the validity and reliability of the scale on different demographic groups. Additionally, testing the scale in different cultural contexts may increase the overall validity of the scale. Studies to be conducted in different cultural and social contexts will also reveal the universality and adaptability of the scale. Ensuring cultural compatibility of the scale in such studies will help obtain more accurate results in evaluating teachers' soft skills. The developed scale will help detect the presence and level of soft skills in teachers, thereby contributing to the design of teacher training programs and in-service training to develop these skills. Teachers' possession of soft skills will positively affect the social-emotional development of students as well as their academic success and will contribute to raising them as individuals with twenty-first century skills. Therefore, this study constitutes an important step in terms of teacher competencies and student development. In addition, thanks to the developed scale, teachers' precise skill levels can be determined and the effects of these skills on teacher and student outcomes are able to be examined in future studies. In this way, the importance of soft skills and their contribution to the education system can be revealed more clearly.

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Exploring Formative Feedback in Virtual Primary Education: Towards a Conceptual Structure

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Abstract

Formative feedback is a key resource for promoting learning among primary school students. In virtual environments, it gains greater relevance as it intervenes at different stages of the educational process, highlighting the need to understand how teachers perceive it, apply it, and which factors condition their pedagogical practice. The objective of this study was to understand how primary school teachers conceive and implement formative feedback in virtual contexts and, on that basis, to develop a conceptual structure that synthesizes their experiences. A qualitative exploratory approach was adopted, grounded in grounded theory, which included semi-structured interviews with 65 teachers from 15 educational institutions in the Tacna region of Peru. Data analysis was supported by Atlas.ti 23 software and involved the identification of emerging categories through open, axial, and selective coding processes. The findings indicate that teachers understand feedback as a comprehensive pedagogical process oriented toward formative assessment, progressive improvement of learning, capacity development, and student-centered support. The study also identified that strategies perceived as more effective were those related to interactive and personalized use of diverse resources, whereas less effective strategies were linked to approaches primarily focused on grading. In conclusion, a conceptual structure of virtual formative feedback is proposed, which articulates cognitive, socio-emotional, and techno-pedagogical dimensions. This structure also describes the factors that influence feedback, its types, the purposes attributed by teachers, and the student-centered approach. The study contributes both to the foundations of pedagogical practice and to future research in primary education.

Keywords:

Formative Feedback, Virtual Teaching, Primary Education, Grounded Theory, Conceptual Structure.

Introduction

Formative feedback is presented in the educational context as the information provided to the student in order to improve their performance and reduce the gap between their current level and the level that is expected or desired to achieve (Brandmo & Gamlem, 2025; Brown et al., 2023). Formative feedback can be defined as the type of

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feedback that continuously and specifically attempts to help the student carry out their learning process, unlike summative feedback, which only pursues the moment of the final grade (Anijovich & Cappelletti, 2020; Chand & Pillay, 2024). That is why it is considered one of the most powerful didactic methods to improve learning since it generates self-regulation, critical reflection, and greater involvement of the student (Black & Wiliam, 2018; Moya-Muñoz et al., 2025).

In primary education, the characteristics of child cognition require strategies that adjust to the needs of students. Recent studies show how formative and process-centered feedback increases motivation, understanding, and autonomy at early ages (Brandmo & Gamlem, 2025; Imaicela Vega et al., 2025). Clear and constructive feedback not only contributes to correcting errors but also contributes to self-regulation and meaningful learning (Casa-Coila et al., 2022; Moya-Muñoz et al., 2025). This is the argument that reaffirms the need to address the design of this type of strategies with the cognitive and emotional specificities of students at this level of studies (Paz-Perea et al., 2024). On the other hand, the design and systematization of conceptual structures of formative feedback adapted to the virtual primary environment remains an important gap in current educational research.

Several studies have agreed that formative feedback is a powerful mechanism that contributes to enhancing learning. In basic education, particularly in primary education, its impact is strengthened when these strategies are adapted to the cognitive, motivational, and affective characteristics of children, as demonstrated by studies within the framework of inclusive and differentiated education (Töllner et al., 2025).

Regarding the resources that facilitate feedback, a repertoire of strategies has been developed that combines oral, written, graphic, and digital modalities. Thus, Kusairi (2020) developed a feedback system based on isomorphic items, which proved to be effective in providing automatic responses differentiated according to individual or group levels. Likewise, other findings show that automated feedback through technologies tends to be ignored by students (mainly in the early grades) when it is not contextualized or when pedagogical dialogue is absent (Maier & Klotz, 2025).

As a consequence of the experience during the COVID-19 pandemic, various forms of virtual teaching were strengthened at different levels of the educational system, including primary education. This transformation, driven by the health emergency, gave way to the virtual modality which continues to be implemented today. However, the transition to virtual environments brought with it important challenges in the application of formative feedback, mainly at the level of primary education. Among the main difficulties are unequal access to technological resources, the reduction of immediate interactions between teachers and students, the limited training of teachers in the pedagogical use of digital platforms, and the increase in their workload (Altmann & Arnold, 2024; Casa-Coila et al., 2022).

Added to this is the persistent digital divide, the lack of strategies adapted to the virtual environment, and the limited teacher preparation to sustain effective feedback processes (Imaicela Vega et al., 2025; Moya-Muñoz et al., 2025). These conditions reduce the frequency and quality of feedback, affecting its equity and formative impact on basic education students (Brandmo & Gamlem, 2025). In response to this situation, several studies have highlighted the need to strengthen teacher training in digital competencies and active methodologies in order to ensure the continuity of the feedback cycle even in non-face-to-face contexts (Paz-Perea et al., 2024). In this scenario, the practice of formative feedback in virtual primary education remains limited and inconsistent, revealing the urgency of investigating how it is actually being implemented in teaching practice.

However, despite the extensive evidence on the benefits of feedback, there is a scarcity of studies examining how primary school teachers implement formative feedback in real virtual environments and what tensions they face in this process. Although some studies acknowledge progress in the integration of digital feedback tools, others warn that superficial or technical use, without solid pedagogical criteria, limits its transformative potential (Vilca et al., 2022). This study arises from the need to understand in greater depth how primary school teachers confront the challenge of applying formative feedback strategies in virtual environments. Gaps still persist regarding its effective implementation in daily practice, especially in contexts where distance education was adopted in response to exceptional circumstances and required teachers to adapt rapidly. In this sense, the purpose of this work is not to once again demonstrate the usefulness of feedback (an aspect already widely documented), but to investigate how teachers carry it out in real scenarios, what obstacles they encounter, and with what resources or strategies they seek to overcome them.

The research is also justified because there is currently no validated conceptual model that organizes formative feedback in virtual basic education from the teachers' perspective. The existing theoretical frameworks are usually general in nature or focus on higher educational levels, without addressing the particularities of the primary level nor the tensions that emerge when transferring face-to-face practices

to digital environments. Hence, the generation of situated knowledge is essential for capturing teaching experience and translating it into a pertinent, flexible, and pedagogically sound conceptual structure.

The study gains practical relevance because it seeks to provide an organized foundation that guides both reflection and pedagogical decision-making, as well as teacher training in virtual settings, and leads to higher-quality pedagogical practice in distance learning processes in primary education. By highlighting the real exaperiences and limitations of teachers, the research aims to become a resource for the design of educational policies, training programs, and technological tools aligned with the dynamics of the virtual classroom at this level.

Therefore, the objective of this study is to understand how primary school teachers apply formative feedback in virtual environments, identify the factors that condition its effectiveness, and, based on these experiences, construct a conceptual structure that organizes and explains these practices.

Method

Design

This study was conducted using a qualitative approach with a grounded theory design, with the purpose of understanding how primary school teachers conceive of and implement formative feedback strategies in virtual environments. Since the phenomenon under study is scarcely documented from a contextualized perspective, the design allows for the construction of categories and a conceptual structure based on the analysis of the data collected (Strauss & Corbin, 2002). This approach proved particularly suitable for capturing the complexity of the phenomenon, giving priority to teachers' voices, their concrete experiences, and their pedagogical strategies. The systematic tradition of grounded theory proposed by Strauss and Corbin was adopted, which involved the use of constant comparative analysis and the development of analytical memos during conceptual construction. Although grounded theory usually employs theoretical sampling, in this study it was not possible to implement it fully due to field constraints, which is acknowledged as a methodological limitation. The research was carried out in a context where many schools have maintained or combined virtual teaching formats without implementing a feedback model adapted to the primary level.

Participants

The sample consisted of 65 practicing teachers at the primary education level, belonging to 15 educational institutions in the Tacna region, Peru. The selection was carried out through convenience sampling, taking as criteria a minimum of five years of professional experience and the management of techno-pedagogical tools applied to virtual teaching. It should be noted that the Tacna region is recognized for its achievements in learning (it ranks first in Peru in learning achievements) and for the progressive use of educational technologies in basic education. The variety of virtual experiences of the teachers contributed to the collected data, allowing the identification of both common patterns and singular tensions in the use of virtual formative feedback.

Instrument

The main instrument for data collection was the semi-structured interview, as it allows for an in-depth exploration of teaching practices and teachers' perceptions regarding virtual formative feedback. The script was constructed based on a review of the literature and the research objectives. It was organized around four key areas: definition of formative feedback, strategies used, factors that influence its application, and types of feedback utilized. This thematic openness led to the emergence of a conceptual structure on virtual formative feedback in primary education during the analysis.

The interviews were conducted in coordination with the principals of the participating educational institutions and were carried out in person, adapting to the availability of each teacher. Informed consent was requested prior to the interview, ensuring anonymity and confidentiality of the information provided. The responses were recorded in audio and field notes. The interview instrument included open-ended questions to facilitate flexible exploration and encourage the free narration of the interviewees' experiences. These questions were designed based on the literature and research objectives, addressing general aspects of virtual formative feedback and allowing for the subsequent identification of emerging categories during the analysis. The interviews were conducted in Spanish, lasted an average of 35 to 50 minutes, and were recorded with the participants' permission. They were then transcribed verbatim and reviewed through cross-checking to ensure accuracy and fidelity in the records. Some guiding questions included: How would you define virtual formative feedback? What feedback strategy do you consider effective in the virtual teaching you have conducted? What factors do you attribute to the inability to provide good feedback in virtual teaching? And what types of feedback do you usually use when addressing virtual teaching?

Analysis

The analysis of the data was conducted following the guidelines of grounded theory with support from Atlas.ti 23, which ensured coherence and methodological

rigor (Ahmed et al., 2025). It began with open coding, which allowed the identification of expressions and key terms used by teachers to define and describe virtual formative feedback. Subsequently, through axial coding, the codes were grouped and related, giving rise to categories that represent fundamental dimensions of this pedagogical practice, such as its purpose, its procedural nature, the student-centered approach, and its connection with competency development. Finally, through selective coding, the categories were integrated to produce an emerging central category that synthesizes teachers' conceptions of formative feedback in virtual primary education environments.

The coding process was carried out independently by two researchers, who later compared and agreed upon the categories to strengthen the reliability of the analysis. Likewise, qualitative rigor strategies were applied, such as peer debriefing and internal consistency review of the category system. The process was complemented with the criteria of Miles and Huberman (1994), which include data reduction, data display, and verification, in order to reinforce the systematic nature and internal validity of the analysis.

Results

Emerging teacher conceptions from open coding

In this section of the qualitative analysis, those words were outlined and identified allowing us to reach an understanding of how teachers considered formative feedback in the teaching–learning process in virtual environments, based on the terms that were selected (extracted) through the use of open coding and that, as noted previously, were contextualized with representative quotes that allowed us to interpret the meanings that the participating subjects had given to the pedagogical practice. This analysis included a word cloud and its categorization to identify the open codes.

Figure 1.
Word cloud generated from teachers' definitions of formative feedback



Note: Own elaboration in Atlas.ti. Responses to the question: "How would you define formative feedback?"

The word cloud was created from teachers' responses to the question: How would you define formative feedback? The most frequently repeated answers reveal central notions when conceptualizing this pedagogical strategy within the context of virtual basic education. Words such as feedback, formative, evaluate, objectives, achievements, and performance show an understanding oriented toward monitoring learning and guiding students toward clear educational goals. On the other hand, words such as support, constant, strengthening, reinforcing, and process suggest that teachers conceive feedback as a continuous and personalized process aimed at facilitating the progressive development of competencies. The presence of words such as reflection, motivates, learned, and positively indicates the value placed on the formative and motivational component, which is related to improved performance and the establishment of meaningful learning. Likewise, the emphasis on child, activities, and development reiterates the existence of a student-centered conception, consistent with the usual practices of primary education in virtual environments. Similarly, the results presented here constitute the basis for identifying emerging conceptual categories, which will be described below.

Contextual analysis of keywords in teachers' definitions of formative feedback in virtual teaching

As part of the open coding, keywords of high recurrence and conceptual value were identified, extracted from the responses to the question: "How would you define formative feedback?" These expressions allowed a deeper exploration of the meanings attributed by teachers to this practice in the context of virtual teaching. Below is presented the contextual analysis of these keywords, accompanied by representative quotes.

The analysis of the key words associated with the definitions provided by the teachers makes it possible to identify the central elements that structure their understanding of formative feedback in virtual environments. The most frequent expressions show that teachers do not conceive feedback as a one-time or exclusively corrective action, but rather as a process linked to continuous evaluation, the verification of learning, and pedagogical support.

Similarly, terms such as children, achievements, reflection, and improvement indicate that feedback is oriented toward individual progress and active student participation, revealing a markedly student-centered conception. This repeated presence of notions related to process, competencies, and learning objectives allows for the delineation of the initial meaningful cores from which the analytical categories developed in the following stages of the analysis were constructed.

Axial categorization of teachers' perception of formative feedback

At this stage of the qualitative analysis, the previously identified open codes were grouped to construct categories that articulate the meanings teachers assign to formative feedback. The grouping was carried out based on recurrent patterns observed in the open codes, whose constant comparison made it possible to identify conceptual connections among them. This axial coding strategy allowed the establishment of relationships between emerging concepts and delineated four dimensions that structure teachers' practices and conceptions in virtual environments: the purpose of feedback, its procedural nature, the student-centered focus, and the link with competence development. These categories constitute the interpretive core of the phenomenon under analysis and form the central interpretive framework at this stage of the analysis.

Table 1

Keywords, representative quotes, and contextual interpretation of formative feedback in virtual teaching

Keyword	Literal teacher quote (age, gender, experience)	Contextual interpretation	Suggested open code
Evaluate	"Nowadays feedback is given more because of the pandemic, and we have to evaluate the criteria in attitudes, emotionally descriptive values." (Female teacher, 33 years old, 9 years of experience)	Feedback is related to a comprehensive evaluation that considers attitudinal and emotional aspects, beyond technical knowledge.	Comprehensive evaluation of learning
Competencies	"Well, I would say that formative feedback is to reinforce based on the competencies worked through open questions." (Female teacher, 26 years old, 5 years of experience)	Feedback is used as a tool to consolidate specific competencies through active strategies.	Reinforcement of competencies in virtual environments
Performance	"It is a series that is generated from the children's performance, in order to achieve the learning objectives." (Female teacher, 52 years old, 13 years of experience)	Feedback is a sequence oriented toward progress based on the analysis of student performance.	Performance-based feedback
Children	"It is a process of reflection that motivates children to create new productions and to identify their achievements." (Female teacher, 27 years old, 3 years of experience)	The focus is on students as active subjects of the reflective process, recognizing their capacity to improve.	Student-centered approach
Learned	"Formative feedback is to evaluate the child to know what they learned." (Female teacher, 58 years old, 19 years of experience)	Feedback becomes a direct way to confirm whether meaningful learning has been achieved.	Verification of acquired learning
Objectives	"It is a series that is generated from the children's performance, in order to achieve the learning objectives." (Female teacher, 52 years old, 13 years of experience)	The purpose of feedback is linked to the progressive fulfillment of pedagogical objectives.	Monitoring the achievement of objectives
Improvement	"Feedback, well, is a process through which students' learning is improved." (Female teacher, 45 years old, 12 years of experience)	Feedback is valued as a tool for continuous improvement, focused on learning progress.	Progressive improvement of learning

Table 2.

Axial coding: emerging categories around formative feedback

Emerging category	Grouped open codes	Representative excerpt
Purpose of feedback	Comprehensive evaluation of learning, Verification of acquired learning, Monitoring the achievement of objectives	"Formative feedback is to evaluate the child to know what they learned." (Female teacher, 58 years old, 19 years of experience)
Pedagogical process	Feedback as a formative process, Progressive improvement of learning, Performance-based feedback	"Feedback, well, is a process through which students' learning is improved." (Female teacher, 45 years old, 12 years of experience)
Student-centered	Student-centered approach, Pedagogical accompaniment in feedback	"It is a process of reflection that motivates children to create new productions and to identify their achievements." (Female teacher, 27 years old, 3 years of experience)
Development of competencies	Reinforcement of competencies, Valuation of achievements and progress	"Well, I would say that formative feedback is to reinforce based on the competencies worked through open questions." (Female teacher, 26 years old, 5 years of experience)

From the grouping of open codes that resulted from the interviews, four emerging categories were extracted that synthesize teachers' perceptions of formative feedback in the context of virtual teaching in primary education. These categories reflect how meanings are constructed around this pedagogical practice in non-presential settings, marked by the use of technologies, family mediation, and the particularities of child development.

1. Purpose of feedback: This integrated category consists of expressions that refer to feedback, linking it with learning assessment in the formative sense and with the objective of achieving educational goals. For the primary teacher, providing feedback in a non-presential modality means verifying whether children have understood and achieved the expected learning outcomes in virtual communication. As one teacher (58 years old with 19 years of experience) argues: "Formative feedback is to evaluate the child to know what they learned." In this sense, formative feedback is a function of pedagogical adjustment, since it makes it possible to identify progress and needs individually for each student.

2. The pedagogical process: Feedback is conceived as a cyclical process that supports the development of learning during sessions in virtual classrooms. The category emphasizes the sequential, orderly, and progressive nature of the didactic action, rather than a simple punctual correction. As expressed by one teacher (45 years old with 12 years of experience): "Feedback, well, is a process through which students' learning is improved." This conception reinforces the idea of the need to provide feedback in a continuous and planned manner, shaping the particularity of a class without the young student being physically present in the classroom.

3. Student-centered: In primary education, where learning is accompanied with kindness and motivation, feedback is seen as a mechanism that enables active participation, the children's effort, and their achievements. The category integrates the emotional, expressive, and reflective dimensions that teachers bring through questions, positive contributions, and spaces opened for self-assessment. One teacher (27 years old with 3 years of experience) states: "It is a reflective process that makes children create new productions and be able to see what they have done." Consequently, feedback is therefore considered a personalized experience to reinforce self-confidence and commitment to learning.

4. Development of competencies: Finally, this category includes those perceptions that associate feedback with a way to reinforce specific skills, address difficulties, and consolidate learning in accordance with the competencies included in the curriculum. In the virtual context, teachers adapt their strategies to continue strengthening these capacities, often with the support of digital materials and family mediation. One teacher (26 years old with 5 years of experience) notes: "Well, I would say that formative feedback is to reinforce based on the competencies worked through open questions." This view responds to a logic of progression and differentiated attention, centered on the progress of each student.

Results of selective coding and emerging central category

In this stage of the analysis, the categories built in axial coding were integrated through selective coding, which made it possible to identify a central category that articulates the phenomenon of study as a whole (Table 3). This category emerged by identifying the concept that offered the greatest explanatory capacity and cohesion among the dimensions developed in the axial analysis.

Table 3

Transition from axial coding to selective coding and central category

Axial categories	Selective coding result	Emerging central category
Purpose of feedback	Feedback is conceived as a pedagogical adjustment function that verifies, monitors, and guides learning achievement in virtual contexts.	Formative feedback as a comprehensive pedagogical process centered on the student
The pedagogical process	Feedback is understood as a cyclical, sequential, and continuous process that supports and improves student learning in virtual classrooms.	Formative feedback as a comprehensive pedagogical process centered on the student
Student-centered	Feedback emphasizes active participation, reflection, motivation, and recognition of children's achievements as protagonists of their own learning.	Formative feedback as a comprehensive pedagogical process centered on the student
Development of competencies	Feedback is associated with the reinforcement of skills, overcoming difficulties, and strengthening curricular competencies through adapted strategies.	Formative feedback as a comprehensive pedagogical process centered on the student

The emerging central category was: "Formative feedback as a comprehensive pedagogical process centered on the student." This category synthesizes teachers' conceptions of feedback in virtual teaching contexts in primary education, highlighting its continuous, formative, and goal-oriented nature.

According to the teachers, its purpose is to evaluate, verify achievements, and readjust the process; its dynamic relies on planning that is continuous and adapted to the needs and performance of each child. Its impact on the development of competencies and on meaningful learning is recognized, even in situations of low connectivity.

Also, based on the integration of the evidence, it is proposed to consider virtual formative feedback as a complete, continuous, and planned pedagogical process of assessment aimed at verifying the achievement of learning, readjusting teaching processes, achieving and strengthening competencies, within a student-centered approach. In non-presential primary education, this process articulates accompanying, motivating, and recognizing the student's progress, adjusting strategies according to performance, and creating favorable conditions for the construction of meaningful learning through technological mediation and, in many cases, family support.

Teaching practices and critical conditions for feedback in virtual settings: contributions to the construction of the model

In addition to inquiring about the general meaning of formative feedback, additional questions were asked to teachers in order to access their practical experiences in virtual teaching. These questions made it possible to identify strategies, difficulties, and critical conditions for providing feedback in primary education. Table 4 summarizes the significant thematic issues that emerged: effective strategies, ineffective strategies, difficulties, suggestions for improvement, types of feedback, and determining factors for the choice of strategies.

The complementary results allow for a deeper understanding of how teachers develop feedback in virtual contexts; the most effective practices can be observed in relation to personal interaction and the variety of resources, while the less effective practices are associated with a one-dimensional, grade-centered approach. Structural difficulties conditioned the development of the types of strategies used (connectivity, resources, and participation). In parallel, teachers suggest planning feedback with greater timeliness, clarity, and a diversity of formats, highlighting the role that families played as support in the feedback processes. In addition, there is a flexible use of synchronous and asynchronous modalities, depending not only on the teacher's technological skills but also on the students' family and social context. These findings show how pedagogical, technological, and family dimensions intertwine in the practice of virtual feedback. Taken together, these complementary results deepen the understanding of how teachers conceive and implement formative feedback in virtual settings, providing insights for building the study's emerging conceptual structure.

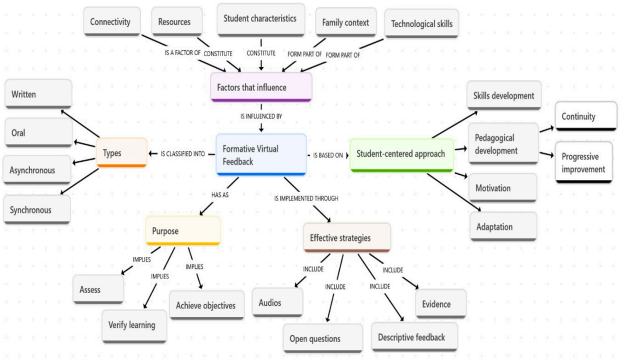
Table 4

Complementary results: teaching practices and critical conditions for formative feedback in virtual teaching

Explored dimension	Synthesis of findings	Representative example (teacher quote)
Effective strategies	Use of open-ended questions, personalized audios, descriptive feedback, work with evidence, and family involvement.	"It was through open-ended questions on the Meet platform and also based on their worksheets, which were their evidence." (Female teacher, 26 years old, 5 years of experience)
Ineffective strategies	Generalized feedback, exclusive use of grades or marks, closed questions, and sessions with many students without individual follow-up.	"It didn't work for me to give feedback only through final grades... students didn't know what they were doing wrong." (Female teacher, 45 years old, 12 years of experience)
Difficulties in providing feedback	Lack of connectivity, low participation, parental intervention, limited attention of children, lack of resources, and limited technological skills.	"Constant intervention of parents when their children wanted to answer the questions." (Female teacher, 27 years old, 3 years of experience)
Suggestions to improve feedback	Provide timely feedback, maintain direct contact with students, use varied media (videos, questions, drawings), promote reflection, and family support.	"Ask, ask questions about what we worked on throughout the class and finish in a general way... I usually talk with the parents on Fridays so that they talk with their children about what they did." (Female teacher, 55 years old, 22 years of experience)
Most frequently used types of feedback	Synchronous, asynchronous, oral, and written modalities predominate, depending on the teacher's technological and communicational context.	"I frequently use synchronous feedback for my virtual classes." (Female teacher, 12 years of experience, I.E. El Faro)
Factors influencing the choice of strategies	Connectivity, student characteristics, family context, resource accessibility, teacher's technological skills.	"My students' connectivity was a great challenge, so I chose to send activities through WhatsApp and use them as feedback in class." (Female teacher, 12 years of experience, I.E. República Argentina)

Figure 2

Conceptual structure of virtual formative feedback from the teachers' perspective



The conceptual model presented in the figure organizes in an integrated manner the categories that emerged from the analysis and allows for visualizing how teachers structure formative feedback in virtual environments. The representation shows that this practice is composed of different elements that relate to one another: the influencing factors, such as connectivity, available resources, student characteristics, and the family context; the types of feedback used; the purposes that guide its application; and the concrete strategies employed by teachers. Likewise, the model demonstrates that these dimensions are articulated around a student-centered approach, which operates as the organizing axis of the practices described. Taken together, the figure graphically synthesizes the conceptual structure derived from the study and allows for understanding how teachers combine contextual conditions, pedagogical decisions, and forms of interaction to carry out feedback in virtual primary education.

Discussion

The study was based on the analysis of interviews with primary education teachers in virtual environments, which made it possible to identify common patterns summarized in a conceptual map. The interpretation process revealed three central dimensions of formative feedback for education: cognitive, focused on guiding understanding and self-regulation; socio-emotional, linked to motivational support and recognition of effort; and techno-pedagogical, related to the use of digital resources to streamline and personalize feedback. In this way, the data analysis revealed that, in their daily practice, teachers think of and perform feedback as a process that intertwines the academic, the emotional, and the technological.

Unlike previous studies focusing mainly on secondary or university levels, the present work provides a situated understanding of formative feedback in virtual primary education, a context scarcely explored in the international literature. The specificity of the primary level, marked by technological dependence, family mediation and the cognitive and socioemotional characteristics of children, generates a particular way of providing feedback that is not observed in other educational levels. This uniqueness justifies the need for a conceptual model specific to this segment, which was not systematized previously. The three dimensions identified in the conceptual model derive directly from the coding process. The cognitive dimension emerges from categories associated with understanding, objectives and performance; the socioemotional dimension arises from codes related to support, motivation and recognition of effort; while the technopedagogical dimension is grounded in the accounts referring to the use of digital tools and the management of online interaction. This direct link between the data and the model strengthens the interpretive coherence of the study.

The emerging conceptual model differs from approaches described in the international literature because it integrates within a single framework pedagogical, socioemotional and technopedagogical elements that in other studies are often addressed separately. In secondary and higher education contexts the emphasis tends to be on learner autonomy or technological efficiency, whereas in our study the teachers' practices reveal an interdependence between family mediation, technological availability and the need for continuous support characteristic of virtual primary education. This integrated approach constitutes a distinctive and necessary contribution to understanding feedback at this educational level.

Regarding the cognitive dimension, as mentioned, teachers emphasize that feedback ceases to be efficient when it is limited to pointing out errors. From there, the need for explanations and possible routes for improvement that support the development of understanding and self-regulation of learning is observed. Authors of studies agree with these perceptions; for example, Van der Kleij and Lipnevich (2020) argue that feedback is more efficient when it is clear, procedural, and actionable. However, some participants admitted that, despite their intervention, the feedback they usually provide is reduced to numerical grades. This reflects a culture centered on summative evaluations practiced by teachers (Vilca et al., 2022).

The socio-emotional dimension appears with the purpose of encouraging and boosting students' confidence with messages that seek to sustain motivation in virtual contexts, recognizing students' effort. This emotional role of feedback aligns with the findings of Green (2023), who details how children particularly value comments that encourage them to persevere, so that they may invent their own solutions.

Furthermore, current research has shown that feedback could have a beneficial impact on students' motivation, along with cognitive successes (Sortwell et al., 2024).

With regard to the techno-pedagogical dimension, teachers stated that they used platforms such as Google Classroom or WhatsApp to provide quick responses, maintaining contact with their students. Although these tools streamline the process, they admitted the lack of training to take advantage of resources that allow for more systematic and personalized follow-up. These results align with experiences from other contexts where student response systems simplify reciprocal feedback cycles (Pai, 2025), and video analytics help enrich collaboration and productive classroom discourse (Tong et al., 2025). Additionally, current literature has shown that digital technologies, including artificial intelligence–based solutions, can expand the possibilities of personalization and the speed of feedback, despite the challenges associated with the digital divide and teacher training (Anastasopoulou et al., 2024; Zhang et al., 2025).

By contrasting these three dimensions with international literature, significant coincidences and nuances appear. The results are consistent with those indicated by Van der Kleij and Lipnevich (2020), who emphasize that the effectiveness of feedback depends on its timeliness, clarity, and above all, its relevance so that it can be adequately used by students. At the same time, the most recent systematic reviews show that formative assessment generates positive effects on the learning of basic education students depending on the type of strategy and the content area (Sortwell et al., 2024). This article contributes by offering a qualitative perspective, since it shows that, in online primary teaching, the value given to feedback is measured not only in cognitive achievement but also in its capacity to sustain the pedagogical bond and motivation.

In this regard, the present study expands previous findings by showing that, in virtual primary education, formative feedback takes on a more distinctly dialogic and relational character than in other educational levels. While studies in secondary and higher education emphasize learner autonomy or instructional efficiency, primary school teachers describe a process shaped by adult mediation, the need to sustain affective bonds, and the adaptation to technological limitations. This contrast shows that feedback in virtual primary education constitutes a phenomenon with its own dynamics that justify its specific study. These elements do not usually appear in studies at other educational levels, and therefore represent original contributions of the analysis conducted.

Other authors highlight the central role of teachers' conceptions. Brown et al. (2025), in their research, found that if teachers value assessment as improvement, this tends to generate more coherent feedback practices, a fact that aligns with the designed model, which supports the idea of belief in assessment as a learning mechanism, as the basis of feedback practices. In the same line, Green's (2023) study in a primary education context shows that students appreciate processual feedback that allows them to develop their own solutions, which also agrees with the perceptions that, up to that point, a similar study collected in this work generated in its participants.

The most recent literature also draws attention to the role of technologies in the framework of feedback improvement. Pai (2025) proposes a reciprocal cycle of feedback through student response systems that allow the teacher to update instruction in real time. Likewise, Tong et al. (2025) indicate that the use of video analytics improves collaborative work and productive dialogue of low-achieving students. Both contributions establish dialogue within the techno-pedagogical dimension of the model. Research carried out in Latin America, such as that of Vilca et al. (2022), also warns that the school culture based on numerical grading cancels out the potential of feedback, which contrasts with the model presented here, centered on the construction of shared meanings. Our data show that technological effectiveness is conditioned not only by the availability of tools but also by their integration into the affective and support dynamics that characterize virtual primary education.

The search for recent literature nourishes this approach. Anastasopoulou et al. (2024), for example, explain that digital technologies (AI, LMS, VR/AR) facilitate immediate and personalized feedback while warning that they may also hinder pedagogy in different languages due to the digital divide or lack of teacher preparation. Altmann and Arnold (2024) show how peer learning feedback and interaction with e-tutors in international collaborative contexts (COIL) can foster learning and lighten teacher workload, which can serve as inspiration for other practices in virtual school contexts; while McCarthy et al. (2025) insist on the conceptual clarification of feedback and formative assessment, an important aspect for the coherence of models such as the one being presented. Recent research also explores the potential of AI-based automatic feedback tools, such as RATsApp, or frameworks based on language models that provide immediate, personalized, and scalable feedback (Kuzminykh et al., 2024; Steinert et al., 2024; Zhang et al., 2025).

In this study, we found findings that dialogue both with what has already been reported in the literature and with aspects specific to the context analyzed. As noted

by Green (2023) in primary students, the participating teachers expressed that feedback is experienced as a motivating and accompanying process, rather than as a simple correction of errors. The accounts also highlighted the centrality of the student and the role of feedback in the development of competencies, in line with what was described by Moya-Muñoz et al. (2025) and Imaicela Vega et al. (2025).

However, unlike exploratory research conducted at higher educational levels, here factors that are scarcely documented emerged: the influence of family mediation, the limitations derived from connectivity, and the need to employ strategies adjusted to children's age. These elements, according to the teachers themselves, condition the way feedback can be implemented in practice.

This contrast highlights the relevance of constructing a concrete conceptual structure for virtual primary education. In our view, this is an original contribution, since most of the studies preceding this research offer general feedback frameworks (Black & Wiliam, 2018; Van der Kleij & Lipnevich, 2020), but do not specify what conceptual structures respond to the particularities of this educational level.

Regarding the limitations, the present study is based on a small sample of teachers from a specific regional context, which restricts the generalization of the results. Likewise, the students' voices were not systematically included, an essential element to know the degree of congruence between teachers' intentions and the way feedback has been received (Van der Kleij & Lipnevich, 2020). Finally, the conceptual model we have developed has not yet been validated in terms of its direct impact on academic performance, which represents an aspect to be addressed in future research.

The implications are diverse. In terms of pedagogical practice, the results point to the need to strengthen teachers' feedback literacy, understood as their ability to provide models of comments that are clear, relevant, and usable by students (Brown et al., 2025). There is also a need to establish digital tools critically and contextually, leaving aside instrumentalization and emphasizing their pedagogical value (Anastasopoulou et al., 2024). Regarding future research, it is suggested to carry out comparative studies that include both teachers' and students' voices, and to conduct interventions whose impact is related to cognitive and socio-emotional learning.

Conclusions

As for the conclusion, the study carried out provides a conceptual model of formative feedback based on virtual primary education that articulates cognitive, socio-emotional, and techno-pedagogical dimensions. Its main contribution is to show that feedback is a dialogical and motivating process, deployed through technological resources and subordinated to teachers' conceptions. Although exploratory, the model serves as a basis for advancing pedagogical practice and guiding future research in more inclusive and technology-mediated contexts. However, the study presents limitations related to the regional nature of the sample, the absence of the students' perspectives, and the lack of empirical validation of the model, aspects that should be considered and further examined in future research.

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Understanding by Design (UbD) Model in Mathematics Teaching and its Impact on Students

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Abstract

The purpose of this study was to examine the impact of Understanding by Design (UbD) model in mathematics teaching on students' creative thinking skills, cognitive flexibility, and learning retention. Employing a pre-test post-test control group quasi-experimental design, the study involved 40 seventh-grade students, with 20 in the experimental group and 20 in the control group, attending a public school in Istanbul, Türkiye. While mathematics lessons were conducted using unit plans developed with the UbD instructional design model in the experimental group, no changes were made to the teaching approach in the control group. Data collection tools included the Torrance Creative Thinking Test, Cognitive Flexibility Scale, and a mathematics follow-up test. Data analysis involved Mann-Whitney U Test and Wilcoxon Signed Ranks Test. The results revealed a significant difference favoring the experimental group in terms of creative thinking skills, cognitive flexibility, and learning retention. These results suggest that UbD model in teaching plans can serve as valuable tools in enhancing creative thinking, cognitive flexibility, and learning retention.

Keywords:

Understanding By Design, Creative Thinking, Cognitive Flexibility, Learning Retention.

Introduction

Learning mathematics is crucial and indispensable in all facets and stages of life, as it fosters advanced skills such as problem-solving, communication, and creative, autonomous, and analytical thinking (Surya et al., 2017). In traditional mathematics teaching, teachers often emphasize abstract mathematical concepts and formulas, which may sometimes be presented with fewer concrete examples (Schoenfeld, 2022). Students are then tasked with reproducing this information through given exercises. However, Kılcan (2005) states that the most important purpose of mathematics is to develop the thinking skills that people possess since they were born to the world. The effectiveness of mathematics courses, designed to cultivate skills like logical, communication, creative, and critical thinking—crucial for problem-solving in daily life, is questionable within a traditional classroom setting where the teacher holds exclusive control (Stigler & Hiebart, 2009). The notion of 21st-century skills, a relatively new concept in the literature, encapsulates a framework outlining the skills

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that children need to be equipped with as they are prepared for the world they inhabit. To keep pace with evolving global conditions and even to drive change, it is imperative to nurture individuals capable of comprehending their era, analyzing societal needs innovatively, and embracing lifelong learning as a lifestyle. Achieving these goals necessitates aligning the education system with the acquisition of 21st-century skills (Sholihah et al., 2017; Uçak & Erdem, 2020).

Problems in Traditional Mathematics Teaching

Mathematics holds significant importance for improving students' cognitive capabilities and communication skills, both of which are vital for their everyday lives. However, most students struggle to develop an interest in mathematics, find it difficult to succeed in, and view it as abstract and unengaging. For some students, mathematics is a feared and hated subject (Huda et al., 2021). The challenges in mathematics education, such as insufficient concretization, lack of differentiation according to students' learning styles, and underutilization of necessary tools and materials, are widely recognized in the literature (Biber & Bakırcı, 2023; Filiz, 2023; Vitale et al., 2014). In education, the need for interactive methods where the learner is active, and the teacher is in a guiding position is increasingly evident in mathematics teaching as well (Hayati et al., 2024). Students struggle to learn subjects because they find it challenging to mentally visualize abstract concepts (Cao et al., 2021). For this reason, teachers should use various materials in their lessons to concretize abstract concepts.

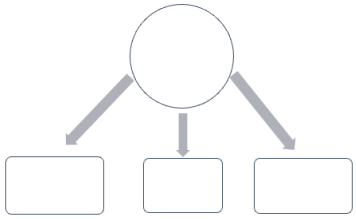
The Need for Innovative Approaches

Altun and Yurtseven (2019, p. 17) state that "The teacher is not just someone who mechanically follows a pre-set script in the classroom; rather, they are the primary orchestrator who crafts the script based on the classroom's atmosphere and dynamics, engages with their students in enacting the script, and assesses the resulting outcomes." This perspective signifies a process of acquiring a new identity and adopting a different perspective. In the construction of this new identity, there is a need for qualified professional development processes and the enhancement of teachers' design skills (Garet et al., 2001). Among the areas contributing to teachers' professional development are subject knowledge, planning and instructional skills, assessment competency, classroom management, and addressing individual differences in learning. The concept that emerges from the combination of these knowledge and skills is instructional design and there are numerous instructional design models that can be used while crafting the learning environment (Belay et al., 2022; Risnanosanti et al., 2023). Understanding by Design (UbD) is among these instructional design models.

The Understanding by Design (UbD) Model

The novel viewpoint introduced by UbD empowers teachers to shift from merely delivering pre-existing knowledge to students in a standardized format, enabling them to enhance both the teaching process and students' learning experiences, fostering active engagement in the learning journey (Yurtseven, 2016). From this perspective, learning retention is deeply connected to meaningful learning, as students are more likely to retain knowledge when they can actively apply it across different contexts. The ability to seamlessly transfer and utilize knowledge in various real-world situations demonstrates not only retention but also a deeper understanding, reinforcing the importance of instructional strategies that promote both long-term memory and practical application (Andrews et al., 2023). Moreover, the conveyance of content in teaching evolves from a fundamental objective to being a tool (Wiggins & McTighe, 2011). UbD stands as an instructional design framework emphasizing the cultivation of the learning retention and the transfer of knowledge to new environments through a backward design approach. The key aspects of this approach are setting goals that students can achieve, selecting evidence that demonstrates their achievement, and structuring activities accordingly (Altun & Yurtseven, 2019). Unlike traditional models where the learning plan takes precedence and the content delivery is prioritized, UbD puts strong emphasis on aspects such as students' inclination toward transfer of knowledge, their capacity to foster learning retention, and the emergence of evidence throughout the learning journey. UbD encourages students to investigate big ideas and find answers to essential questions, which improves higher-order thinking and the capacity to apply taught concepts across disciplines. The UbD framework excels at supporting creative thinking and cognitive flexibility. This model is frequently demanding in the sense that it encourages students to analyze, synthesize, and evaluate material and this promotes divergent and convergent thinking. Compared to other instructional design models that often emphasize content coverage and standardized assessments, UbD offers a structured yet flexible approach that is consistent with the goals of 21st-century skills, especially by promoting critical thinking, creativity, and problem-solving (Aristanti & Fatayan, 2024; Lai, 2023).

Figure 1.
Study Framework



UbD possesses distinguishing features that set it apart from other design models, including the big idea, essential questions, understanding, and transfer. As outlined by Wiggins and McTighe (2005), big ideas are impactful statements that are both memorable and centered on the core of the subject matter. Essential questions, introduced at the onset of each unit, prompt students to seek answers based on the information they acquire throughout the unit, serving to ignite students' curiosity. Furthermore, they constitute a pivotal component of UbD, capable of dispelling any misconceptions that may have previously taken root in students through the responses provided during the learning process. Essential questions, characterized by criteria such as avoiding binary yes-or-no responses and not being readily sourced from a singular origin, also play a crucial role in motivating students and nurturing their capacity for creative thinking. Another fundamental aspect of UbD is understanding and transfer (Altun & Yurtseven, 2019). To effectively apply their existing knowledge to novel scenarios, individuals must first establish learning retention in their current knowledge base. A pedagogical approach centered on learning retention equips students with skills applicable throughout their educational journey, fostering their capacity for critical thinking and inquiry rather than focusing solely on short-term exam success (McTighe, Seif & Wiggins, 2004). In essence, transfer refers to students' ability to utilize the knowledge and skills acquired in school through their own cognitive abilities, both within and beyond academic settings and in unfamiliar contexts (Azaryahu et al., 2023; Wiggns & McTighe, 2007). From this perspective, it can be deduced that the transfer component lays the groundwork for learning retention among students.

In recent years, various cognitive skills such as analytical, critical, creative, lateral, reflective, and collaborative thinking have gained prominence in academic research and educational policies worldwide. Among these, creative thinking plays a pivotal role in fostering diverse thinking skills (Ritter & Mostert, 2016). It can be viewed that creative thinking skill, in this context, serves as a comprehensive task encompassing other high-level thinking skills. As highlighted by Evans et al. (2023), nurturing curiosity in lessons fosters students' inclination towards inquiry, prompting them to delve deeper into the questions that pique their interest. Research emphasizes the importance of nurturing creative thinking skills, particularly in educational contexts, to establish supportive settings that foster children's creativity (Kalogeratos et al., 2023; Khotinets & Shihsova, 2023; Nurjanah et al., 2024; Sari et al., 2021). Moreover, creative thinking is increasingly valued in the 21st century, underlining its significance in personal and professional realms (Misechko & Lytnyova, 2022). Various researchers have proposed that creativity comprises four core dimensions: fluency, flexibility, originality (authenticity), and elaboration (enrichment) across diverse disciplines (Fisher, 1995; Rawlinson, 1981; Torrance, 1962). Creativity is essential for generating innovative solutions and outcomes, recognized as a metacognitive process that drives inventive problem-solving (Jung, 2013).

Various subjects have been linked to problem-solving skills, among which cognitive flexibility stands out. An individual who excels in problem-solving, a cognitive process, is also anticipated to demonstrate cognitive flexibility. Students' progress in mathematics learning hinges not only on their problem-solving skills but also on their cognitive flexibility (Taş & Deniz, 2018). Cognitive flexibility refers to an individual's capacity to restructure their own knowledge and respond adaptively to significantly changing situational demands (Martin & Rubin, 1995; Spiro et al., 1988). Drawing from these insights, Taş and Deniz (2018) have characterized cognitive flexibility as the ability to adopt different perspectives and the confidence in generating alternative solutions. In light of these definitions, flexibility and enrichment are observable within the dimensions of creative thinking skills inherent in cognitive flexibility. Flexibility entails embracing diverse viewpoints, exhibiting creativity in various forms, while enrichment involves delving into the intricacies of varied perspectives and evaluating them meticulously, all integral aspects of cognitive flexibility. Bilgin (2009) underscored the resemblance between cognitive flexibility and problem-solving skills, noting that both involve the exploration of diverse solutions. This observation highlights the significant and interconnected nature of cognitive flexibility and problem-solving skills. Individuals with high cognitive flexibility exhibit ease in making unexpected adjustments, while those with limited cognitive flexibility tend to resist change and encounter challenges (Mones & Massonnié, 2022). From this perspective, cognitive flexibility can be perceived as the capacity to adjust to varying circumstances, transition between different ideas, and approach diverse problems with multifaceted strategies. It encompasses the ability to alter response patterns, learn from mistakes, develop alternative strategies, allocate attention effectively, and process copious amounts of information simultaneously. Conversely, individuals lacking cognitive flexibility or possessing limited cognitive flexibility rely on rigid behavioral patterns and struggle to adapt to changes in sequence (Orakçı, 2021; Spiro et al., 1988).

Mathematics stands out as one of the most effective avenues for nurturing creative thinking skills, serving as a fundamental tool applicable in various facets of life and decision-making processes (Ibrahim et al., 2024). Hence, there exists a robust correlation between mathematics and creative thinking skills, which complement each other synergistically (Kim et al., 2016). By prioritizing and emphasizing the

problem-solving process, creativity can be fostered and observed during real-world problem-solving endeavors (Basadur et al., 2014). Implementing the UbD model in mathematics instruction entails designing and structuring lessons to facilitate students' comprehension and application of mathematical concepts. These plans offer significant advantages by also promoting and enhancing students' creative thinking capabilities. Within this framework, the UbD affords students the opportunity to cultivate problem-solving, critical thinking, and analytical skills. Engaging with and resolving real-world problems in mathematics classes contributes to the development of students' creative thinking skills. The emphasis on 'understanding' advocated by the UbD model encourages students to explore problems from diverse perspectives, fostering the discovery of innovative solutions (Wiggns & McTighe, 2005).

Rationale and Significance of the Study

Mathematics education is vital for helping students develop key skills like problem-solving, communication, and analytical thinking. Yet, traditional teaching methods often fall short, as they focus heavily on memorization and abstract concepts, leaving little room for creativity, adaptability, or meaningful connections to real-life situations. Research has shown the importance of cause-and-effect reasoning in math (Thuneberg et al., 2018), integrating 21st-century skills into teaching (Azaryahu et al., 2023), using effective instructional materials (Kul et al., 2018), and employing strategies to boost student success (Gürbüz et al., 2022). Still, there's a noticeable lack of studies that explore how 21st-century skills can be developed or how learning can be retained using innovative, design-focused teaching methods. One promising approach is Understanding by Design (UbD), a framework that flips the traditional way of planning lessons by starting with the desired learning outcomes and working backward to create activities that help students achieve those goals. This method encourages deeper understanding and helps students apply what they've learned to new situations. However, research on how UbD affects creativity, cognitive flexibility, and learning retention is still limited. Filling this gap is especially important for mathematics, a subject often seen as difficult but uniquely suited to foster creativity and adaptability—two skills that are crucial for thriving in today's rapidly changing world. This study addresses that challenge by examining how using UbD in math instruction impacts students' creative thinking, cognitive flexibility, and ability to retain knowledge. It also compares these results to traditional teaching methods, aiming to shed light on how innovative teaching approaches can better prepare students to meet the demands of the 21st century. In this regard, the purpose of this study was to examine the impact of Understanding by Design (UbD) model in mathematics teaching and its effects on students' creative thinking skills, cognitive flexibility, and learning retention. The research questions were outlined as follows:

1. What is the impact of the Understanding by Design (UbD) model on students' creative thinking skills in mathematics?
2. What is the impact of the Understanding by Design (UbD) model on students' cognitive flexibility in mathematics?
3. What is the impact of the Understanding by Design (UbD) model on students' learning retention in mathematics?

Method

Research Model

This study employed a quasi-experimental design with pre-test and post-test control groups to investigate the impact of UbD model in mathematics teaching on students' creative thinking skills, cognitive flexibility, and learning retention. While quasi-experimental studies do not involve randomization, they can still provide valuable insights into the impact of educational interventions. By comparing outcomes between groups that receive the intervention and those that do not, researchers can draw conclusions about the effectiveness of the intervention on the measured outcomes (Creswell, 2012). In this study, two pre-existing classes were designated as the experimental and control groups. Measurements were collected from both groups before and after the intervention to examine changes attributable to the UbD-based math instruction (Büyüköztürk et al., 2013). The research model can be found in Table 1.

Table 1

Research Model

Group	Pre-Tests	Intervention	Post-Tests
Experimental Group	Creative Thinking Test 1 Cognitive Flexibility Scale 1 Math Follow-Up Test 1	UbD-Based Math Instruction	Creative Thinking Test 2 Cognitive Flexibility Scale 2 Math Follow-Up Test 2
Control Group	Creative Thinking Test 1 Cognitive Flexibility Scale 1 Math Follow-Up Test 1	Traditional Math Instruction	Creative Thinking Test 2 Cognitive Flexibility Scale 2 Math Follow-Up Test 2

As seen in Table 1, the study included an instructional intervention, and pre and post-tests for both the experimental and control groups. The experimental group received UbD-Based Math Instruction, while the control group followed traditional math instruction. Both groups were assessed before and after the intervention using Creative Thinking Tests, the Cognitive Flexibility Scale, and the Math Follow-Up

Test to measure changes in learning outcomes.

Participants

The participants consisted of a total of 40 seventh-grade students, 20 of which were experimental and 20 of which were control students, enrolled in a public secondary school in Istanbul, Türkiye. Within the experimental group, 55% were female and 45% were male, in the control group, the gender distribution was 53% female and 47% male. The convenience sampling technique was used since the first researcher's students were included in the study, making it easier to access and involve participants and it ensured the feasibility and practicality of the study. The experimental and control groups were formed based on the principle of neutrality, ensuring that both groups had comparable academic achievement levels during the selection process.

Measures

Torrance Creative Thinking Test Verbal A and B forms, Torrance Creative Thinking Test Figural A and B forms, Cognitive Flexibility Scale and Mathematics Follow-Up Tests were used to collect the data in the study.

Torrance Test of Creative Thinking. The Torrance Test of Creative Thinking was published by Torrance (1966) and The Turkish equivalence, validity, and reliability studies for the test were conducted by Aslan (1999), affirming its validity and reliability in the Turkish context. Reliability assessments included test-retest and internal consistency calculations, yielding Cronbach's alpha correlation coefficients ranging between .89 and .86 for primary education. The test comprised verbal and figural subtests in two separate parallel forms, A and B. Each form consisted of 10 activities, with 7 in the verbal form and 3 in the figural form. Verbal tasks encompassed activities such as asking questions, estimating reasons, estimating results, product development, unusual uses, unusual questions, and achievement tests. The figural tasks involved picture construction, picture completion, and lines/circles tests, respectively. Following studies by Torrance and Ball (1984), new scoring criteria were established for the figural tests, resulting in two sets of scores: Norm-Resistant and Criterion-Resistant. Norm-resistant scores included originality, fluency, abstractness of titles, enrichment, and resistance to premature closure, whereas criterion-resistant scores consisted of thirteen categories, including emotional expression, story expression, movement or activity, expressiveness of titles, synthesis of incomplete figures, synthesis of lines, unconventional visualization, internal visualization, extending or crossing boundaries, humor, richness of imagination, colorfulness of imagination, and fantasy. The verbal form A booklet and figural form A booklet were administered as pre-tests, while the verbal form B booklet and figural form B booklet were administered as post-tests. Scoring of the administered Torrance Tests of Creative Thinking was conducted using a scoring guide. The scoring guide included a compilation of sentences that students might write (approximately 75-100 sentences) and specified the points that could be obtained for each sentence. Scoring for the figural forms was based on sub-dimensions such as fluency, originality, abstractness of titles, enriching details, resistance to premature closure, and creative strengths list.

Cognitive Flexibility Scale. Developed by Martin and Rubin (1995), Çelikkaleli (2014) studied the validity and reliability of the Turkish version of the Cognitive Flexibility Scale. The scale was a 6-point Likert-type measurement tool with responses ranging from 1 (strongly disagree) to 6 (strongly agree). The scale included items related to understanding the problem solving and cognitive flexibility levels of the participants. Following the adaptation study, the 11-item Turkish version of the scale, originally comprising 12 items, demonstrated a unidimensional structure that aligned with both exploratory (EFA) and confirmatory factor analysis (CFA) results. In reliability studies, internal consistency coefficients in three different samples were obtained as .74, .73 and .75 respectively.

Mathematics Follow-Up Tests. Follow-up tests were created and administered by the first researcher before and after the intervention to assess students' learning retention levels. These follow-up tests were designed based on the learning outcomes outlined in the unit plans. Initially, a pre-test encompassing all the learning outcomes for the semester was administered to two separate groups just before the intervention process. The multiple-choice test consisted of 20 questions and was scored on a scale of 100. The second follow-up test, administered after the implementation process was completed, served as a post-test for two distinct groups. Like the pre-test, the post-test contained 20 multiple-choice questions, with scores measured on a 100-point scale. Since the test was prepared by the teacher, steps were taken to ensure its validity and reliability. To ensure content validity, initial item pools of questions were generated based on the learning outcomes specified in the curriculum for both tests. Three mathematics education experts independently reviewed each item for relevance, alignment with the curriculum, cognitive level, and linguistic clarity. Revisions were made based on their feedback, and overlapping or irrelevant items were removed from tests. Before the implementation, each test underwent a pilot study with separate groups of students who were not included in the main study to evaluate clarity, difficulty level, and consistency. The item difficulty and discrimination indexes were calculated. Item difficulty ratings varied from.40 to.78, indicating a moderate overall difficulty level, while item discrimination values ranged from.32 to.67, meeting suggested levels

for classroom assessment tools. Items falling below acceptable limits were revised or replaced prior to final administration. Internal consistency reliability was examined using Cronbach's alpha. The pilot study yielded an alpha coefficient of .81, and the final version produced an alpha of .84 in the main study, indicating good reliability.

Data Analysis

The Mann-Whitney U Test and Wilcoxon Signed Ranks Test were employed to analyze the data due to the small sample size and non-parametric nature of the data distribution. These methods are appropriate for comparing pre-test and post-test scores within and between groups.

Procedure

As part of the study, official approval was obtained from the school administration where the intervention took place, as well as ethics committee approval from the researchers' affiliated university. Subsequently, two separate classrooms were set up, each assigned to either the experimental or control group. Throughout the semester, continuous evaluations were conducted to monitor the progress of the experimental process and ensure its effectiveness.

For the experimental group, seven unit plans were crafted in accordance with the UbD instructional design model. For each unit, Stage 1 identified the desired learning outcomes aligned with the national mathematics curriculum; Stage 2 specified acceptable evidence of learning, including performance tasks and formative assessments; and Stage 3 outlined the detailed learning experiences and instructional activities. To strengthen creative thinking and cognitive flexibility, the lessons incorporated open-ended tasks, problem-based activities, and structured games that required reasoning, flexible thinking, and multiple-solution exploration. The lesson plans included specially designed materials, such as manipulatives, graphic organizers, learning stations, and reflective worksheets. The researcher–teacher prepared all necessary resources (e.g., task cards, visual prompts, digital applets, and problem scenarios) and ensured their availability before each session. To enrich the cultivation of creative thinking skills and cognitive flexibility among students, specific components tailored to these aspects were integrated into the lesson plans. Careful selection of games and activities aimed at nurturing creative thinking and cognitive flexibility ensued to meet these objectives. Furthermore, supplementary materials and resources essential for the smooth execution of these activities were identified, prepared, and made readily accessible by the researchers.

To illustrate the instructional process, the unit on "Polygons" included a 150-minute lesson implemented as follows:

1. Hook / Warm-Up (10 minutes): To spark students' curiosity and interest, the lesson began by introducing the "big idea." The big idea was discussed together with the students. For the polygons unit, the big idea was introduced by showing students an image of a shape composed of many overlapping triangles and asking, "How many triangles do you think are in this figure?" a discussion environment was created based on students' responses.

2. Exploration Task (50 minutes): First, the questions "What is a polygon?", "Where do we encounter polygons in our daily lives?", "How do we define a polygon?", and "Is every shape in geometry a polygon?" were presented to the students, and a brainstorming session was conducted to collect their ideas. The purpose of this stage was to assess students' prior knowledge and eliminate any misconceptions they held. Using the fishbowl (Aquarium) discussion technique, students expressed their thoughts on statements that were open to debate or closely related to possible misconceptions. Sample questions included:

> *"Is a rhombus a regular polygon?"*
>
> *"Can we draw a polygon with infinitely many sides?"*
>
> *"How do we calculate the sum of the interior angles of a polygon?"*
>
> *"Can a polygon be drawn using only two line segments?"*
>
> *"Does a triangle have a diagonal?"*

The teacher asked these questions in an order aligned with the unit outcomes. Using students' responses, the topic was taught systematically, and misconceptions were addressed.

3. Concept Development (30 minutes): The activity "Create Your Cubism Artwork" was implemented. The Six Thinking Hats technique was used during this activity. Students were asked to research the influence of Cubism in artwork. Then, examples of Picasso's Cubist paintings were shown in class. Each student was given one of the six hat colors and asked to create their own artwork in the Cubist style, ensuring that the polygon types learned in the lesson were prominently used in their drawings. Afterwards, students presented their artwork and explained their perspectives based on the color of their hat. The goal of using the Six Thinking Hats technique was to develop students' creativity, multi-dimensional thinking, and decision-making skills.

4. Performance Task (50 minutes): The performance task titled "What If Countries Had Polygon Shapes?" was carried out. Students examined the world map and the borders of countries and then redesigned these borders so that each country would become a polygon (based strictly on the polygon rules discussed in class—for example, all polygons must have straight edges, and every polygon must be a closed shape). In this task, students assumed the role of map engineers who highly value art. They presented their performance task to an audience consisting of their classmates and teacher. While creating their redesigned maps, students were free to use all types of polygons they had learned (such as concave or convex polygons). Throughout the task, the teacher served as a guide, and students kept a project journal in which they documented and planned their process. A rubric prepared by the teacher beforehand was used to assess students' performance.

5. Reflection (10 minutes): Finally, a summary activity titled "What Did We Learn?" was conducted to review the unit. Students completed a brief reflection card focusing on how they used flexible reasoning during the activity. Table 2 demonstrates examples about the linking of learning outcomes to UbD-based tasks and types of thinking:

These examples demonstrate how UbD stages were operationalized through authentic, inquiry-driven, and creativity-enhancing learning activities. While the experimental group engaged in lessons structured as described above, the control group followed the school's standard mathematics curriculum using traditional direct instruction, textbook-based practice, and routine exercises. No UbD-specific activities, open-ended tasks, or creativity-focused materials were used.

Following the comprehensive preparations for the experimental process, pre-tests were administered to gauge students' baseline levels, after which the planned implementations commenced. Throughout the implementation period, rigorous attention was devoted to ensuring that the activities effectively elicited creative thinking and cognitive flexibility, thereby fostering a vibrant and captivating learning environment for the students.

Table 2

Examples about learning outcomes, UbD-based tasks, and types of thinking

Unit Name	Learning Outcome	UbD-Integrated Activity	Type of Thinking Targeted
1. Ratio and Proportion	Students understand that the constant of proportionality in direct proportion is obtained by dividing one quantity by another.	"MiniaWorld 3D Virtual Tour" activity	Creative thinking: • Enrichment • Flexibility Cognitive flexibility: • Ability to view from different perspectives
2. Percentages	Students understand that concepts such as discount, increase, inflation, and decrease become easier to interpret when expressed using percentages.	"Silent Cinema with Percentages" activity	Creative thinking: • Fluency • Flexibility Cognitive flexibility: • Awareness and use of alternative options
3. Lines and Angles	Students understand that angles are the fundamental factor in the construction of all structures—small or large, simple or magnificent—worldwide.	"Let My Bicycle Describe Me" activity	Creative thinking: • Originality • Richness Cognitive flexibility: • Transferability of knowledge to new contexts
4. Polygons	Students understand that a polygon cannot be drawn with two line segments, and that at least three line segments are required for a closed shape.	"What If Countries Had Polygon Shapes?" activity	Creative thinking: • Richness • Fluency Cognitive flexibility: • Moving away from narrow and rigid viewpoints
5. Circle and Disk	Students state that the filled interior of a circle is a disk, and that the region between the arms of a central angle is a sector of the disk.	"Alternative Mandala: Slices from Nature" activity	Creative thinking: • Originality • Enrichment Cognitive flexibility: • Transferability of knowledge

Results

Determining the readiness levels of the experimental and control groups before the implementation is important for the healthier conduct of the research. As such, initially, the pre-test scores of both groups in verbal creativity, figural creativity, cognitive flexibility, and learning assessments were compared using the Mann-Whitney U Test. Table 3 displays the pre-test scores of students in verbal creativity, Table 4 shows the pre-test scores of students in figural creativity, Table 5 outlines the pre-test scores of students in cognitive flexibility, and Table 6 illustrates the pre-test scores of students in the learning assessment, based on the results of the Mann-Whitney U Test.

Table 3

Results of Mann-Whitney U Test Regarding Verbal Creativity Pre-test Scores

	N	Average Rank	Total Rank	U	p	Effect Size (r)
Experimental Group	20	16.95	339.00	129.00	.055*	0.30
Control Group	20	24.05	481.00			

* p>0.05

Table 3 presents the results regarding the Mann-Whitney U test conducted on the verbal creativity scores of the students participating in the study to determine whether there was a difference in verbal creativity pre-test scores between the experimental and control groups. The analysis revealed that there was no significant difference in the pre-test scores of verbal creativity between the experimental and control groups (U = 129.00, p > 0.05, r = 0.30).

Table 4

Results of Mann-Whitney U Test Regarding Figural Creativity Pre-test Scores

	N	Average Rank	Total Rank	U	p	Effect size (r)
Experimental Group	20	19.95	399.00	189.00	.76*	0.04
Control Group	20	21.05	421.00			

* p>0.05

The results of the Mann-Whitney U Test concerning the pre-test scores of students' figural creativity are displayed in Table 4. The analysis indicated that there was no significant difference in figural creativity pre-test scores between the experimental and control groups (U = 189.00, p > 0.05, r = 0.04).

Table 5

Results of Mann-Whitney U Test Regarding Cognitive Flexibility Pre-Test Scores

	N	Average Rank	Total Rank	U	p	Effect size (r)
Experimental Group	20	18.52	370.50	160.50	.28*	0.17
Control Group	20	22.48	449.50			

* p>0.05

The results of the Mann-Whitney U test regarding the cognitive flexibility scores of the students involved in the study are shown in Table 5, examining whether there were variations in the cognitive flexibility pre-test scores between the experimental and control groups. According to the analysis, there was no notable distinction in cognitive flexibility pre-test scores between the experimental and control groups (U = 160.50, p > 0.05, r = 0.17).

Table 6

Results of Mann-Whitney U Test Regarding Learning Pre-Test Scores

	N	Average Rank	Total Rank	U	p	Effect size (r)
Experimental Group	20	20.88	417.50	192.50	.83*	0.03
Control Group	20	20.13	402.50			

* p>0.05

Table 6 presents the results of the Mann-Whitney U test regarding the learning scores of the students participating in the research, examining whether the learning pre-test scores differed between the experimental and control groups. The analysis revealed that there was no significant difference in learning pre-test scores between the experimental and control groups (U = 192.50, p > 0.05, r = 0.03).

Results Regarding the First Research Question

To answer the first research question, which was stated as "What is the impact of the Understanding by Design (UbD) model on students' creative thinking skills in mathematics?", the pre-test and post-test scores of students from the Torrance Test of Creative Thinking Test were compared.

Table 7

Results of the Mann-Whitney U Test Regarding Verbal Creativity Post-Test Scores

	N	Average Rank	Total Rank	U	p	Effect size (r)
Experimental Group	20	30.50	610.00	0.00	.00*	0.85
Control Group	20	10.50	210.00			

* p<0.05

Table 7 displays the results concerning the distinction in post-test scores for verbal creativity between the experimental and control groups. The analysis indicated a significant difference in verbal creativity post-test scores between the experimental and control groups (U = 0.00, p < 0.05). Furthermore, a large effect was found in favor of the experimental group (r = 0.85), indicating strong gains in verbal creativity. In other words, the post-test scores for verbal creativity were markedly higher in the experimental group compared to the control group, indicating a notable impact of the intervention on enhancing verbal creativity skills.

Table 8

Results of the Mann-Whitney U Test Regarding Figural Creativity Post-Test Scores

	N	Average Rank	Total Rank	U	p	Effect size (r)
Experimental Group	20	29.35	587.00	23.00	.00*	0.75
Control Group	20	11.65	233.00			

* p<0.05

Table 8 presents the results regarding the difference in figural creativity post-test scores between the experimental and control groups of the students participating in the research. The analysis revealed that there was a significant difference in figural creativity post-test scores between the experimental and control groups (U = 23.00, p < 0.05) and a significant and large effect favored the experimental group (r=0.75). In other words, it was found that figural creativity post-test scores favored the experimental group.

Table 9

Results of the Wilcoxon Signed Ranks Test for Experimental Group Verbal Creativity Pre-Test and Post-Test Scores

Pre-Test – Post-Test	N	Average Rank	Total Rank	Z	p	Effect size (r)
Positive Rank	18	10.83	195.00	-3.36	.01*	0.75
Negative Rank	2	7.50	15.00			
Equal	0					

*p < 0.05

Table 9 illustrates the results of the Wilcoxon Signed Ranks Test aimed at assessing the potential difference between the pre-test and post-test scores for verbal creativity within the experimental group. The examination unveiled a statistically significant difference between the pre-test and post-test scores (Z = -3.36, p < 0.05) and there was a large effect size (r = 0.75). This difference favored the post-test outcomes, suggesting a significant enhancement in the verbal creativity scores of students following the group interventions.

Table 10

Results of the Wilcoxon Signed Ranks Test for Verbal Creativity Pre-Test and Post-Test Scores of the Control Group

Pre-Test – Post-Test	N	Average Rank	Total Rank	Z	p	Effect size (r)
Positive Rank	0	0.00	0.00	-3.92	.00*	0.88
Negative Rank	20	10.50	210.00			
Equal	0					

*p<0.05

Results of the Wilcoxon Signed Ranks Test for Verbal Creativity Pre-Test and Post-Test Scores of the Control Group are presented in Table 10. The analysis revealed that there was a statistically significant difference between the pre-test and post-test scores (Z=-3.92, p<0.05) and the effect size was large (r=0.88). This difference occurred in favor of the pre-test.

Table 11

Results of the Wilcoxon Signed Ranks Test for the Pre-Test and Post-Test Scores of Figural Creativity of the Experimental Group

Pre-Test – Post-Test	N	Average Rank	Total Rank	Z	p	Effect size (r)
Positive Rank	17	11.71	199.00	-3.51	.00*	0.79
Negative Rank	3	3.67	11.00			
Equal	0					

*p<0.05

Table 11 displays the outcomes of the Wilcoxon Signed Ranks Test assessing the pre-test and post-test scores of figural creativity within the experimental group. The analysis uncovered a statistically significant difference between the pre-test and post-test scores with a large effect size (Z = -3.51, p < 0.05, r = 0.79). This difference favored the post-test scores. In other words, the figural creativity scores of the students in the experimental group significantly increased after the interventions.

Table 12

Results of the Wilcoxon Signed Ranks Test for the Pre-Test and Post-Test Scores of Figural Creativity of the Control Group

Pre-Test – Post-Test	N	Average Rank	Total Rank	Z	p	Effect size (r)
Positive Rank	0	0.00	0.00	-3.92	.00*	0.88
Negative Rank	20	10.50	210.00			
Equal	0					

*p<.05

As seen in Table 12, the Wilcoxon Signed Ranks Test was conducted to determine if there was a significant difference between the pre-test and post-test scores of figural creativity for the students in the control group. The statistical analysis revealed a significant difference in the ranks' means with a large effect size (Z = -3.92, p < 0.05, r = 0.88). This difference favored the pre-test scores.

Results Regarding the Second Research Question

To answer the second research question, stated as "What is the impact of the Understanding by Design (UbD) model on students' cognitive flexibility in mathematics?", the pre-test and post-test scores of students from the Cognitive Flexibility Scale were compared.

Table 13

Results of the Mann-Whitney U Test Regarding Cognitive Flexibility Post-Test Scores

	N	Average Rank	Total Rank	U	p	Effect size (r)
Experimental Group	20	30.10	602.00	8.00	.00*	0.82
Control Group	20	10.90	218.00			

* p<0.05

Table 13 displays the analyses of the Mann-Whitney U test regarding the cognitive flexibility scores of the participating students. According to the analyses, there was a significant difference in cognitive flexibility post-test scores between the experimental and control groups with a large effect size (U = 8.00, p < 0.05, r = 0.82). In other words, cognitive flexibility post-test scores favored the experimental group.

Table 14

Results of the Wilcoxon Signed-Rank Test for Experimental Group Cognitive Flexibility Pre-Test and Post-Test Scores

Pre-Test – Post-Test	N	Average Rank	Total Rank	Z	p	Effect size (r)
Positive Rank	20	10.50	210.00	-3.92	.00*	0.88
Negative Rank	0	0.00	0.00			
Equal	0					

*p<.05

Table 14 illustrates the results of the Wilcoxon Signed-Rank Test for the pre-test and post-test scores of cognitive flexibility in the experimental group. The analysis indicated a statistically significant difference between the pre-test and post-test averages with a large effect size (Z = -3.92, p < 0.05, r = 0.88). This difference favored the post-test. In other words, the cognitive flexibility scores of the experimental group students significantly increased after the group interventions.

Table 15

Results of the Wilcoxon Signed-Rank Test Regarding Control Group Cognitive Flexibility Pre-Test and Post-Test Scores

Pre-Test – Post-Test	N	Average Rank	Total Rank	Z	p	Effect size (r)
Positive Rank	18	10.36	186.50	-3.76	.00*	0.84
Negative Rank	1	3.50	3.50			
Equal	1					

*p<.05

Table 15 displays the outcomes of the Wilcoxon Signed-Rank Test conducted to determine whether there was a significant difference between the cognitive flexibility pre-test and post-test scores of the control group students. According to the analysis, there was a statistically significant difference between the pre-test and post-test means with a large effect size (Z = -3.76, p < 0.05, r =0.84). This difference occurred in favor of the post-test. In other words, the cognitive flexibility scores of the students in the control group significantly increased after the group interventions.

Results Regarding the Third Research Question

To answer the third research question, "What is the impact of the Understanding by Design (UbD) model on students' learning retention in mathematics?", the pre-test and post-test scores of students from the mathematics course follow-up test were compared.

Table 16

Results of the Mann-Whitney U Test Regarding Learning Retention Post-Test Scores

	N	Average Rank	Total Rank	U	p	Effect size (r)
Experimental Group	20	26.00	520.00	90.00	.03*	0.47
Control Group	20	15.00	300.00			

* p<0.05

Table 16 displays the results of the Mann-Whitney U test regarding the learning retention scores of the students involved in the study. The analysis indicated a notable distinction in learning post-test scores between the experimental and control groups with a medium effect size (U = 90.00, p < 0.05, r = 0.47). In other words, it was found that learning retention post-test scores favored the experimental group.

Table 17

Results of the Wilcoxon Signed Ranks Test Regarding Pre-Test and Post-Test Scores of the Experimental Group for Learning Retention

Pre-Test – Post-Test	N	Average Rank	Total Rank	Z	p	Effect size (r)
Positive Rank	20	10.50	210.00	-3.94	.00*	0.88
Negative Rank	0	0.00	0.00			
Equal	0					

*p<.05

As can be seen in Table 17, the analysis regarding pre-test and post-test scores of the experimental group for learning retention revealed a statistically significant difference between the pre-test and post-test averages with a large effect size (Z = -3.94, p < 0.05, r =0.88). This difference favored the post-test scores, indicating that the learning retention scores of the experimental group significantly increased after the group interventions.

Table 18

Results of the Wilcoxon Signed Ranks Test Regarding Pre-Test and Post-Test Scores of the Control Group for Learning Retention

Pre-Test – Post-Test	N	Average Rank	Total Rank	Z	p	Effect size (r)
Positive Rank	11	9.86	108.50	-.55	.58*	0.12
Negative Rank	8	10.19	81.50			
Equal	1					

*p>.05

The Wilcoxon Signed Ranks Test was conducted to determine if there was a significant difference between the pre-test and post-test scores obtained from the learning retention test by the students in the control group. As seen in Table 18, the analysis revealed that there was no statistically significant difference between the mean scores of the pre-test and post-test and the effect size was small (Z = -.55, p > 0.05, r = 0.12).

Discussion

The study demonstrated that UbD model in mathematics teaching had a positive impact on students' creative thinking skills, cognitive flexibility, and learning retention. The experimental group showed significantly higher post-test scores compared to the control group in all three areas, indicating the effectiveness of these interventions. These findings highlight the potential of UbD model to enhance critical cognitive and creative skills in secondary school mathematics education. The results support the integration of UbD principles into teaching practices to improve student outcomes and suggest further research to validate these benefits across diverse educational settings and extended timelines.

A further analysis of the learning–teaching experiences adopted in the experimental group could provide basis for understanding these positive findings. Performance tasks, real life problem scenarios, concept maps construction and model development were some of the activities in which students were involved during the UbD intervention program in this study to enable them to apply mathematical concepts in reality. Essential questions and big ideas supported learners to think deeply conceptually, while intentionally constructed formative assessments prompted them to explain their thinking, challenge assumptions, and further develop their ideas. In addition, the learning environment situated students as problem-solvers and designers rather than consumers of knowledge passively waiting to be filled. Over time, hands-on materials, group-based investigations, and opportunities for diverse solution paths supported creativity and cognitive flexibility as students were constantly asked to create alternatives, consider options and justify decisions. These specific aspects of the practice of UbD – in particular, a focus on transfer, authentic tasks, and student agency – led directly to the significant gains in creative thinking, cognitive flexibility and learning retention found with students participating in experimental group.

The UbD instructional design model holds significant importance in enabling students to engage in various actions such as designing, exhibiting, deriving, modeling, illustrating, narrating metaphorically, storytelling, constructing, producing original products, inventing, imagining, and role-playing, thus contributing to the demonstration of their creativity during math classes. The UbD-based activities initiated in the experimental group in this study certainly helped produce these gains, and a clear cause-effect relationship can therefore be drawn between the instruction and its effects. Throughout the whole intervention, students used concrete materials, created models, formulated their own questions and reflected in classroom discussions that were organized based on big ideas and essential questions. These activities enabled students to reflect on the problems from several viewpoints, generate new solutions and progressively elaborate upon them. Since the instructional design constantly placed students in a needful position for designing, reasoning, representing and evaluating while operating the dynamic models, only through independent practicing their creative thinking power could be strengthened instead of simply exposure to. In the control group, in contrast, opportunities pertained to direct explanation and procedural exercises. As a result, the fact that the control group achieved lower creativity scores reflects in their limited chances to conceptualise or develop other concepts or come up with unique ideas.

A creative learning environment is essential for children to demonstrate their creative thinking skills. Learning environments where children interact with each other the most, when designed accordingly, will facilitate the development of their creative abilities (Fan & Cai, 2020). Moreover, it is important to provide a learning environment where students are active, can apply what they have learned to real-life situations, and can acquire long-term knowledge and skills, as opposed to traditional and memorization-based learning (Som et al., 2016). Considering that traditional teaching methods were applied in the control group, it was observed that control group students experienced disengagement from classes, submitted their assignments late and carelessly, and their interest and attendance in classes decreased over time. This situation is thought to have affected the students' post-test results. From this perspective, it can be said that UbD's unique learning approach, encouraging curiosity, interaction, and active learning experiences, contributes to the creative thinking skills of the experimental group students.

The higher average post tests results in the experimental group can be understood by examining how students were engaged during learning. UbD-based lessons were always learner-active lessons: students engaged in collaborating tasks to solve problems; they discussed aloud alternative ways to solve them and give reasons for it with their classmates; they compared representations of mathematical entities. In addition to promoting deeper understanding, the structured opportunities for dialogue and collaboration stimulated students' consideration of multiple perspectives—a strong predictor both of creativity and cognitive flexibility. Concrete examples provided for students helped them understand abstract ideas, which in turn supported stronger understanding and enabled more consistent retention of information. Thus, the better performance of the experimental group is not merely an effect but instead a natural consequence of participatory, interactive and meaning-centred learning processes integrated in the UbD framework.

The emergence of cognitive flexibility depends on two types of interaction: the interaction of several cognitive mechanisms and the interaction of sensory-motor mechanisms, cognition, and context over developmental time. Comprehensive and integrated cognitive flexibility is highly beneficial and important in encouraging students to engage in effective problem-solving and creativity (Lonescu, 2012). Cognitive flexibility holds significant importance in the education of students, shaping them into individuals capable of navigating life successfully, adapting to new circumstances and changes, fostering curiosity, productivity, creativity, and innovation. It entails the capacity to alter response patterns, derive lessons from errors, devise alternative approaches, manage attention effectively, and handle substantial information simultaneously (Gabrys et al., 2018). This is because cognitive flexibility focuses on the transfer of knowledge and the use of knowledge in different learning environments after initial learning situations (Braem & Egner, 2018; Tello-Ramos et al. 2019). The UbD model in mathematics teaching conducted in the scope of the research contributed to the development of the mentioned skills in lessons within the framework of cognitive flexibility. Flexible learning processes, where information can be used from different perspectives and alternative solutions to problems are sought, provide valuable contributions to the development of such skills.

The fundamental concept of transfer, emphasized by the UbD instructional design model, highlights areas where students can transfer what they have learned to independent and new learning environments, corresponding to their needs for lasting understanding or learning. For a teacher to determine whether their students have genuinely learned and comprehended the material, they need to pay attention to certain actions during the application process, such as explaining, expressing, convincing, predicting, proving, synthesizing, evaluating, transforming, judging, suggesting, utilizing, making decisions and choices, investigating reasons, comparing, distinguishing similarities and differences, drawing conclusions, making connections, being aware, self-assessing, and empathizing (Altun & Yurtseven, 2019). A teaching process based on enduring understanding not only contributes to students' success in short-term exams but also helps them acquire skills they can use throughout their educational lives, enhancing their critical thinking and questioning abilities (McTighe et al., 2004). In this context, the studies conducted within the scope of the current study may have had a positive impact on the learning retention levels of the experimental group students.

"Schools may perceive themselves as ambitious when striving to achieve uniformity among all students, yet they fail to recognize that educational systems promoting homogeneity inadvertently label themselves as dull institutions that overlook the unique differences among students." (Altun & Yurtseven, 2019, p. 22). However, in the 21st century, to adapt to changing world conditions and even to influence change, it is necessary to raise individuals who understand the era they live in well, can analyze the needs of the society they are in, think innovatively, and have made lifelong learning a lifestyle. Undoubtedly, all of these are possible through adapting educational systems to impart 21st-century skills. Among these skills, creative thinking skills contribute to versatile skills such as demonstrating originality and creativity in the workplace, developing new ideas that will benefit others, being open and adaptable to new and different perspectives, and providing concrete and useful assistance with creative ideas in areas where innovation is developing. On the other hand, cognitive flexibility will enable individuals to be aware of their alternatives before deciding on their actions, be flexible in adapting to situations, and feel competent when they are flexible in situations where they can be flexible.

The study's findings align with similar research outcomes in the literature, underscoring the effectiveness of UbD model in enhancing students' critical thinking, skills, and knowledge retention. Bodur and Yurtseven (2021) highlighted how using UbD model in creative drama activities improve student engagement and skills, while Alper and Deryakulu (2008) showed significant gains in cognitive flexibility, achievement, and learning retention through web-based problem-based learning. Gürbüz et al. (2022) demonstrated positive impacts on academic success and learning retention in mathematics, supporting the benefits of UbD model. Additionally, findings from the

studies conducted by Gül, Altun, and Yücel-Toy (2021) revealed that during the implementation process, the UbD model's fundamental components, such as big ideas, essential questions, and transfer expressions, significantly facilitated students' comprehension and transfer of knowledge by encouraging them to think critically and question the subject matter. In another study, Lai (2023) examined the integration of the UbD-Internet of Things (UbD-IoT) education framework with design thinking and computational thinking, demonstrating its effectiveness in enhancing students' problem-solving abilities and deeper thinking skills and gound out that the UbD framework had a critical role in fostering cognitive flexibility. Lastly, Çelikman-Hanratty and Eveyik-Aydın (2023) aimed to investigate the effectiveness of UbD in English as a Foreign Language (EFL) instruction. They found out that it promoted creative instructional designs that supported contextual learning, ultimately enhancing creativity and adaptability among learners.

Conclusion

The results demonstrate the value of embedding UbD model in teaching mathematics to develop students' creativity, cognitive flexibility, and learning retention. This study provides evidence supporting the adoption of UbD model in designing the instruction secondary school mathematics teaching. Future research would be well-advised to investigate the long-term impact of UbD on diverse student populations as well as cross-disciplinary exploration of its effectiveness to validate and expand its value in education.

Limitations

Despite the positive outcomes, several limitations should be noted. Firstly, the small sample size (N=20 per group) limits the extent to which the findings can be generalized, as a larger sample might yield more reliable data. Although the pre-test comparisons indicated no significant differences between the groups, the relatively small sample size may have reduced the statistical power of these tests. Future research should aim to address these limitations by incorporating larger sample sizes and diverse educational settings. As a second limitation, the duration of the study might be mentioned as it may not adequately reflect the long-term impacts of the UbD model on students' creative thinking, cognitive flexibility, and learning retention. Future studies can integrate longitudinal designs to validate and extend the findings. Finally, the study was conducted in a specific educational setting, which may limit the applicability of the results to other contexts or subjects. Future research should consider expanding the study to include a broader range of educational settings or subjects to enhance the applicability of the results. By diversifying the contexts in which similar research is conducted, researchers can better understand how findings may vary across different environments and populations.

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O.G.: writing the original draft, implementation, data collection, data analysis, interpretation of the data. N.Y.: conceptualization, research design, writing the original draft, review and editing, data curation.

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Data availability

The dataset used in this research is available upon request.

Competing interests

The authors declare no competing interests.

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The ECRIF Framework for enhancing vocabulary learning among Elementary EFL learners in Ecuador

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Abstract

Vocabulary plays a fundamental part in learning English as a Foreign Language (EFL). A solid vocabulary base allows learners to understand others and, concurrently, communicate adequately. The effectiveness of the ECRIF (Encounter, Clarify, Remember, Internalize and Fluently Use) framework in triggering vocabulary learning among sixth-grade EFL students in a public school in Ecuador was explored using the mixed-methods design. Quantitative and qualitative approaches were combined to assess how students' vocabulary improved and understand the perceptions of the teacher on using the framework. Fifty-six students were assigned to experimental and control groups. The experimental group used the ECRIF framework for sixteen weeks, whereas the control group did according to the conventional method of memorization. Data were obtained through pre and post-tests and a semi-structured interview with the teacher of the experimental group. The results showed that the experimental group enhanced their vocabulary significantly in comparison to the control group. The qualitative results indicated that ECRIF helps learners to become more involved, autonomous and motivated through its interactive and student-oriented instruction. Overall, the study concludes that the application of ECRIF can increase students' vocabulary development, retention and independent learning, particularly in cases where there is a common use of traditional methods for teaching English. It is thus advised that EFL teachers adopt the ECRIF framework for strengthening students' vocabulary and presenting them with more stimulating learning experiences.

Keywords:

ECRIF Framework, Vocabulary Learning, EFL Students, Student-Oriented Instruction.

Introduction

Students who are learning English need to develop their English vocabulary as it is a fundamental aspect of understanding and producing proper language utterances. The function of vocabulary in language use is central because it helps learners construct meaningful and contextually appropriate output (Robiya et al., 2024; Yuldosheva, 2024). In English as a Foreign Language (EFL) classrooms, particularly at the secondary level, vocabulary proficiency is often a reliable predictor of learners' overall

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language competence and academic success (Schmitt & Schmitt, 2020; Webb & Nation, 2020). As Wilkins (1972) noted, "Without grammar, very little can be conveyed; without vocabulary, nothing can be conveyed" (p. 111). Before mastering the four skills, students need to acquire vocabulary to support them during their learning process (Mahamed, 2024; Simamora & Oktaviani, 2020). Vocabulary is therefore central to language learning, as it enables learners to construct meaningful communication. The more vocabulary a learner knows, the easier it will become to strengthen other writing and speaking skills (Sari & Aminatun, 2021; Serang & Sahib, 2023). Moreover, having a good grasp of vocabulary directly impacts the capacity to build language proficiency (Nation, 2022).

In Ecuador, English is considered a key component in the national curriculum and is a compulsory subject from basic education through secondary education. In addition, the Ministry of Education has promoted projects for optimizing English language teaching, curriculum updates, and the provision of teaching support materials. Despite curriculum reforms and teacher training initiatives, many students continue to rely on memorization and translation, resulting in limited productive vocabulary use and the ability to participate in more complex linguistic exercises (Ministerio de Educación, 2020). The 2024 Education First English Proficiency Index ranked Ecuador in the 82nd out of 113 countries in the 'low proficiency' category (Education First, 2024). This result reflects overall communicative performance, and it does not necessarily indicate that students' vocabulary proficiency is low. Some studies in Latin American EFL contexts have shown that English proficiency scores mask significant differences across linguistic components, particularly in students' vocabulary knowledge (Caldas & Békés, 2020; Nur & Jusoh, 2022). In Ecuador, classroom observation and curriculum evaluations indicate that many students can identify isolated words but still have difficulties in using vocabulary productively, especially in tasks that require retrieval, contextualization, and fluency (Caldas & Békés, 2020; Ghalebi et al., 2020) Empirical and theoretical work also shows that there is a persistent challenge in English language teaching, where students often assume passive roles and accomplish a limited mastery of vocabulary use (Boers, 2021; Nation, 2022).

Several factors contribute to this issue, including structural weaknesses in the educational system, insufficient initial and ongoing training for English teachers, and the predominance of grammar-based instruction in many institutions (Selvi & Galloway, 2024). As Richards and Rodgers (2014) also explain, English teaching mainly focuses on memorizing grammar rules and structures, without considering communicative and intercultural dimensions. Although these approaches have provided a theoretical foundation, they have been widely criticized for restricting learners' ability to use English effectively in real-life contexts (Naghiyeva, 2025).

Recent research on vocabulary acquisition highlights the importance of providing learners with opportunities to move from initial exposure to long-term retention and contextual application of new words (Ayana et al., 2024; Mohammed, 2023). This is especially relevant in schools where vocabulary is often taught through translation and memorization, resulting in limited language production. Hence, pedagogical approaches that promote cognitive engagement, interaction, and repeated retrieval are highly recommended to address issues such as vocabulary-use gaps (Schmitt & Schmitt, 2020; Webb & Nation, 2020). To effectively foster vocabulary development, language teachers and scholars have investigated various pedagogical models. The ECRIF framework, sometimes referred to as an approach in the literature, is considered an innovative framework for improving foreign language teaching. This framework, which stands for 'Encounter, Clarify, Remember, Internalize, and Fluently Use,' was proposed by Kurzweil and Scholl in 2007, and has become popular among EFL teachers, as it facilitates vocabulary learning and enhances students' retention in actual social contexts through language interactions pertinent to their needs and interests. Using the principles of this framework, teachers can design interactive activities that promote students' vocabulary learning and use rather than relying on memorization, as in traditional methodologies. Current studies highlight the advantages of ECRIF in increasing students' vocabulary, as it focuses on active learning strategies that help level out students' linguistic differences in various contexts (Caiza Aucapiña et al., 2022; Okumuş Dağdeler, 2023).

The ECRIF framework proposes clear and defined phases that guide students from passive reception to active classroom participation. ECRIF also improves students' ability to internalize their linguistic competence inside and outside their classrooms. Due to its flexibility, this framework can be used in tandem with constructivist and task-based teaching methodologies as these frameworks also promote students' cooperation and interaction (Richards & Rodgers, 2014). Despite the strong support it has received in Latin America, and particularly in Ecuador's public education system, there is a significant lack of research on the use of the ECRIF in foreign language instruction. By situating the research within Ecuador's socioeconomic and educational context, this study contributes to identifying valuable localized insights that align with global discussions on effective EFL instruction. Sixth grade was selected because it

represents a critical stage in the national curriculum, where learners transition from basic vocabulary recognition to more complex communicative tasks, making it an ideal point to assess the pedagogical value of ECRIF. Accordingly, this study aims to examine the effectiveness of the ECRIF framework in enhancing English vocabulary learning among sixth-grade EFL students in a public school in Ecuador. Through this local perspective, the findings could enrich existing research on student-centered vocabulary instruction.

This study revolves around the following research questions:

1. To what extent does the implementation of the ECRIF framework improve vocabulary learning among sixth-grade EFL students compared to traditional vocabulary teaching methods?

2. What are the perceptions of the teacher who implemented the ECRIF framework for vocabulary instruction in the sixth-grade EFL classroom?

Literature Review

The Role of Vocabulary in Language Learning

Acquiring vocabulary is important because it underpins other language skills, as it plays the highest level of importance within people's verbal interactions (Iwaizumi & Webb, 2022; Richards & Rodgers, 2014). Linguists have long recognized the importance of expanding English language learners' vocabulary to bridge the gap between the lexical knowledge of native speakers and that required by learners (Nordlund & Norberg, 2020; Zhang & Liang, 2024). Kim and Webb (2022) underscore the necessity for a robust semantic structural framework in global foreign language teaching programs. Building on this foundation, considerable attention has been focused on facilitating vocabulary learning, particularly in foreign language teaching, thanks to the emergence of the lexical framework and the contributions of scholars who have extensively studied vocabulary acquisition (Lei et al., 2022; Nazeer et al., 2023). Central concerns in this area include determining the size of the English vocabulary, identifying instrumental vocabulary, and defining the most appropriate sequence for teaching high-frequency terms (Caldas & Békés, 2020; Chowdhury, 2024).

Nazeer et al. (2023) investigated the vocabulary expansion strategies and their effect on university-level foreign language learners. The results reveal that, regardless of students' academic achievements, the practice of vocabulary learning strategies is directly related to the size of their vocabulary. The students reported that using vocabulary in context also increased their engagement and helped them better understand the material. To improve vocabulary learning outcomes, their research suggests incorporating a variety of learner-centered frameworks and supporting strategy-based instruction in foreign language classrooms. In line with this, Kazu and Kuvvetli (2023) found that beginning-level learners tend to rely more on basic determination strategies rather than on the use of cognitive strategies, highlighting the need for instruction that supports useful ways to learn new vocabulary. Finally, Andari (2022) carried out an action research that investigated the effect of flashcard use in language retention among elementary EFL learners. The outcomes indicated increased student involvement and motivation, as they benefitted from visual and repetitive process that the strategy provided.

Acquiring a large number of words is essential when learning a foreign or second language at different proficiency levels. Many students usually find speaking and writing exhausting because they frequently use the same expressions and words, and their conversations are abruptly interrupted due to the lack of words to communicate (Ghalebi et al., 2020). One common issue faced by language learners is forgetting new words despite seeking effective methods to improve long-term memory retention (Nur & Jusoh, 2022). One possible reason is that, unlike syntax and phonology, vocabulary lacks rules. That is, it is unclear to learners which rules apply when using vocabulary items in a dialogue or short interaction. Language learners still face constant evaluations, as vocabulary has traditionally been assessed through tests. Consequently, learners often dedicate significant time to memorizing word lists and depending on bilingual dictionaries as their communication tools (Kurniarahman, 2023). As a result, language educators are increasingly acknowledging the significance of vocabulary acquisition and investigating various methods to assist students in expanding their vocabulary (Schmitt & Schmitt, 2020).

Much of the research on vocabulary acquisition strategies typically pinpoints the most effective techniques along with the development of strategy taxonomies (Citrayasa et al., 2022; Mohammed, 2023). EFL instructors also underscore the value of incorporating stimulating activities to help students achieve lexical proficiency, thereby fostering confidence and self-esteem (Samachalam et al., 2025). Thus, vocabulary learning is essential to students' academic success, as most formal and informal information is communicated in the English language. Consequently, vocabulary learning strategies in language contexts are crucial tools for EFL teachers to help students achieve their educational goals (Serang & Sahib, 2023). Despite its importance, many EFL students struggle with difficulties in learning vocabulary. Learners frequently experience difficulty remembering and using new words, especially when

instruction presents them in isolation and relies on memorization, which hinders long-term retention and meaningful communication (Boers, 2021). These traditional frameworks often fail to promote effective student participation or accommodate diverse learning styles, resulting in frustration, inadequate vocabulary growth, and poor linguistic performance (Nation, 2022).

The Emergence of ECRIF in Vocabulary Instruction

The ECRIF framework, proposed by Kurzweil and Scholl (2007), focuses on the learning process students experience when using the target language. In this way, the teacher can rely on ECRIF to plan lessons and adapt coursebook materials to activities conducive to learning. ECRIF was later described as a strategy that allows moving from teacher-centered to student-centered lessons. Similarly, it was asserted that ECRIF is a student-centered strategy that allows students to interact with and use materials independently (Al-Qahtani, 2022). Furthermore, ECRIF was described as a 'framework system' in which the student is the center of everything (Iwaizumi & Webb, 2022; Tosuncuoğlu, 2017). It addresses students' needs, promotes learning, and turns lessons into a cooperative and fun environment (Dalkıran & Semerci, 2020). ECRIF examines how students learn a language rather than advising teachers on what they should or should not do. Further studies supported ECRIF as a valuable framework for enhancing vocabulary and fostering lasting learning, which is essential for effective language production (AlSaleem, 2018). The ECRIF framework is one important tool for understanding how students can take an active role in learning a foreign language.

ECRIF is described as a framework that supports teachers in designing their lessons as it permits the adjustment of content to meet students' needs while promoting students' interaction with educational materials (Tamayo et al., 2023). The primary objective of ECRIF is not only to facilitate the acquisition of a new language but also to provide students with various opportunities to employ the target language communicatively both inside and outside the classroom. When learning vocabulary, students face the challenge of forgetting words immediately after the teacher has elicited their meaning, correctly pronouncing English sounds, or spelling long-syllable words (Salam & Nurnisa, 2021). Moreover, implementing traditional techniques for teaching English vocabulary has not attracted learners since it does not lead to effective practice. Neither students' motivation nor their level of participation seems to be enhanced since students become distracted easily and demotivated as they may assume that they will not successfully achieve their tasks. Therefore, the ECRIF framework is more effective than traditional methods in enhancing vocabulary acquisition. The structured sequence of exposure, clarification, repetition, internalization, and fluent use appeared to scaffold learners' understanding in a way that encouraged both retention and practical application of new vocabulary.

Recent research has demonstrated that student-centered strategies are particularly effective in situations where teacher-centered instruction prevails (Nazim et al., 2024). Therefore, positioning ECRIF as a framework that combines structured progression with communication practice responds directly to Ecuador's need for methodologies that are both pedagogically sound and pragmatically feasible in public education. Although other studies analyze the effectiveness of ECRIF in improving oral expression skills and overall participation, few examine its specific role in vocabulary retention and mastery. The framework is investigated in recently published studies that focus on contexts of oral expression or fluency (Caiza Aucapiña et al., 2022; Tamayo et al., 2023). However, there is a lack of empirical evidence on its direct impact on students' vocabulary development, particularly in public schools facing the typical socioeconomic challenges found throughout Latin America. This imbalance within existing research strongly suggests the need to empirically investigate ECRIF's potential role for fostering long-lasting vocabulary knowledge, particularly within instructional contexts that continue to be predominantly traditional.

Selecting instructional frameworks that not only foster lexical development but also align with students' sociocultural contexts is essential. The Presentation–Practice–Production (PPP) model, for instance, remains widely used; however, it often results in mechanical practice with limited transfer to real-life situations (Harris & Leeming, 2024). This concern aligns with Qureshi et al. (2025), who noted that form-focused approaches restrict opportunities for authentic language use, emphasizing the need for more communicative instructional models. Similarly, Task-Based Language Teaching (TBLT) promotes authentic tasks and communicative competence, but it requires significant preparation on the part of the teacher and is not always feasible in public schools with limited resources (Nurhadi et al., 2024). The Lexical Framework also highlights vocabulary chunks as essential components for fluency, but it lacks sufficient scaffolding for memorization and active use (Thuratham, 2024). While ECRIF provides a cyclical progression from recognition to fluent application, harmonizing structure with student autonomy (Kurzweil & Scholl, 2007), its effectiveness also depends on careful implementation and teacher training, particularly in contexts where traditional methods remain dominant.

ECRIF and its underlying stages

Every phase within ECRIF is viewed as active, during which students engage with the target language or structure. This implies that language educators should meticulously evaluate students' performance and accomplishments at the end of the lesson based on the intended outcomes. Language instructors must arrange lessons to facilitate content comprehension, maintain an equilibrium between accuracy and fluency exercises, and offer incremental progression toward learning goals (Kurzweil & Scholl, 2007).

Encounter is the first stage in which students are exposed to new information. The teacher activates prior knowledge to introduce background and new situations about the target topics. Generally, the teacher begins by activating the learner's prior knowledge. It includes 'noticing', during which students realize the type of vocabulary they need to perform a specific communicative task. The students do not have to produce a new language during this stage.

Clarify is the second stage, during which students attempt to understand the meanings and structures of the new language. They explore new meanings and how the words are pronounced and spelled. Students take on a central role, as it is an opportunity to clear up doubts about the target language or the skills needed to produce it. Hence, the students actively participate in assimilating new knowledge by comparing meanings and consciously focusing on the target language. The idea is to encourage students to use the new knowledge they have learned (Tosuncuoğlu, 2017).

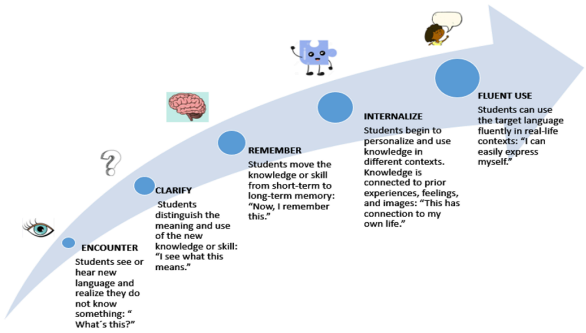
Remember is the third stage, which consists of transferring knowledge from short-term to long-term memory. With the frequent use of the information by a student, it appears that it is part of the long-term memory (Tosuncuoğlu, 2017). This stage provides students with the opportunity to practice the new language by repeating, drilling, and referring back to the supporting material provided by the teacher.

Internalize is the fourth stage that relies on less controlled and freer practices without any teacher's support. Students are encouraged to make informed decisions and select the appropriate language based on their specific needs. At this stage, students are expected to be introduced to student-centered activities that apply the new knowledge and help them internalize the target language. As for the teachers, they provide indirect clues to the students to promote self-correction of mistakes in semi-controlled contexts (Tosuncuoğlu, 2017).

In the Fluent Use Stage, the students are required to demonstrate their comprehension and assimilation of the new language and produce it spontaneously. To showcase their abilities, students are encouraged to use the target language according to their needs through meaningful and interactive language tasks. Thus, it is important to create contextual and student-pertinent classroom activities that emulate real-life language interactions and situations where students can choose what they want to talk about. Figure 1 illustrates the five stages of the ECRIF framework.

Figure 1

ECRIF Stages



Methodology

Research design

A mixed-methods explanatory sequential design was employed, which integrates quantitative and qualitative approaches to provide a comprehensive analysis of the phenomenon under investigation (Creswell & Creswell, 2018). This study was conducted in two phases: an initial quantitative phase, followed by a qualitative phase designed to explain and expand the quantitative results. The first phase evaluated the effectiveness of the ECRIF framework in facilitating vocabulary learning among sixth-grade students, while the second phase examined the teacher's experiences during the implementation, focusing on increased student engagement, autonomy, and the flexibility afforded by the ECRIF framework.

For the quantitative phase, the researchers implemented a quasi-experimental design. This approach was used because sixth-grade classes were already established, and random assignment was not feasible due to institutional constraints. The qualitative phase consisted of semi-structured interviews that explored the teacher's in-depth perception of ECRIF in practice.

Participants

This research comprised 56 sixth-grade students from two different classes at a public school located in Quito, Ecuador. Thus, each class constituted one

group (one experimental and one control group). The experimental and control groups consisted of 28 students each. The participating students were between 11 and 12 years old, and the majority of them had an A2 level of English, according to the Common European Framework of Reference for Languages (CEFR). Over 16 weeks, the experimental group received vocabulary instruction using the ECRIF framework. In contrast, the control group adhered to the school's conventional instructional framework, which primarily involves translation, drilling, and memorization strategies. With the approval of the school administration, the selection of classrooms was purposive, but aimed at minimizing selection bias by matching groups based on variables such as age, socioeconomic background, and level of English proficiency. The use of intact groups was necessary, given the real-world classroom setting where random assignment was not feasible.

Regarding the teacher participants, one was a 40-year-old female and the other was a 38-year-old male. Both had a B2 level of English proficiency according to CEFR, as required for English teachers in the country. They each had more than five years of experience in EFL instruction and held a Bachelor's degree in English teaching from an Ecuadorian university. The male teacher was responsible for the experimental group, while the female teacher taught the control group. The teacher from the experimental group was the focus of the qualitative component, participating in four semi-structured interviews. His participation was central because he implemented the ECRIF framework in his classroom to increase students' vocabulary learning.

Ethical considerations

This research was conducted in accordance with the ethical standards approved by the school and academic board. Informed consent was obtained from teachers and all participants' legal representatives after they understood the purpose and scope of the study. Confidentiality was strictly maintained. All data collected were treated anonymously, ensuring the privacy and protecting the identity of participants during and after the study.

Instruments

Quantitative instrument

The researchers developed a customized vocabulary test administered as both a pre-test and a post-test to gauge students' grasp of vocabulary. The test consisted of 50 items covering five vocabulary topics: description of people, description of places, accommodation, weather, and transportation. These topics are included in the EFL curriculum.

Each topic included ten items, which were developed in various formats designed to assess receptive skills (association and recognition) and productive skills (sentence completion and recall), as shown in Table 1. To streamline analysis, raw scores from the 50-item test were converted to a 10-point scale, where a score of 50 would equal a 10.0 and a score of 0 would equal a 0.0. To ensure validity, three experienced English as a Foreign Language (EFL) teachers from local universities reviewed the test items to assess their alignment with the curriculum developed by the Ecuadorian Ministry of Education and with the established proficiency level for sixth grade. Based on the experts' suggestion, some test items were refined to achieve greater clarity, contextual relevance, and lexical precision. After incorporating the experts' recommendations, the researchers conducted a pilot administration of the same 50-item test with 15 sixth-grade students from a nearby school. The purpose of the pilot test was to assess the level of difficulty of the test items, time allocation, and the clarity of instructions. Following the pilot test, minor adjustments were made, including rewording unclear instructions and modifying the time limits.

To ensure the test reliability, the researchers calculated its internal consistency using Cronbach's alpha. The results showed a coefficient of $\alpha = 0.84$, indicating high internal consistency (Roco-Videla, 2024).

Table 1.
Topics for the Vocabulary Test

Topic (1)	Description of people Instruction: Which sentence does NOT match the picture?
Topic (2)	Description of places Instruction: Choose the word that matches the definition
Topic (3)	Accommodation Instruction: Select the word that best completes the sentence
Topic (4)	Weather Instruction: Match the vocabulary to the picture.
Topic (5)	Transportation Instruction: Read the description of things found in a bus station. What is the word for each one?

As detailed in Table 1, the vocabulary test, which was the same for the pretest and the posttest, was divided into five sections. In sections 1 and 4, multiple-choice questions were included. In section 1, students had to read full sentences describing images to figure out which sentences did not match the image. In section 4, there was a vocabulary test with individual words, in which students had to choose the one that corresponded to a provided image. The main difference between these two sections was the length and the way the instructions were set up. In Section 2, students had to match definitions with the correct

answer of familiar places, such as parts of a school. In this case, understanding was crucial because there were no pictures to aid in comprehension. In Section 3, students had to fill in the blanks by selecting the right words from a list to make the sentences grammatically correct. Finally, in Section 5, students had to read short descriptions and choose the correct words.

To clarify how the previously described test sections align with the ECRIF stages, the following examples illustrate the types of questions used in each topic. For the Description of People (Encounter/Clarify) activity, students had to examine an image and choose the sentences that did not match the image. For Descriptions of Places (Clarify/Remember), they had to match the definition, such as a place where students usually borrow books, with the word library. For Accommodation (Remember), students had to complete sentences by selecting the correct word; for example, a hotel room has a ____, options: balcony, elevator, garden. For Weather (Encounter/Remember), students had to select the word that matched the image that depicts weather conditions. Finally, for Transportation (Internalize/Fluent Use), students had to read short descriptions, such as a bus station, and identify the correct word. These examples helped demonstrate how each item type was related to each stage of the ECRIF framework and to assess the use of vocabulary in context.

Table 2 shows that the experimental group had a mean of 4.5 and a standard deviation of 0.25. The control group, on the other hand, had a mean of 4.61 and a standard deviation of 0.233. Initial findings indicate that before the intervention, the two groups showed comparable vocabulary knowledge. Also, the standard deviations suggest that the scores were evenly distributed within each group.

Table 2.
Pre-test scores of the experimental and control groups

Groups	N	$\bar{x}$	SD	t	p
Experimental	28	4.5	0.25	-0.33	0.70
Control	28	4.61	0.233		

To determine whether there were differences in vocabulary gains between the groups, an independent-samples t-test was applied. Additionally, a paired-samples t-test was used to determine whether there were time-related differences across all groups. All inferential statistical analyses were conducted with an alpha level of $p < 0.05$; all statistical tests were performed in this manner. Consequently, the two groups began the study with similar vocabulary proficiency.

Qualitative Instrument

Semi-structured interviews were conducted with the teacher who implemented ECRIF with the experimental group after a 16-week intervention. The interview protocol was designed to explore their experiences with the ECRIF framework, focusing on student engagement, learner autonomy, and the flexibility afforded by the framework.

To secure the trustworthiness of the qualitative component, the researchers adhered to the procedure suggested by Ahmed (2024). With respect to credibility, the researchers remained at school for a total of twenty weeks. The intervention lasted for sixteen weeks, followed by a four-week period dedicated to conducting the interviews. This time enabled the researchers to develop rapport with the participating teacher and facilitated his willingness to engage in the interviews. Transferability is supported throughout the detailed descriptions provided in this study regarding the context, participants, and the teacher. Concerning confirmability, the researchers conducted the qualitative data analysis independently, and subsequently, they met with the teacher to discuss the results. This process helped minimize subjectivity and strengthen the reliability of the findings.

Data Collection

Quantitative Data Collection

A pre-test was administered to both groups before the intervention to assess their initial vocabulary knowledge levels. Following this, the experimental group underwent weekly instruction structured around the five ECRIF stages:

- Encounter: Real-life contexts, images, and multimedia introduction
- Clarify: Group activities focused on form, meaning, and pronunciation
- Remember: Repetition and cognitive reinforcement through practice
- Internalize: Semi-controlled tasks promoting autonomous use
- Fluent Use: Role-plays, dialogues, and games encouraging spontaneous production

During the same period, the control group was taught vocabulary with word lists, dictionary definitions, and sentence translation. After the intervention, both groups took the same pre- and post-tests.

Qualitative Data Collection

Following the post-test, the teacher in the experimental

group participated in semi-structured interviews that explored the previously described aspects and the results of the quantitative phase. These interviews were audio-recorded and transcribed for subsequent thematic analysis. In total, the researchers conducted four interviews with the participating teacher at his school, amounting to approximately four hours of recorded data.

Findings

Quantitative Findings

The pre- and post-test quantitative data were analyzed using SPSS (version 25). Descriptive statistics (means and standard deviations) were calculated for both groups. An independent-samples t- test was used to examine whether there were any differences in vocabulary improvement between the two groups, while a paired-samples t-test assessed changes over time within each group. All analyses, including inferential tests, were conducted using an alpha level of $p < 0.05$.

The results of the pretest and post-test administered to the experimental and control groups are presented as follows:

Table 3.
Pretest and Post-test Scores for the Experimental Group

Tests	*N*	$\bar{x}$	*SD*	*t*	*p*
Pretest	28	4.5	0.25		
Posttest	28	8.97	0.13	- 41.31	<0.001

Table 3 shows the mean $\bar{x}$ =4.5 and standard deviation 0.25 of the pretest of the experimental group. The mean score in the post-test was $\bar{x}$ =8.97, and the standard deviation was 0.13. These findings indicate that the students enhanced their vocabulary following the intervention. A paired-samples t-test was conducted to determine whether the difference between the pre-test and post-test scores was statistically significant. The results indicated a statistically significant difference (t (27) = -41.31, $p < 0.001$). The effect on the experimental group's vocabulary achievement was quite evident.

Table 4.
Pretest and Post-test Scores for the Control Group

Tests	N	$\bar{x}$	SD	t	p
Pretest	28	4.61	0.23		
Post-test	28	6.54	0.16	-34.27	<0.001

Table 4 shows that the mean of the pre-test for the control group was $\bar{x}$ = 4. 61, and the standard deviation was 0.23. The mean score of the post-test was $\bar{x}$ =6.54, and its standard deviation was 0.16. A paired-samples t-test revealed that this difference was statistically significant (t (27) = -34.27, $p < 0.001$). Although the gain was meaningful, it was less substantial than the improvement observed in the experimental group, highlighting the relative limitations of traditional vocabulary instruction methods. To further examine the difference between the groups, an independent-samples t-test was conducted on the post-test scores, shown in Table 5:

Table 5.
Post-Test Comparison between Experimental and Control Groups

Tests	N	$\bar{x}$	SD	t	p
Post-test (Exp. group)	28	8.97	0.13	59.10	<0.001
Post-test (Control Group)	28	6.54	0.16		

Table 5 shows that the experimental group (M = 8.97, SD = 0.13) significantly outperformed the control group (M = 6.54, SD = 0.16), with a calculated t-value of 59.10 ($p < 0.001$). This significant difference supports the conclusion that the ECRIF framework resulted in more substantial vocabulary gains compared to traditional instruction. The experimental group's post-test scores show a lower standard deviation, suggesting a more consistent improvement across the learners.

Qualitative Findings

While the quantitative analysis demonstrated significant lexical gains in the experimental group, the qualitative data help explain the pedagogical mechanisms underlying these improvements. To identify recurring patterns in the perspectives of the teacher involved in the implementation of the ECRIF framework, a thematic analysis was conducted on the transcribed interviews. The qualitative findings were then used to interpret and deepen the understanding of the quantitative findings. The teacher of the experimental group provided key insights into ECRIF implementation, emphasizing two main themes: increased student engagement and autonomy, and the flexibility of the ECRIF framework.

Increased Student Engagement and Autonomy were evident as the teacher reported a significant shift in the students' motivation and behavior after the implementation of the ECRIF framework. This perspective, especially during the Encounter and Fluency phases, seemed to shift the educational environment from a conventional teacher-centered one to one in which students played a more active role in their own learning. As the teacher explained, "With traditional methods, I felt like I was just throwing words into students' heads, and after a moment, they forgot. However, when I used the ECRIF model, my students were able to identify their own vocabulary and find the meaning of the new words. This learning is also created in groups as a result of active learning strategies. When I use active learning strategies, my

students are more energetic". These lines exemplify how teachers can enhance their classes and vocabulary learning by utilizing ECRIF.

Another aspect of ECRIF addressed by the teacher was the Flexibility of the ECRIF framework. The teacher highlighted this characteristic by mentioning that ECRIF proposes a variety of activities that can be adapted to different learning styles, making the framework responsive to students' diverse needs. The teacher explained this in the following lines: "ECRIF is not a prescriptive framework. It is open enough for teachers to insert their own views of language teaching, which promotes creativity. This dynamism allows students to play a central role in the language learning process".

Based on the teacher's comments, it can be inferred that when teachers plan their activities to teach vocabulary, the ECRIF framework becomes a good alternative, as it provides a series of phases that promote interactions among learners. The dynamic nature of the framework facilitates teaching innovation. Thus, teachers need to develop instructional materials that encourage students' linguistic exchanges, including the vocabulary being learned.

Discussion

Extent of the implementation of the ECRIF framework to improve vocabulary learning

The improvements in the experimental group's vocabulary indicate that ECRIF-based instruction has the potential not only to facilitate vocabulary learning but also to provide an effective way for students to internalize and actively use new words. This is directly supported by the qualitative feedback from the teacher, who noted an improvement in students' active participation and autonomy. It can also be inferred that this is a result of the flexibility of the framework, which allowed a teaching paradigm shift, placing students at the center of the teaching process.

The significant vocabulary improvement observed in the experimental group reinforces prior research, which demonstrates that ECRIF promotes deeper processing, repeated retrieval, and contextualized practice. These components are highly acknowledged as essential for long-term vocabulary learning (Schmitt & Schmitt, 2020; Webb & Nation, 2020). The findings also aligned with those of AlSaleem (2018) and Al-Qahtani (2022), who reported that instruction based on the ECRIF framework resulted in greater vocabulary retention compared to traditional memorization methods. Similarly, the increase in autonomous use of vocabulary identified in this study supports the argument of Dalkıran and Semerci (2020) that ECRIF encourages learners to take an active approach, creating conditions for successful vocabulary acquisition. The qualitative insights provided by the teacher are consistent with those of Tamayo et al. (2023), who reported that the ECRIF framework fosters learner autonomy and sustained classroom participation.

A shift in the teaching paradigm has encouraged students' participation in language exchanges as evidenced by the increased vocabulary, which reflects the principles of processing depth and active recall (Soori et al., 2023; Türker, 2024). This could also be related to the interactive and cyclical nature of the ECRIF framework, which motivates teachers to be innovative in developing their class activities that include target vocabulary teaching and strategies revolving around vocabulary use in real-life situations. For example, comprehension activities that result in spontaneous language use, avoiding individual practices and memorization, were followed by discussions on common topics and language practice activities that connect the newly learned vocabulary to real-life scenarios. These activities can increase students' vocabulary, which is the bedrock for communication (Zhang & Liang, 2024). Thus, the role of ECRIF is fundamental in vocabulary acquisition as it allows students to learn it freely, fluently (Hanzawa, 2024), and collaboratively (Ta'amneh, 2021). Furthermore, when the activities center on the students, their vocabulary increases more compared to when their learning is individual (Ayana et al., 2024; Zhou et al., 2025).

The two stages of the ECRIF framework, 'Encounter' and 'Clarification'; suggest that to teach vocabulary, teachers need to design activities that progressively present students with new words pertinent to their individual contexts, making this significant for them. The next stages, 'Internalize' and 'Fluent use', can develop students' language use autonomously, allowing them to engage in different language exchanges. When students engage in linguistic interactions, they need to retrieve the language they have learned. This corresponds to the 'Remember' phase, which also encourages students to use the language in natural contexts (Webb & Nation, 2020). When these two phases are correctly implemented, students may expand their vocabulary, particularly in social settings.

Additionally, the strong performance of the experimental group aligns with research emphasizing the importance of cognitive involvement and active recall in effective vocabulary development (Ayana et al., 2024; Boers, 2021). Students' ability to retrieve and apply new words during the Internalize and Fluent Use phases aligns with the findings from Hanzawa (2024) and Zhou et al. (2025), who argue that the meaningful use of vocabulary enhances fluency

and supports integration into long-term memory. The data further showed that the control group exhibited some degree of lexical development under traditional instruction, largely characterized by memorization and repetitive practice of isolated vocabulary items. These instructional practices may support initial vocabulary learning; however, such learning often remains confined to short-term memory, thereby limiting transfer to long-term retention and hindering fluent language production (Boers, 2021). In this respect, this study extends current evidence by showing that ECRIF can be successfully implemented within public school contexts similar to those in Ecuador.

In line with the advocacy for more ELT strategies that focus on students' language needs and vocabulary, the ECRIF framework helps them increase their register through processes of clarifying word meanings, reinforcing vocabulary, and internalizing vocabulary through sustained practice and appropriate contexts. Student interaction within a learning-conducive environment, coupled with meaningful peer engagement, can significantly enhance learners' language retention and recall. Apart from the students' vocabulary increase as a result of this study, the use of the ECRIF framework improved students' autonomy and class participation which are considered necessary skills in the 21st century (Kurniawan et al., 2025). These skills are particularly needed in Ecuador, as most of the EFL classes have been conducted using traditional methods that focus on memorization without much peer interaction, thereby diminishing spontaneous language use. Moreover, this interaction can help students notice and correct their mistakes, resulting in the production of accurate vocabulary (Ta'amneh, 2021).

Teachers' perceptions and roles in implementing the ECRIF framework to improve vocabulary

The current study's data, which supports the use of ECRIF, highlights the crucial role teachers play in enhancing vocabulary learning outcomes. In ECRIF, the appropriate selection of vocabulary and the opportunities to practice it are essential to attaining the ultimate goal: increasing students' vocabulary. Choosing activities and suitable topics is a process of deep thinking, effective planning, and open-mindedness that will enable students to control their interactions (Ardayati & Ramasari, 2025). Excellent teachers are facilitators of vocabulary learning through ECRIF. Their challenge is to generate realistic environments and provide constant feedback that leads to effective learning, contrary to the traditional role where teachers dominate the class without allowing for interaction (Salam & Nurnisa, 2021).

Interview evidence reinforced these points, showing how ECRIF reshaped the teacher's role. The teacher emphasized that planning activities around students' interests created more authentic participation, noting: "When I connected vocabulary topics they care about, they were engaged and eager to ask for more examples." He also mentioned the shift in classroom dynamics, explaining: "Instead of me leading every step, some students took initiative using new words in their sentences and correcting each other." Finally, he reflected on the flexibility of the framework, stating: "ECRIF allowed me to adapt tasks considering the group's needs, something I could not do with traditional lesson plans." These insights illustrated how ECRIF empowered the teacher to take the role of facilitator, fostering autonomy and engagement.

It is also worth noting that although the control group experienced some improvement, their progress was neither as steady nor as significant as that of the experimental group. This underscores the idea that methods relying on passive exposure and translation may fall short in fostering substantial vocabulary growth, particularly when learners are not prompted to actively use or engage with new language. Thus, the importance of promoting and using strategies that place students at the center of all EFL practices (Nazim et al., 2024).

The findings of this study bring important implications for theory, practice, and policy in EFL vocabulary instruction. Theoretically, the findings reinforce models of vocabulary learning that emphasize depth of processing and cyclical engagement, positioning ECRIF as a model that can help integrate these principles. From the practical standpoint, the results suggest that teachers can contribute to effective vocabulary acquisition by adopting instructional designs such as ECRIF that promote student autonomy and authentic communication activities. These insights underscore the need for sustained training and professional development that provide teachers with the skills for a successful implementation of these frameworks. At the policy level, the study supports the integration of structured and process-oriented frameworks into the national curriculum and teacher-training programs, especially in contexts where traditional approaches prevail. Incorporating such frameworks into the English curriculum planning could help foster long-term improvements in students' vocabulary development and overall communicative competence.

Conclusion

This mixed-methods study aimed to examine the effectiveness of the ECRIF framework in enhancing vocabulary skills among sixth-grade EFL students at a public school in Ecuador. Specifically, it addressed two research questions: To what extent does the implementation of the ECRIF framework improve vocabulary learning among sixth-grade EFL students compared to traditional vocabulary

teaching methods? What are the perceptions of the teacher who implemented the ECRIF framework for vocabulary instruction in the sixth-grade EFL classroom? The quantitative findings showed that compared to traditional teaching methods, ECRIF resulted in significantly greater and more consistent vocabulary gains by fostering engagement, cognitive reinforcement, and learner autonomy.

The qualitative findings provided important contextual insight into these results. Teacher interviews revealed that the ECRIF framework fostered learner participation and autonomy, shifting the classroom dynamic from a traditional, teacher-centered environment to one characterized by active and sustained student involvement. The flexibility of the ECRIF framework was identified as a strength, allowing adaptation to diverse student needs and sustaining motivation. Importantly, ECRIF also contributed to activating students' prior knowledge, resulting in an engaging and learner-centered experience. Notably, the experimental group demonstrated consistent lexical development, indicating that ECRIF extends beyond the presentation of new vocabulary by encouraging active participation with the vocabulary, thereby gradually strengthening learners' autonomy and confidence in their language use.

Effective implementation of the ECRIF strategy requires careful scaffolding and progressive changes to meet the learner's needs. It is the teacher's responsibility to create a collaborative environment and favorable conditions that foster meaningful interactions and promote long-lasting cognitive engagement. From a practical perspective, these findings suggest that teachers should view themselves not only as transmitters of knowledge but as facilitators who design meaningful activities and adapt instruction to students' interests and contexts.

The results should also be interpreted within Ecuador's broader linguistic context. With the country ranked in the 'low proficiency' category in the EF English Proficiency Index (2024), integrating frameworks like ECRIF into teacher training and diversifying instructional activities in the curriculum planning could help address persistent gaps in public education. Such integration may enhance vocabulary development, communicative competence, and student motivation.

Although the findings highlight valuable insights, care must be taken when generalizing these results. The study relied on intact classroom groups within a single institution, meaning that factors such as educational settings, student background, and teacher and classroom dynamics may have influenced the outcomes. The 16-week duration may have been sufficient to observe some benefits and improvements, but they may not have been long enough to determine whether these improvements last over time or can be adapted across varying cultural and institutional contexts within Ecuador and Latin America.

To guide future research and strengthen the empirical foundation of ECRIF-based instruction, several recommendations can be proposed. Future research should extend implementation to diverse schools, evaluate long-term retention, and investigate ECRIF´s adaptability across different linguistic and socio-economic contexts. Additional studies could also explore how ECRIF interacts with other approaches, examine its effectiveness at various proficiency levels, and analyze specific teacher practices that influence the learning outcomes. Longitudinal designs would be valuable for determining the sustained effects over complete academic years, while comparative studies could clarify how ECRIF performs against traditional vocabulary teaching approaches. At the policy level, educational policymakers and curriculum designers in Ecuador and Latin America should consider ECRIF not only as a classroom strategy but as a sustainable framework that boosts learner autonomy, strengthens communicative competence, and supports long-term language development.

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Investigating Mathematics Teachers' Technology Acceptance and Self-Efficacy for Technology Integration: A Structural Equation Modeling Approach

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Abstract

The effective integration of technology into educational environments is closely related to teachers' digital skills and their willingness to use these tools in teaching processes. In this respect, the study aimed to examine the relationship between mathematics teachers' acceptance levels towards technology and their self-efficacy beliefs about technology integration. The study was designed using the relational survey model and the data were analyzed with structural equation modeling (SEM). The research sample consisted of 381 mathematics teachers working in different school types. The Technology Acceptance Scale (TAM) and Self-Efficacy Perception Scale for Technology Integration (S-ET) were used as data collection tools. The results of the analyses revealed that there was a statistically significant and moderately positive relationship between technology acceptance and self-efficacy towards technology integration (r = 0.541; β = 0.42; p < .001). The findings showed that teachers' positive attitudes towards technology supported their self-efficacy towards technology integration. However, it is concluded that positive attitudes alone are not sufficient for effective technology integration; teacher education programs should be structured to strengthen practical skills and pedagogical approaches to technology use. It is also suggested that contextual factors (infrastructure, technical support, in-service training) should be taken into consideration.

Keywords:

Technology Acceptance Model, Self-Efficacy, Technology Integration, SEM, mathematics teachers

Introduction

Digital technologies are rapidly transforming educational environments and opening new possibilities for teaching and learning. This is especially evident in mathematics, where abstract concepts benefit from visualization and interactive engagement. However, the effectiveness of technological integration in the classroom depends significantly on teachers' attitudes towards technology, their willingness to adopt it, and their competencies in applying

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it to real teaching scenarios (Ertmer & Ottenbreit-Leftwich, 2010).

Today's education systems are being profoundly shaped by ongoing digital transformation, which increasingly requires teachers to continuously develop both their professional expertise and their technological skills. As technology becomes more integral to teaching and learning, educators are expected not only to master digital tools but also to integrate them effectively into their instructional practices. Simply having access to digital tools is insufficient; teachers must also possess the knowledge and confidence required to use them effectively (Ursavaş, Şahin&McIlroy, 2014).

For teachers to meaningfully incorporate digital tools into their instructional practices, they must possess not only technical proficiency but also pedagogical digital competence, which involves the ability to select, adapt, and apply technological resources in ways that genuinely support learning (McGarr, 2024). In mathematics education, technology is particularly valuable because it enables teachers to make abstract concepts more tangible, enhance students' problem-solving abilities, and foster interactive and engaging learning experiences (Weigand et al., 2024).

Consequently, the role of mathematics teachers extends far beyond simply delivering content through digital platforms. Teachers are increasingly expected to use technology as an intentional pedagogical strategy that transforms how mathematical concepts explored, discussed, and understood. Effective integration of technology, therefore, is not about using digital tools for their own sake but about leveraging them thoughtfully to enrich learning experiences and deepen students' conceptual understanding.

Research indicates that factors such as perceived usefulness, ease of use, and self-efficacy play a critical role in teachers' willingness to embrace technology and apply it effectively in their teaching practices (Davis, 1989; Teo, 2009). Positive attitudes among mathematics teachers linked to the successful integration of technology in their classrooms (Öksüz et al., 2009). Nevertheless, teacher candidates still lack sufficient knowledge, skills, and guidance regarding the pedagogical use of technology (Clark-Wilson et al., 2020; Liu et al., 2024).

This study aims to examine the relationship between technology acceptance (as described by the Technology Acceptance Model, or TAM) and self-efficacy beliefs related to technology integration among mathematics teachers. The study's significance lies in its potential to inform the design of more effective teacher education programs by illuminating how these two factors interact. Additionally, the findings are expected to shed light on the ways technology-based teaching practices contribute to the pedagogical development of future teachers.

Theoretical background

Technology Integration from the Teacher's Perspective

Technology's role in education has become a prominent focus of research and practice because of its ability to revolutionize the way teachers instruct and students learn. Its integration into classrooms offers opportunities for personalized learning, interactive teaching methods, and access to vast resources, redefining traditional educational environments. Mayer (2003) emphasized that multimedia learning improves understanding and recall of information. Similarly, a meta-analysis by Tamim et al. (2011) showed that students in technology-enhanced learning environments performed better than those in traditional environments.

By integrating technology into their classrooms, educators can create personalized and engaging learning experiences for their students. Educators can also lead their students to access rich sources of information by implementing innovative learning strategies. This change has redefined traditional educational models, paving the way for dynamic and collaborative environments that meet diverse learning needs. However, despite the long-standing emphasis on the transformative effects of technology, its full potential in classroom practices is still underutilized. Mayer (2003) emphasized the value of multimedia tools to help students understand and remember mathematical concepts, while Tamim et al. (2011) showed that technology-supported learning environments yield better learning outcomes compared to traditional methods. Research suggests that teachers often do not use technology effectively in classroom settings, limiting their application to superficial uses such as games or exercises (Mercader & Gairín, 2020; Isa et al, 2025). Bayhan et al. (2002) found that 81.8% of teachers did not use computers for instructional purposes, attributing this to a lack of confidence and insufficient professional development. Similarly, studies from the United Kingdom revealed that teachers face barriers to technology integration, including limited technical support, insufficient equipment, and lack of awareness about the pedagogical benefits of technology (Jones, 2004).

Teachers are decisive to the successful integration of technology in education, as their attitudes, beliefs, and skills directly influence how technological tools are utilized in classrooms. By fostering innovation, facilitating student engagement, and adapting technology to meet diverse learning needs, teachers shape how technology enhances educational outcomes. Their willingness to embrace and effectively apply technology ensures its potential to transform

teaching and learning processes is fully realized. Zhao and Hoge (2004) stressed the importance of teachers' conceptual understanding of technology's role in teaching and learning to cope with ongoing innovations. Moreover, teachers' attitudes and beliefs are crucial determinants of how effectively technology could integrate into classroom practices. In this context, understanding the factors influencing teachers' beliefs in technology is imperative. Teo (2009) found perceived usefulness, ease of use, and self-efficacy as critical factors affecting teachers' adoption of technology. Specifically, Öksüz et al., (2009) found that mathematics teachers with positive beliefs of technology are more inclined to use it effectively, particularly in visualizing abstract concepts and enhancing problem-solving skills. The influence of mathematics on technological advancements is clear, but technology also plays a significant role in improving mathematics learning and shaping students' attitudes toward the subject. Moreover, how teachers integrate technology into their teaching impacts students' perceptions of these tools (Erdener & Kandemir, 2019). Teachers use a more passive, traditional approach, where students have limited engagement with technology, while others actively use technology to present information and foster participation in their classrooms.

When teachers incorporate technology into their instructional practices, they create an environment where students have greater agency over their own learning, with the teacher acting as a facilitator rather than simply a transmitter of information. This approach aligns closely with student-centered learning frameworks, as it encourages active engagement and participation from students (Erdener & Kandemir, 2019).

Although the clear potential benefits of integrating technology into mathematics education, teachers continue to face substantial challenges that can hinder effective implementation. These obstacles can broadly categorize into external and internal factors. External challenges often include limited access to adequate digital devices, unreliable internet connectivity, insufficient technical support, and a lack of comprehensive professional training (McGarr, 2024). Such systemic constraints can prevent teachers from fully leveraging technological tools, even when they motivated to do so. Internal challenges are equally significant and may involve low self-confidence regarding technological proficiency, resistance to changing established teaching practices, and deeply ingrained pedagogical beliefs that may not align with technology-enhanced learning approaches.

These challenges highlight that successful integration of technology into mathematics teaching is not a matter of simply providing digital tools. Rather, it requires careful planning, sustained professional development, and reflective practice to ensure that technology used in ways that meaningfully enhance learning. Teachers must navigate both the practical and cognitive dimensions of technology adoption, aligning new tools with curriculum goals, pedagogical strategies, and the diverse needs of their students. Research suggests that when these factors addressed thoughtfully, technology can facilitate more interactive, personalized, and conceptually rich learning experiences. Conversely, neglecting these considerations may result in superficial or ineffective use of technology, where digital tools are present but fail to contribute meaningfully to student learning outcomes.

Central to overcoming these barriers is the concept of teacher self-efficacy. As Abu Bakar et al. (2018) have demonstrated, teachers who possess a strong belief in their capacity to effectively use technology are more likely to adopt and experiment with digital resources in their classrooms. However, research by Clark-Wilson et al. (2020) highlights that pre-service mathematics teachers do not receive sufficient guidance on how to meaningfully incorporate technology into their practice. Liu et al. (2024) argued that teacher education programs must address these deficiencies to enable effective integration, while Gumiero and Pazuch (2024) underscore the necessity of developing professional knowledge for designing and implementing technology-enhanced mathematics instruction.

The literature consistently emphasizes that mathematics teachers' acceptance and integration of technology is crucial for improving both instructional quality and student learning outcomes. Teachers who are confident in their technological competence are more likely to employ digital tools in ways that promote engagement and conceptual understanding (Abu Bakar et al., 2018; Bakar et al., 2018). This self-efficacy not only encourages innovation but also supports teachers in overcoming the inevitable challenges that arise when adopting innovative technologies.

Moreover, Erdener and Kandemir (2019) point out that the strategies mathematics teachers use to integrate technology can significantly influence students' attitudes towards these tools. Student-centered, technology-rich environments foster greater engagement and allow students to manage their learning more independently, with appropriate guidance from the teacher. Nonetheless, many educators still tend to use technology primarily for surface-level tasks, such as presenting content or supporting routine exercises, rather than fully exploiting its potential to foster deeper conceptual understanding or enhance students' problem-solving skills (Clark-Wilson et al., 2020; Erdener and Kandemir, 2019).

Targeted professional development has emerged as a key strategy for addressing these issues. Teachers who participate in specialized training are better equipped to integrate digital tools meaningfully into mathematics instruction (Liu et al., 2024). Furthermore, Gumiero and Pazuch (2024) advocate systematic improvements in teacher education programs, emphasizing the importance of professional knowledge in fostering effective and sustainable technology adoption in mathematics classrooms.

The Technology Acceptance Model, or TAM, first introduced by Davis in 1989, has long been recognized as a foundational framework for understanding why individuals choose to adopt and engage with new technologies. At its core, TAM emphasizes two key constructs. The first, perceived usefulness, reflects the degree to which users believe that a particular technology will meaningfully enhance their performance or productivity. The second, perceived ease of use, pertains to the extent to which a technology is perceived as intuitive, straightforward, and free from unnecessary complexity or effort. Over the past three decades, numerous studies have confirmed the predictive power of these constructs. When users perceive a technology as both useful and easy to use, they are significantly more likely to integrate it into their professional or daily practices. This insight has made TAM a cornerstone not only in general technology adoption research but also in education, where understanding teachers' attitudes toward digital tools can inform strategies to promote effective technology integration.

TAM's popularity is not just theoretical; it has widely applied across various sectors, from education and healthcare to business. Its straightforward approach allows researchers and practitioners alike to assess the psychological factors driving technology adoption. For instance, research consistently demonstrates that pre-service teachers who perceive technology as both beneficial and manageable develop more positive attitudes toward integrating it in their future classrooms (Erdener & Kandemir, 2019; Erdoğan, 2025; Teo, 2009; Venkatesh & Davis, 2000).

Nevertheless, TAM has its shortcomings, particularly in educational contexts. While it effectively predicts initial adoption, it does not adequately address the deeper factors that contribute to sustained, meaningful integration of technology into teaching practices. Long-term use often depends on more complex influences, such as teachers' self-efficacy, pedagogical beliefs, and the level of institutional support available. Elements like ongoing professional development, resource accessibility, and the alignment of innovative technology with instructional goals all play a pivotal role in determining whether technology becomes a routine part of teaching, rather than a temporary experiment. For example, Teo (2009) emphasizes that, although TAM's constructs foster positive initial attitudes, deeper factors such as self-efficacy and underlying pedagogical beliefs are critical for lasting integration. Furthermore, TAM's broad approach frequently overlooks subject-specific challenges—for instance, mathematics teachers may require tools that specifically address the visualization of abstract concepts (Erdener & Kandemir, 2019).

Current research on technology acceptance highlights the intricate interplay between individual beliefs, technical resources, and broader contextual factors in influencing teachers' use of technology. Self-efficacy and attitudes toward technology are significant predictors of willingness to adopt new tools. The actual availability and functionality of technological resources, meanwhile, dictate how these tools incorporated into instruction. Environmental factors, including institutional support, school culture, and opportunities for professional growth further shape the integration process. Together, these variables underscore the importance of a comprehensive approach to promoting sustained technology use in education. Studies by Paraskeva et al. (2008) show that teachers' computer self-efficacy impacts their ability to integrate technology effectively. Thong et al. (2002) note that technological complexity can deter adoption, while Ngai et al. (2007) identify technical support, time, and equipment access as critical facilitators. Ultimately, understanding teachers' attitudes and the interplay of these diverse factors is essential, particularly when developing professional development programs for both pre-service and in-service educators.

Teachers' Self-Efficacy in Using Technology

The successful integration of technology in educational settings relies not solely on teachers' technical skills, but significantly on their self-efficacy beliefs. It is not enough for teachers to possess a positive attitude toward digital tools; they must also perceive themselves as capable of utilizing these resources effectively in their teaching practices. Bandura's (1977) social cognitive theory conceptualizes self-efficacy as an individual's belief in their ability to execute specific actions successfully. This belief, as Bandura (1994) later explained, exerts a strong influence on one's thinking, emotional responses, and behaviors. In the context of education, research has consistently demonstrated that teachers' self-efficacy regarding technology integration is a critical factor shaping how often and how effectively they employ digital tools in instruction (Sang et al., 2010; Tondeur et al., 2017).

Self-efficacy is shaped by four main sources: mastery experiences (direct success in relevant tasks), vicarious experiences (learning by observing others), verbal persuasion (encouragement from peers or

mentors), and physiological or emotional states (such as stress or anxiety levels). Understanding these dimensions underscores the necessity of fostering self-efficacy among teachers to achieve meaningful and sustainable technology integration.

Within the sphere of educational technology, self-efficacy refers to teachers' confidence in their capacity to use digital tools to enhance instruction. Zhang (2023) expands on this by describing self-efficacy in technology integration as teachers' belief in their ability to utilize technology actively and interactively in the teaching and learning process. This perspective highlights not only technical proficiency, but also the adaptability required to integrate technology into various pedagogical strategies, thereby enriching the learning environment.

Teachers' self-efficacy beliefs have a profound impact on their pedagogical decisions, instructional approaches, and willingness to pursue innovation (Pajares, 1997a, 1997b). Furthermore, self-efficacy is connected to the wider school climate. Tobin et al. (1994) characterized self-efficacy as a marker of teaching success, affecting teachers' thought processes, motivation, classroom behavior, and emotional responses. It also shapes the selection of classroom activities, persistence in overcoming obstacles, and the time dedicated to resolving challenges (Pintrich & Schunk, 2002). Tschannen-Moran and Woolfolk Hoy (2001) argue that teaching effectiveness should be examined both as an overall quality and through specific practices, such as classroom management. Teacher effectiveness, as defined by researchers, includes the ability to foster student engagement, manage classrooms, motivate learners, and facilitate academic achievement within the broader context of the school environment (Adolfo & Ducot, 2025).

Ertmer (1999) identified two categories of barriers to technology integration: primary (external) and secondary (internal). Primary barriers encompass physical obstacles, such as insufficient hardware, technical problems, and lack of support. Secondary barriers, in contrast, involve teachers' beliefs, attitudes, and self-efficacy related to technology use. Ertmer's (1999) research emphasizes that internal barriers frequently exert a greater influence than external ones in determining actual technology adoption. Recognizing and addressing these internal dynamics is therefore essential for promoting sustained and effective technology integration in educational practice.

Teacher Self-Efficacy and Technology Integration

Ertmer and Ottenbreit-Leftwich (2010) identified four essential factors for teachers to effectively integrate technology into their teaching: knowledge, self-efficacy, pedagogical beliefs, and school culture. Teachers who possess high self-efficacy are more inclined to experiment with innovative technologies and address challenges as they arise. Notably, a teacher's knowledge and beliefs closely interconnected in shaping their sense of self-efficacy (Chand et al., 2020). In other words, what teachers know and what they believe about their abilities directly influence how confident they feel in managing their teaching practices and integrating new strategies or tools.

Research by Joo et al. (2018) highlighted that higher TPACK (Technological Pedagogical Content Knowledge) levels are associated with stronger teacher self-efficacy. Birisci and Kul (2019) found that there is a strong positive correlation between pre-service teachers' self-efficacy in technology integration and their technology-pedagogical content knowledge (TPACK), and that TPACK is a significant predictor of self-efficacy Thomson et al. (2016) further confirmed a relationship between pedagogical content knowledge (PCK) and self-efficacy, emphasizing the influence of teachers' internal belief systems on their ability to integrate technology.

Importantly, teachers' self-efficacy in technology use is a multidimensional concept shaped by confidence, pedagogical expertise, and contextual factors—not just technical skills. Ertmer (1999) categorized the barriers to technology integration as either external (such as limited hardware, software issues, or lack of technical support) or internal (such as attitudes and beliefs). Effective teacher education must address both types of barriers, with a particular focus on strengthening teachers' beliefs in their own abilities to use technology. Such efforts can support more meaningful and effective classroom technology integration.

Purpose of the Study

The effective integration of technology in contemporary educational settings depends not only on the availability of digital tools but also, and perhaps more importantly, on teachers' proficiency in using these tools and their attitudes toward adopting innovative technologies. In this context, the present study investigates the relationship between mathematics teachers' technology acceptance and their self-efficacy beliefs regarding the integration of technological tools into their instructional practices. Examining this relationship offers valuable insight into how teachers' openness to technology shapes their confidence, motivation, and perceived capability to incorporate digital resources effectively. By exploring these dynamics, the study aims to contribute to the development of informed strategies that promote more purposeful and confident technology use among mathematics teachers.

More broadly, this research highlights the need for well-designed professional development programs that not only equip teachers with technical skills but also foster positive attitudes toward adoption of technology. Such programs are essential for supporting teachers in adapting to increasingly technology-rich learning environments and ensuring that digital tools used to enhance, rather than simply supplement, mathematics instruction.

Based on this theoretical grounding, the study's hypothesis follows:

H1: Mathematics teachers' levels of technology acceptance influence their self-efficacy perceptions regarding technology integration.

Methodology

This research adopted a relational study model, a quantitative approach designed to explore both the direction and strength of relationships among multiple variables (Karasar, 2012; Creswell, 2012). Quantitative research provides a systematic way to evaluate objective theories by analyzing relationships among variables or identifying differences across groups. In this approach, constructs translated into measurable indicators, analyzed with statistical techniques, and interpreted in ways that can be generalized to broader populations (Creswell & Creswell, 2023). In this study, the key constructs were measured using established scales, and the collected data were analyzed using quantitative methods.

To explore how mathematics teachers' levels of technology acceptance influenced their self-efficacy beliefs regarding technology integration, Structural Equation Modeling (SEM) was employed. SEM is a powerful analytical method that brings together both latent and observed variables, making it possible to evaluate complex theoretical models (Heck & Thomas, 2020). By incorporating both the measurement model and the structural model, SEM allows researchers to visualize and examine direct and indirect links among variables within a unified framework (Schumacker & Lomax, 2004). This makes SEM particularly valuable when the goal is to understand intricate patterns of interaction and the underlying processes shaping teachers' beliefs and behaviors.

Interpreting the results of Structural Equation Modeling depends on evaluating several model-fit indices. According to Kline (2016), indices such as χ^2/df, p-values, RMSEA, CFI, and TLI offer a sufficient basis for evaluating whether a model fits the data well. Commonly accepted thresholds include a χ^2/df value below 5, SRMR and RMSEA values below 0.08, and CFI and TLI values above 0.90. Together, these indicators help determine how well the proposed model represents the observed data. When supported by both statistical evidence and theoretical grounding, these results strengthen the reliability and interpretive clarity of the study's conclusions.

Sample Characteristics

The study's sample consisted of 381 teachers working across different school levels. A convenience sampling strategy was used, in which participants were selected based on their accessibility, willingness, and availability (Dornyei, 2007). Table 1 presents a detailed overview of the participants' demographic characteristics. Although convenience sampling is not the most rigorous form of sampling, it remains a practical and commonly used approach in studies where time, resources, or access to participants are limited.

Table 1.
Descriptive Statistics of Participants' Demographic Variables

Variable	Frequency	%
Gender		
Female	262	68,77%
Male	119	31,23%
Type of school he/she works at		
Anatolian High School	101	26,51%
Vocational High School	81	21,26%
Science High School	17	4,46%
Other	182	47,77%
Postgraduate studies		
Master's Degree	158	41,47%
Doctorate	30	7,87%
None	193	50,66%
Years of professional seniority		
1-5 years	76	19,95%
6-10 years	52	13,65%
11-15 years	67	17,59%
16-20 years	52	13,65%
21 years and above	134	35,17%
Taking a technology course		
Yes	260	68,24%
No	121	31,76%
Using Web 2.0 tools in classes		
Yes	242	63,52%
No	139	36,48%
Participating in an in-service training program on technology		
Yes	255	66,93%
No	126	33,07%

The study recruited participants who were easily accessible and willing to take part, following the approach described by Saumure and Given (2008). Data collection conducted online using Google Forms, which distributed to teachers digitally. Participation was entirely voluntary and teachers independently completed the forms at their own convenience. Ethical considerations were addressed thoroughly: the research team obtained approval from the institutional

ethics committee before starting data collection, and all necessary official permissions secured to ensure compliance with relevant guidelines. All participants participated in the study on a voluntary basis.

Tools of Data Collection

For data collection, two established tools were employed: the Technology Acceptance Scale (T-TAM) and the Self-Efficacy Perception Scale for Technology Integration. These instruments were specifically selected to assess participants' levels of technology acceptance, as well as their confidence in integrating technology into their teaching practices.

Technology Acceptance Scale (T-TAM)

In this research, the Technology Acceptance Scale (T-TAM), originally developed by Ursavaş et al., (2014) was used to assess teachers' levels of technology acceptance. Rooted in the Technology Acceptance Model (TAM), the T-TAM provides an in-depth evaluation by examining eleven dimensions: perceived usefulness, perceived ease of use, behavioral intention, self-efficacy, subjective norm, anxiety, facilitating conditions, technological complexity, perceived enjoyment, convenience, and attitude toward use. Together, these dimensions offer a nuanced framework to capture the multifaceted nature of technological acceptance in educational environments.

The scale employs a 5-point Likert-type format, allowing participants to indicate their degree of agreement or disagreement with each statement. Its validity and reliability have confirmed in prior studies, supporting its appropriateness for educational research. By encompassing a wide range of cognitive, emotional, and contextual factors, the T-TAM reflects the complexity inherent in technology adoption and facilitates a comprehensive understanding of the variables influencing teachers' integration of technology.

The items comprising the 'Technological Complexity' and 'Anxiety' sub-dimensions of the T-TAM scale—such as 'It takes too long to learn how to use IT', 'I need to spend a lot of time learning how to use new technologies', 'Using IT is a troublesome process for me', 'I get nervous when using IT', 'Using IT is too complicated for me', and 'I feel challenged when using IT in my classes'—are all negatively phrased. In the original scale developed by Ursavaş et al. (2014), these items were conceptualized as distinct factors and were shown to exhibit negative associations with Perceived Ease of Use. In the present study, the items were similarly analyzed as separate constructs, consistent with the original scale structure, and were not reverse-coded. As a result, the negative factor loadings observed (e.g., T8 = −0.33, T10 = −0.46) should not be interpreted as measurement errors (Table 6), but rather as a theoretically coherent reflection of the expected negative relationship between Technological Complexity, Anxiety, and Perceived Ease of Use (Venkatesh & Bala, 2008).

Self-Efficacy for Technology Integration

To assess how confident mathematics teachers feel about weaving technology into their classrooms, this study utilized the Self-Efficacy Perception Scale for Technology Integration. The original scale developed by Wang et al. (2004) and was later adapted for use in the Turkish educational context by Ünal and Teker in 2018, ensuring its relevance and applicability to local teaching practices. This adaptation went beyond simple translation—it involved rigorous checks for validity and reliability.

The Turkish version of the scale revealed two core dimensions. First, "Computer Technology Proficiency and Strategies," which gauges teachers' confidence in both their technical skills and their ability to meaningfully integrate technology into their instruction. Second, "External Factors Affecting Computer Use," which reflects how things like available resources and institutional support can shape a teacher's ability to use technology effectively.

This adapted scale offers substantive insight into teachers' beliefs and capacities regarding technology integration in education. With a Cronbach Alpha coefficient of .94, its reliability is notably strong—making it a robust instrument for examining self-efficacy in tech-savvy teaching environments.

Reliability Coefficients of the Scales

The values for Cronbach's alpha and McDonald's ω values, which assess the internal consistency of the scales, are presented in Table 2.

Table 2.
Reliability Coefficients of the Scales

	Coefficient α	Coefficient ω
T-TAM	0.669	0.028
S-ET	0.833	0.909
Total	0.735	0.706

Table 2 presents values for both Cronbach's Alpha and McDonald's ω, covering the T-TAM and S-ET categories along with their combined mean. The S-ET sub-dimension demonstrates strong internal consistency, as reflected by Cronbach's Alpha at .833 and McDonald's ω at .909. In contrast, the T-TAM sub-dimension falls short of the generally accepted threshold; Cronbach's Alpha is .669 and McDonald's ω is particularly low at .028, both indicating limited reliability. On the total scale, Alpha (.735) and ω (.706)

suggest that, overall, the scale achieves a sufficient—though not exceptional—level of internal consistency.

Data Analysis

In this research, Structural Equation Modeling (SEM) was utilized to explore the interplay among the study's variables. SEM offers a robust framework for dissecting both the direct and indirect effects within the system, making it particularly effective for analyzing the relationship between mathematics teachers' technology acceptance and their self-efficacy concerning technology integration. By accommodating the simultaneous testing of measurement models and structural paths, SEM allows for a nuanced understanding of these dynamics (Kline, 2016). To assess the quality of the model, several fit indices examined, including chi-square/df, p-value, RMSEA, CFI, and TLI—standards outlined by Kline (2016). The thresholds used for model fit were as follows: chi-square/df values below 5, SRMR and RMSEA values below 0.08, and CFI and TLI values exceeding 0.90 (Byrne, 2016; Kline, 2016).

Additionally, the study evaluated multicollinearity and linear relationships among variables using the Variance Inflation Factor (VIF) and Pearson correlation coefficients. To enhance the reliability of the findings, a Bootstrap method with 5,000 iterations and a 95% confidence interval implemented during the analysis phase.

Cronbach's Alpha and McDonald's Omega coefficients calculated to assess the internal consistency of the data collection instruments. Confirmatory factor analysis (CFA) was then conducted to evaluate construct validity, and relevant goodness-of-fit indices reported. All statistical analyses were conducted using JASP software.

The research aimed to develop a model examining the structural relationships between pre-service teachers' technology acceptance and their self-efficacy regarding technology integration. Technology acceptance was operationalized through the variables of perceived usefulness, perceived ease of use, and behavioral intention, following the Technology Acceptance Model (TAM) as described by Ursavaş et al. (2014). Self-efficacy measured using two sub-dimensions—technology competence and external factors—via the "Self-Efficacy Perception Scale for Technology Integration" created by Wang et al. (2004) and later adapted to Turkish by Ünal and Teker (2018).

Both direct and indirect effects of technology acceptance dimensions on self-efficacy were assessed using structural equation modeling (SEM). To check whether the data met normality assumptions, skewness and kurtosis values for total scale scores were examined. Table 3 presents the skewness and kurtosis values for the latent variables included in the SEM analysis.

Table 3.
Multivariate Test of Normality (Mardia's coefficients).

	Coefficient	z	χ^2	*df*	*p*
Skewness	35.500		816.497	455	< .001
Kurtosis	221.912	8.004			< .001

Table 3 presents the outcomes of Mardia's tests, which evaluate whether the dataset meets the assumption of multivariate normality. The calculated skewness coefficient stands at 35.5, and the related chi-square test produced a value of 816.5 with 455 degrees of freedom ($p < .001$). This clearly indicates a substantial deviation from normality regarding skewness. As for kurtosis, the coefficient reached 221.9, with a z-score of 8.0 ($p < .001$), again pointing to a significant departure from normal distribution. In summary, both skewness and kurtosis measures suggest that the data notably violates the assumption of multivariate normality.

Table 4.
Pearson's Correlations

Variable		T-TAM	S-ET
T-TAM	Pearson's r	—	
	p-value	—	
	Lower 95% CI	—	
	Upper 95% CI	—	
	Effect size (Fisher's z)	—	
	SE Effect size	—	
S-ET	Pearson's r	0.541	—
	p-value	< .001	—
	Lower 95% CI	0.411	—
	Upper 95% CI	0.649	—
	Effect size (Fisher's z)	0.605	—
	SE Effect size	0.086	—

Table 4 displays the results of the Pearson correlation analysis examining the relationship between Technology Acceptance (T-TAM) and Self-Efficacy for Technology Integration (S-ET). The calculated Pearson correlation coefficient ® is 0.541, indicating a moderate positive relationship between the two variables; in other words, higher T-TAM scores are associated with higher S-ET scores.

This correlation is statistically significant ($p < .001$), suggesting that the association observed is highly unlikely to be due to chance. The 95% confidence interval for the correlation ranges from 0.411 to 0.649, further supporting the presence of a moderate relationship. Additionally, the effect size, determined using Fisher's z transformation, is 0.605, with a standard error of 0.086. The low standard error reinforces the reliability of these findings. Overall, these results

suggest that there is a meaningful and statistically robust connection between technology acceptance and self-efficacy for technology integration.

Results

This section outlines the primary findings derived from the quantitative data analysis, which align with the central aim of the study. The results cover the path analyses examining relationships among key variables—specifically, Technology Acceptance and Self-Efficacy for Technology Integration—within the SEM framework. Additionally, explanatory ratios for each variable are reported, alongside measurement details and fit indices for the structural model as a whole. The SEM analysis was conducted with a sample of 213 PSTs. For a comprehensive overview of the model's fit indices, refer to Table 5.

Table 5 details the fit indices for Model 1 within the framework of structural equation modeling (SEM). The chi-square statistic (χ^2) for the model reported at 294.074 with 64 degrees of freedom ($p < .001$). While a significant p value traditionally signals a lack of model fit, it is important to note that the χ^2 test is extremely sensitive to large sample sizes and may flag significance even when the model appropriate (Bentler, 1990). To provide additional context, the χ^2/df ratio presented at 2.93. This falls below the accepted cutoff of three, though it does not meet the more conservative threshold of two for optimal fit (Kline, 2016).

The RMSEA value stands at .161 (confidence interval: [.143, .180]), which notably exceeds the commonly accepted threshold of .08 or below (MacCallum et al., 1996). A high RMSEA value indicates that the model does not fit the data well and that its ability to explain the observed relationships is limited. In contrast, the SRMR is quite low at .0101, comfortably under the .08 benchmark, indicating that the model's residuals are within acceptable limits (Hu & Bentler, 1999).

Table 6 provides the factor loadings for the latent variables (Technology Acceptance and Self-Efficacy for Technology Integration) on their respective indicators, offering an assessment of the measurement model's validity.

Table 5.
Fit Indices of the Structural Equation Model

Model	χ^2	df	p	χ^2/df	CFI	TLI	RMSEA [90% CI]	SRMR	AIC	BIC
Model 1	294.074	64	<.001	2.93	.775	.726	.161 [.143, .180]	.0101	2756.789	2835.825

Table 6.
Factor Loadings of the Measurement Model

Latent	Indicator	Std. estimate	Std. error	z-value	p
T-TAM	T1	0.676	0.050	13.496	< .001
	T2	0.769	0.039	19.719	< .001
	T3	0.762	0.040	19.114	< .001
	T4	0.791	0.036	21.861	< .001
	T5	0.402	0.075	5.367	<.001
	T6	0.818	0.033	25.112	< .001
	T7	0.837	0.030	27.759	< .001
	T8	-0.332	0.079	-4.194	< .001
	T9	0.522	0.066	7.965	< .001
	T10	-0.460	0.071	-6.494	< .001
	T11	0.297	0.081	3.654	< .001
	Y	0.762	0.046	16.705	< .001
S-ET	O1	0.939	0.029	31.897	< .001
	O2	0.859	0.034	25.426	< .001

Table 6 presents the factor loadings, standard errors, z-values, and p-values for the indicators linked to the latent variables Technology Acceptance (T-TAM) and Self-Efficacy for Technology Integration (S-ET), as part of the measurement model validation process. These factors reflect how well each observed variable represents its respective latent construction, offering evidence for the overall construct validity of the model.

With respect to T-TAM, the factor loadings show considerable variability. Indicators T1, T2, T3, T4, T6, T7, and Y all report loadings above 0.67, with T7 (0.837) and T6 (0.818) standing out for their particularly strong contributions. These values surpass the commonly accepted threshold of 0.50 (Hair et al., 2019), supporting the adequacy of these items in measuring the construction. In contrast, T5 (0.402) and T11 (0.297) have low loadings, and T8 (-0.332) and T10 (-0.460) exhibit negative loadings, which raises questions about their suitability as indicators. Despite these concerns, all T-TAM indicators display highly significant z-values ($p < .001$), suggesting the loadings are unlikely to be attributable to chance.

Turning to S-ET, both O1 and O2 demonstrate exceptionally high factor loadings (0.939 and 0.859, respectively), indicating a robust representation of the construct. Their associated z-values (31.897 for O1 and 25.426 for O2) are also highly significant ($p < .001$), providing robust evidence of reliability and convergent validity within this dimension.

In summary, most T-TAM indicators adequately reflect the underlying construct, although certain items (notably T5, T8, T10, and T11) may warrant further examination. The S-ET indicators, meanwhile, show strong and statistically significant relationships with their latent variable, reinforcing the validity of this aspect of the model.

Structural Equation Modelling

The proposed Structural Equation Model was assessed using a variety of fit indices to evaluate how well it represented the observed data (Table 7):

Table 7.
Multiple Fit Indices

χ^2 (64)	294.074
χ^2/df	2.930
p	< .001
RMSEA	.161
SRMR	.101
CFI	.775
GFI	.711
TLI	.726

The model's overall fit isn't flawless; however, certain indices do fall within accepted parameters. Specifically, the χ^2/df ratio stands at 2.930, which is considered acceptable according to established guidelines (Kline, 2016). Additionally, all path coefficients reached statistical significance ($p < .001$), indicating empirical support for the hypothesized structural relationships within the model. The corresponding path diagram illustrating these relationships is provided in Figure 1.

Figure 1.
Path diagram of the SEM with standardized estimates

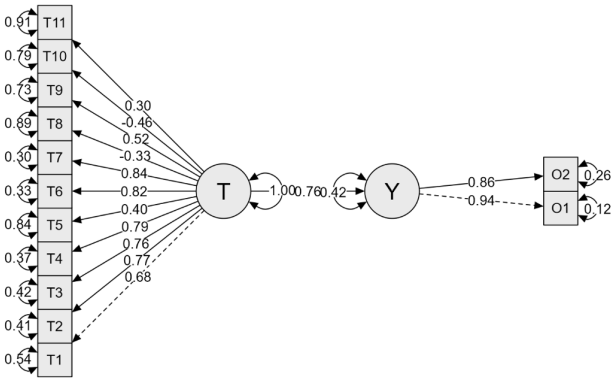


Figure 1 presents the Structural Equation Model (SEM) along with the standardized path coefficients, illustrating the relationships between the latent variables T-TAM (Technology Acceptance Model) and S-ET (Self-Efficacy for Technology). In this model, T-TAM is measured using 11 indicators (T1–T11) that capture mathematics teachers' acceptance of technology, while S-ET is represented by two indicators (O1 and O2) reflecting their self-efficacy in integrating technology into their teaching.

Examining the factor loadings for T-TAM, most indicators—specifically T1, T2, T3, T4, T6, T7, T9, and Y—demonstrate satisfactory values above 0.50, ranging from 0.522 to 0.837. This suggests these items are well-aligned with the T-TAM construct. In contrast, T5 (0.402) and T11 (0.297) show lower loadings, indicating weaker associations. More noteworthy, T8 (-0.332) and T10 (-0.460) exhibit negative factor loadings, which may result from reverse-coding or unexpected theoretical relationships, as noted by Hair et al. (2019).

For the S-ET variable, the indicators O1 (0.94) and O2 (0.86) display extremely high loading factors, indicating a strong measured reliability and capturing the intended dimension effectively within the model. Overall, Figure 1 provides a clear visualization of both the robust and weaker associations present in the measurement model.

The standardized path coefficient between the T-TAM and S-ET latent variables is 0.42, indicating a moderate, positive relationship. In other words, greater technology acceptance (T-TAM) is associated

with higher self-efficacy regarding technology use (S-ET). The covariance between the error terms of T-TAM and S-ET is reported as 0.760, which suggests that the unexplained variance in these constructs is interrelated.

Discussion

This study provides valuable insight into the interplay between mathematics teachers' acceptance of technology and their self-efficacy in integrating technological tools into their instruction. The findings demonstrate a moderate, positive association—indicated by a standardized path coefficient of 0.42—between teachers' openness to adopting technology and their confidence in effectively weaving it into classroom practice. Greater acceptance of technology among mathematics teachers corresponds with heightened self-efficacy regarding technology integration.

This pattern aligns with prior research, such as the work of Abu Bakar et al. (2018), who underscore the importance of self-efficacy and positive attitudes for successful technology integration. Similarly, Teo (2009) and Sang et al. (2010) found that the constructs within the Technology Acceptance Model, including perceived usefulness, contribute meaningfully to teachers' self-efficacy in using technology. Erdener and Kandemir (2019) also highlight the direct influence of teachers' attitudes on their technology-related beliefs and practices.

Further, the observed covariance (0.760) between the error terms of the technology acceptance and self-efficacy variables suggests that unexplained variance in these constructs is interrelated. This points to the possible influence of additional contextual or external factors. As noted by Ngai et al. (2007), environmental conditions such as technical support and accessibility can significantly impact technology integration outcomes. Within the Turkish educational context, challenges such as limited technological infrastructure and insufficient professional development support may contribute to suboptimal results in technology acceptance and efficacy measures—a finding echoed by Erdoğan, (2025), who stress the critical role of contextual influences.

In brief, mathematics teachers face challenges, including curriculum demands and limited resources—that may bear on both their attitudes toward technology and their perceived ability to use it effectively in their classrooms. These findings highlight the importance of both attitudinal and structural support for successful technology integration in mathematics education.

The findings of this study both align with previous research in literature and highlight certain limitations that deserve attention. The moderate positive correlation (r = 0.541) observed between T-TAM and S-ET is consistent with conclusions drawn by Teo (2009) and Venkatesh and Davis (2000), who emphasized that the core components of the Technology Acceptance Model (TAM)—namely, perceived usefulness and perceived ease of use—positively influence teachers' attitudes toward technology integration and their self-efficacy. In the specific context of mathematics instruction, Erdener and Kandemir (2019) and Paraskeva et al., (2008) noted that positive attitudes toward technology can support pedagogical practices such as visualizing abstract concepts and developing problem-solving skills.

The path coefficient of 0.42 identified in this study further confirms the impact of technology acceptance on self-efficacy among teachers, although the moderate strength of this relationship indicates the influence of additional variables, such as pedagogical beliefs or institutional support. Ibrahim et al. (2025) pointed out that TAM does not adequately account for contextual factors, such as a lack of technical support, which can hinder technology integrational—a limitation that may correspond with the less-than-ideal model fit observed here.

Of note are the low and negative factor loadings for items T8 and T10 on the T-TAM scale (–0.332 and –0.460, respectively), which raise concerns regarding the validity of these items. However, the observed negative factor loadings and the modest model fit indices (RMSEA = .161, CFI = .775) reflect a theoretically coherent pattern that is frequently reported in the TAM literature. Technological Complexity and Anxiety conceptualized as negatively valenced determinants of Perceived Ease of Use in extended TAM models (Venkatesh & Davis, 2000; Venkatesh & Bala, 2008). In the Turkish adaptation of T-TAM by Ursavaş et al., (2014), these constructs likewise retained as separate factors, and negative associations with Perceived Ease of Use documented.

In the present study, because these items were not reverse-coded, the measurement model represents these negative relations in a manner consistent with the theoretical nature of the constructs. This pattern does not indicate a scale deficiency or a cultural mismatch; rather, it provides a valid empirical reflection of the continued prevalence of teachers' perceptions of technological anxiety and complexity in the Turkish context. A substantial body of research similarly reports that teachers often experience important levels of anxiety and stress regarding the use of educational technologies, frequently perceiving the process as overwhelming or complex (Fernández-Batanero et al., 2021; Khlaif et al., 2022). In particular, the rapid shift to online teaching during the COVID-19 period has shown to generate significant anxiety and

stress among teachers, due to insufficient training, increased workload, and limited institutional support (Klapproth et al., 2020; Zheng et al., 2022)

Additionally, the T-TAM scale demonstrated low reliability coefficients (α = .669, ω = .028), which may be attributable to insufficient support for preservice teachers in technology integration, as discussed by Clark-Wilson et al. (2020). The internal consistency of the scale may also have compromised by the heterogeneity of the sample, which included teachers from various school types (e.g., Anatolian, Vocational, and Science High Schools) and with differing levels of professional experience. For instance, disparities in access to technology or experience with technology use could have influenced self-efficacy beliefs and, consequently, the scale's reliability. Teachers with less experience may report lower self-efficacy, whereas those with ongoing training or greater familiarity with digital tools may report higher confidence.

These observations suggest that future research should consider revising the T-TAM scale to better account for context-specific factors relevant to Turkish educators. In contrast, the S-ET scale exhibited strong factor loadings and high reliability, indicating that self-efficacy beliefs measured consistently and reinforcing their importance in facilitating technology integration among mathematics teachers (Abu Bakar et al., 2018).

The model's less-than-ideal fit is not exactly surprising, considering the well-documented issues in the literature—violations of normality and measurement inconsistencies have noted repeatedly (Byrne, 2016). Liu et al. (2024) argue that when teacher education programs do not provide clear direction for technology integration, these kinds of inconsistencies tend to crop up. Similarly, Gumiero and Pazuch (2024) highlight that successful technology used in mathematics classrooms closely tied to pedagogical support and domain-specific expertise. In this study, the observed problems with normality and measurement may well reflect the absence of those supports.

To summarize, this research confirms a notable relationship between mathematics teachers' acceptance of technology and their self-efficacy beliefs. Still, certain limitations such as low or negative factor loadings and the model's overall suboptimal fit stand out. These issues underscore the ongoing importance of context: technical support, adequate training, and culturally attuned measurement tools, as emphasized by Erdoğan (2025) and Clark-Wilson et al. (2020).

The findings point to a clear need for teacher education programs to prioritize hands-on technology training and focused pedagogical guidance, aiming to better equip preservice mathematics teachers for tech integration. On the institutional side, schools can help by investing in robust technical infrastructure, offering regular in-service training, and fostering a school culture that values technology. Future research should consider adapting the T-TAM scale for the Turkish context either by revising existing items or creating new ones. Given the data's deviation from normality and the model's weak fit, employing more flexible statistical methods such as Partial Least Squares SEM or Bayesian SEM could generate more reliable results. Including variables like school culture, technical support, and curriculum design as independent factors might provide a deeper understanding of the interplay between technology acceptance and teacher self-efficacy.

Limitations

This study provides valuable insights into the relationship between mathematics teachers' technology acceptance, as measured by the T-TAM scale, and their self-efficacy regarding technology integration, assessed through the S-ET scale. However, several limitations should be acknowledged. Notably, certain items on the T-TAM scale, particularly T8 and T10, displayed low or even negative factor loadings, and the reliability coefficients were below ideal levels (α = .669, ω = .028).

These negative factor loadings stem from the strong inverse relationship between the constructs of Technological Complexity and Anxiety and the Perceived Ease of Use dimension. While future studies could consider reverse-coding these items to integrate them into the Perceived Ease of Use factor and potentially improve model fit, in this study we chose to retain the original theoretical structure of the T-TAM (Ursavaş et al., 2014), which aligns with the negative antecedents described in extended TAM models (Venkatesh & Bala, 2008).

Additional limitations relate to data collection and sample characteristics. Data were collected exclusively online, which may have limited both the diversity and representativeness of the participants. Furthermore, model fit indices were suboptimal, and the data did not fully meet the normality assumption, both of which restrict the generalizability of the findings.

For future research, it is recommended to use measurement instruments that are culturally adapted and validated for the target population, to recruit a broader and more balanced sample, and to consider alternative structural modeling techniques, such as Partial Least Squares Structural Equation Modeling (PLS-SEM). Researchers may also explore whether treating Technological Complexity and Anxiety as separate factors or reverse-coding specific items within the Perceived Ease of Use dimension yields a more parsimonious and statistically robust model.

Declarations

Ethical Approval: Ethical Approval: This study was approved by the University institutional review board.

Consent to Participate: Informed consent was obtained from all individual participants included in the study.

Research involving human participants.

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Integrating E-Comics and Problem-Based Learning (PBL) to Foster Higher-Order Thinking Skills in Elementary Students

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Abstract

The demands of 21st-century education necessitate that students develop Higher Order Thinking Skills (HOTS) to thrive in a dynamic and complex digital era. Nevertheless, elementary-level instruction frequently remains dominated by conventional approaches that inadequately foster critical, creative, and problem-solving competencies. Technology-based learning innovations offer a promising solution, particularly through the integration of E-Comics with Problem-Based Learning (PBL). This study examines the effectiveness of combining E-Comics and PBL to enhance higher-order thinking skills among elementary school students. A quasi-experimental design was employed, utilizing both control and experimental groups. Participants comprised fifth-grade students from two elementary schools in Surakarta, Central Java, Indonesia. Research instruments included HOTS-aligned assessments and structured classroom observation sheets. Data were analyzed using descriptive statistics and inferential t-tests. Results demonstrated that the experimental group, taught using the E-Comic-PBL integration, exhibited a statistically significant improvement ($p<0.05$) in higher-order thinking skills compared to the control group. These findings indicate that integrating interactive digital media such as E-Comics with PBL can serve as an innovative strategy to cultivate students' critical thinking, creativity, and problem-solving abilities. Pedagogical implications and recommendations for further research are also discussed.

Keywords:

E-Comic, Problem-Based Learning, Higher Order Thinking Skills, Elementary School, Digital Learning Media

Introduction

Research Background

Digital technology advancements have catalyzed a transformative impact on education, particularly through the provision of innovative learning media. E-Comics represent one such increasingly prevalent medium, integrating visual narratives with textual content in digital formats (Fianto et al., 2023; Furbani et al., 2025; Pugacheva et al., 2020; Sweller, 2020). Beyond

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enhancing student reading engagement, E-Comics facilitate conceptual comprehension via interactive illustrations. Concurrently, 21st-century curricular demands emphasize cultivating Higher-Order Thinking Skills (HOTS) including analysis, evaluation, and creation. Conventional pedagogical approaches, however, frequently prove inadequate in optimizing HOTS development, necessitating more effective instructional methodologies.

The theoretical underpinning for this integration is supported by the cognitive theory of multimedia learning (Mayer, 2014), which posits that students learn more deeply from words and pictures than from words alone. E-Comics, as a form of structured multimedia, effectively leverage this principle by presenting information simultaneously through visual and textual channels, thereby reducing cognitive load and facilitating the construction of mental models. This dual-coding process is essential for the complex cognitive operations inherent in HOTS, as it allows students to organize and integrate information more efficiently before applying it to novel problems. Furthermore, the narrative structure of comics provides a familiar and compelling framework that can make abstract or complex problems more concrete and accessible to young learners (Dillenbourg, 2016; Schneider et al., 2022).

Problem-Based Learning (PBL) is widely acknowledged as an efficacious approach for fostering HOTS. Within PBL frameworks, students engage with contextual problems that stimulate investigation, collaboration, and problem-solving (Funa & Prudente, 2021; Jonassen, 2024; Naslund & Filipenko, 2016). Nevertheless, PBL implementation in elementary education often encounters constraints due to the inadequate availability of media that supports the presentation of engaging, contextually relevant problems. This underscores the significance of incorporating E-Comics as a medium for presenting problems within PBL. By delivering problem scenarios through relatable visual narratives, E-Comics are posited to enhance student involvement and conceptual understanding.

Although previous studies have consistently reported the effectiveness of Problem-Based Learning in promoting higher-order thinking skills, several researchers note that its implementation at the primary school level often encounters challenges related to students' abstract reasoning abilities and limited contextual understanding. In this regard, visual and narrative-based learning media are increasingly viewed as a necessary scaffold to bridge the gap between problem complexity and learners' cognitive readiness.

The effectiveness of PBL is contingent upon the authenticity and ill-structured nature of the initial problem trigger. E-Comics offer a dynamic solution to this requirement by enabling the creation of rich, narrative-driven scenarios that embed problems within a relatable context. For instance, a comic strip can depict characters facing a real-world dilemma related to science or social studies, instantly providing the "why" and "how" that motivates student inquiry. This narrative presentation moves beyond a simple textual case study, reducing the initial abstraction of the problem and providing visual anchors—such as character expressions, environmental details, and sequential action—that scaffold the students' initial analysis and question-generation phase, which is critical for subsequent critical thinking (Barrows, 1996; Topkaya et al., 2023).

Prior research indicates the positive potential of comics in education, though investigations remain largely confined to aspects of motivation and foundational conceptual comprehension. Meanwhile, studies on PBL in elementary settings have demonstrated improvements in problem-solving abilities. However, the specific integration of E-Comics and PBL for HOTS development remains underexplored. Consequently, this study is designed to address this research void by examining the synergistic potential of E-Comics and PBL in advancing HOTS among elementary school students.

Although previous studies have demonstrated the effectiveness of Problem-Based Learning or digital comic media in improving students' learning outcomes and engagement at the elementary level, most of these studies treat e-comics as supplementary learning resources rather than as an integral instructional scaffold within the PBL process. In addition, limited attention has been given to the systematic alignment between e-comic narrative design, PBL stages, and explicit higher-order thinking skills indicators.

Addressing this gap, the present study proposes an E-Comic–integrated Problem-Based Learning model that is intentionally designed to embed problem scenarios, guiding questions, and reflective prompts corresponding to each PBL phase and HOTS dimensions. By focusing on this integrative and cognitively oriented design at the elementary school level, this study offers a novel contribution to the intersection of PBL, digital comics, and higher-order thinking skills development.

Literatur Review

Higher-Order Thinking Skills (HOTS) encompass cognitive abilities that involve advanced mental processes, including analysis, evaluation, and creation (Anderson & Krathwohl, 2001). Within primary education contexts, cultivating HOTS plays a crucial role in equipping students to address future complex challenges. Research consistently indicates that

these skills can be fostered through challenging and contextually relevant instructional approaches (Brookhart, 2010). Problem-Based Learning (PBL), a constructivist methodology, utilizes real-world problems as the foundation for learning (Hmelo-Silver, 2004). In PBL settings, students collaborate in groups to solve authentic problems, thereby honing their analytical, synthetic, and evaluative capabilities. A meta-analysis by Walker and Leary (Walker & Leary, 2023) underscores PBL's effectiveness in enhancing higher-level cognitive learning outcomes. However, the success of PBL implementation is significantly contingent upon the quality of the problem scenarios presented.

The efficacy of PBL in primary education is further mediated by the developmental stage of the learners. Younger students often require significant scaffolding to deconstruct complex problems and direct their cognitive resources toward analysis rather than mere fact-finding (Kapur, 2016; Sari et al., 2024). This scaffolding is essential to bridge the gap between the problem's complexity and the students' emerging cognitive abilities. Without structured support, the problem-solving process may become overwhelming, potentially hindering the very HOTS development PBL aims to promote. Therefore, the design of the learning environment, particularly the instructional media used to present the problem narrative, becomes a critical variable for successful HOTS cultivation in younger demographics.

E-comics, as digital learning media, offer distinct advantages by delivering content in a visual and narrative format. Studies, such as that by Hosler and Boomer (2011), demonstrate comics' potential to improve students' understanding of scientific concepts. The dynamic and interactive nature of E-comics can further boost student motivation and engagement (Hosler & Boomer, 2011; Suri et al., 2021). Nevertheless, the specific application of E-comics for developing HOTS warrants further in-depth investigation.

Recent empirical work has begun to explore the unique attributes of E-comics that are conducive to critical thinking. The sequential art format inherently requires students to make inferences, connect narrative events, and deduce causality, which are fundamental components of analytical thinking (Wewengkang et al., 2024). Furthermore, the multimodal nature of E-comics—merging text, image, and often audio—supports cognitive load theory by distributing information across different channels, allowing working memory to process information more efficiently for deeper understanding (Kapi et al., 2017). This efficient processing is a prerequisite for engaging in the demanding tasks of evaluation and creation that define HOTS.

Integrating digital media like E-comics with the PBL approach is hypothesized to create a rich learning environment conducive to HOTS development (Clark & Mayer, 2023; Hwang et al., 2023; Mohar & Kovač, 2021). Cognitive Theory of Multimedia Learning posits that combining text and visuals enhances information processing (Mayer, 2022). Presenting problem scenarios through E-comics is expected to heighten student motivation and facilitate a deeper understanding of the problem context, potentially increasing the efficacy of the PBL process. While research by Puriasih and Trisna with junior high school students yielded positive results from integrating digital comics with PBL, comparable studies at the primary school level remain scarce (Puriasih & Trisna, 2022).

Consequently, a significant research gap exists regarding the structured integration of E-comics as a scaffolded problem-presentation tool within a PBL framework for primary education. The question remains whether the narrative and visual scaffolding provided by a well-designed E-comic can effectively prime students' analytical processes and sustain their engagement throughout a PBL cycle. Investigating this integration could provide a replicable model for educators seeking to implement HOTS-oriented pedagogy with younger learners, ultimately empowering them to become more adept and confident problem-solvers. Future research should therefore focus on empirical studies that measure specific HOTS gains when primary school students engage with PBL modules where the initial problem stimulus is delivered via a tailored E-comic narrative.

Research Problem

Despite Problem-Based Learning (PBL) being widely recognized as an effective approach for cultivating Higher Order Thinking Skills (HOTS), its implementation in elementary schools frequently encounters obstacles. A primary challenge lies in designing contextually relevant problems that genuinely engage students' interest. Conventional learning materials such as textbooks or student worksheets often fail to present problems through compelling visual and narrative formats, thereby diminishing student engagement. Concurrently, the potential of visually appealing digital media like E-Comics remains underutilized in supporting PBL methodologies.

Prior research on E-Comic applications in education has predominantly concentrated on literacy development or basic conceptual understanding, with limited exploration of their impact on HOTS. Furthermore, integrative studies examining E-Comics combined with PBL to enhance HOTS at the elementary level remain scarce. Consequently, a comprehensive study is warranted to evaluate the effectiveness of this integrative model in developing students' analytical, critical, and creative thinking abilities. Within the

context of Problem-Based Learning, Multimedia Learning Theory provides a theoretical rationale for the use of E-Comics by emphasizing that learners process information more effectively when verbal and visual representations are meaningfully integrated. Meanwhile, Cognitive Load Theory explains how the structured narratives and sequential visuals in E-Comics can reduce extraneous cognitive load, allowing students to focus more on problem analysis and solution generation. The integration of these theories positions E-Comics not merely as an illustrative tool, but as a cognitive scaffold that enhances the effectiveness of PBL in fostering higher-order thinking skills at the primary school level.

By synthesizing Problem-Based Learning, Higher-Order Thinking Skills, and multimedia-based instructional design within a coherent theoretical framework, this study contributes to the growing body of research on innovative learning media for primary education. Specifically, it offers a theoretically grounded approach to integrating E-Comics into PBL as a means of addressing both cognitive and contextual challenges faced by learners.

Research Focus

This study investigates the development and testing of an integrative learning model combining E-Comics and Problem-Based Learning (PBL). The primary objective is to enhance Higher-Order Thinking Skills (HOTS) among fifth-grade elementary school students within the Natural Science subject area.

Research Aim and Question

This study aims to examine the efficacy of integrating E-Comics and Problem-Based Learning (PBL) in enhancing higher-order thinking skills (HOTS) among elementary school students. The research addresses the following questions:

1. How does the improvement in students' HOTS differ when taught using the integrated E-Comic and PBL model compared to conventional instruction?
2. How do learning activities unfold during the implementation of the E-Comic and PBL integration?
3. What are student perceptions regarding this integrated learning model?

Methodology

Design & Setting

This study employed a quasi-experimental design with a pretest-posttest control group format. The experimental group received instruction integrating E-Comics with Problem-Based Learning (PBL), while the control group experienced conventional teaching methods (lectures and limited discussions). The research was conducted at two class elementary schools in Surakarta, Central Java, Indonesia, between January and March 2025. The selection of elementary schools in Surakarta as the research location was based on the following rational considerations: Representative educational context, Active implementation of policies and curriculum, Accessibility and feasibility of research, Suitability for research objectives. To establish group equivalence, pretest scores were analyzed prior to the intervention. The results indicated no statistically significant difference between the experimental and control groups, suggesting comparable initial higher-order thinking skills before treatment.

Population & Sampling

The study population included all third-grade students in two parallel classes at the school. Purposive sampling was used to select participants based on criteria: (1) relatively homogeneous academic and social characteristics, as recommended by teachers, and (2) division into two separate classes per school. From each school, one class was assigned as the experimental group (n=30) and another as the control group (n=30), yielding a total sample of 60 students. Purposive sampling was employed to ensure that participants possessed comparable curricular backgrounds and learning characteristics relevant to the implementation of the instructional intervention. Although this sampling technique and the localized sample size limit statistical generalizability, the findings are intended to provide analytical generalization within similar educational contexts.

Instruments & Validation

Key research instruments included: 1) HOTS Test: Essay and complex multiple-choice questions measuring analysis, evaluation, and creation abilities. Each item was assigned equal weight, and the total score was obtained by summing the scores across all items. Score interpretation was conducted based on predefined categories to ensure consistency in data analysis; 2) Learning Activity Observation Sheets: Documenting collaboration, problem-solving, and E-Comics utilization; 3) Student Response Questionnaires: Assessing perceptions of the learning model.

Instrument validation was performed by pedagogy specialists and science content experts. Prior to its use in the main study, the instrument underwent reliability testing using the Cronbach's alpha method. The results yielded a reliability coefficient of $\alpha = 0.85$, indicating [good/very good] internal consistency. Therefore, the instrument was considered reliable and appropriate for data collection. Intervention fidelity was ensured through the use of standardized lesson plans, consistent instructional duration across groups, and

regular monitoring during classroom implementation. The same instructor delivered the intervention to minimize instructional variability, and adherence to the planned procedures was documented throughout the study

Data Collection

The data collection procedure involved: 1) Pretest: Administered to both groups before intervention; 2) Intervention: The experimental group received E-Comics integrated PBL instruction across 8 sessions (Science topic: reproduction of living organisms). Each session included: (a) problem presentation via E-Comics, (b) group discussion, (c) investigation, and (d) solution presentation; 3) Posttest: Conducted following the intervention; 4) Observations and Questionnaires: Completed during and after the intervention period.

To address the second research question concerning students' learning activities during the E-Comic–PBL implementation, an observational analysis was conducted using a structured activity rubric aligned with the phases of Problem-Based Learning. Each learning session was analyzed across indicators of engagement, collaboration, problem analysis, and solution development. The collected data were quantified and further interpreted to identify patterns of active learning behaviors that reflect Higher-Order Thinking Skills (HOTS) development.

The third research question, which focuses on students' perceptions of the E-Comic–PBL learning model, was analyzed using descriptive statistics and thematic analysis. Questionnaire responses were grouped into three main aspects: perceived usefulness, learning motivation, and cognitive support. Open-ended responses were coded thematically to capture students' subjective experiences and attitudes toward the learning process.

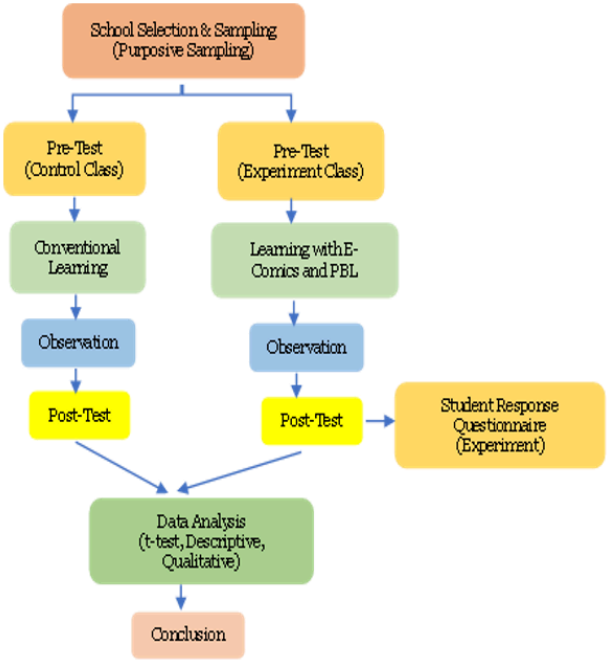
Analytical Approach

Data analysis combined quantitative and qualitative methods: 1) Normality (Shapiro-Wilk) and homogeneity (Levene's test) assessments preceded hypothesis testing; 2) Independent samples t-tests compared HOTS improvement (N-gain scores) between experimental and control groups; 3) Descriptive statistics analyzed observation and questionnaire data; 4) Qualitative analysis interpreted learning activities from observation records.

This analysis is used to analyze differences between groups, as this method is suitable for achieving research objectives and provides accurate and relevant analysis results.

The following presents the research flow chart.

Figure 1:
research flow chart



Findings

Table 1 below shows the Average Pretest, Posttest, and N-Gain HOTS Scores between the experimental and control groups.

Table 1.
Average Pretest, Posttest, and N-Gain HOTS Scores

Group	Pretest (Mean)	Posttest (Mean)	N-Gain	p-value (t-test)
Experiment	45.23	82.67	0.68	0.000
control	44.87	65.45	0.38	

Note: N-Gain is calculated using the formula (Posttest-Pretest)/(100-Pretest).
A p-value <0.05 indicates a significant difference.

As shown in the table, students in the experimental group achieved higher average scores than those in the control group, indicating a positive effect of the implemented intervention. The initial pretest scores for both groups were remarkably similar (Experiment: 45.23; Control: 44.87), indicating a comparable baseline level of HOTS proficiency prior to the instructional intervention.

Following the treatment, a marked disparity in posttest performance was observed. The experimental group achieved a substantially higher mean score of 82.67, compared to the control group's mean of 65.45. This differential improvement is most accurately captured by the N-Gain score, which normalizes for the initial starting point. The experimental group's N-Gain of 0.68 falls into the "moderate" to "high" effectiveness range, according to standard interpretive frameworks

(e.g., Hake, 1998). In stark contrast, the control group's N-Gain of 0.38 is indicative of only "low" to "moderate" effectiveness. This substantial difference in gain scores suggests that the instructional intervention applied to the experimental group was significantly more efficacious in fostering HOTS.

The independent samples t-test results confirm the statistical significance of this finding. The p-value of 0.000, which is well below the standard alpha level of 0.05, allows for the rejection of the null hypothesis. Therefore, it can be conclusively stated that there is a statistically significant difference in the mean HOTS posttest scores between the group that received the experimental treatment and the group that underwent conventional instruction. This result provides robust empirical evidence that the intervention implemented in the experimental group was successful in enhancing students' higher-order cognitive abilities.

Figure 2.
Comparison Diagram of N-Gain HOTS per Indicator

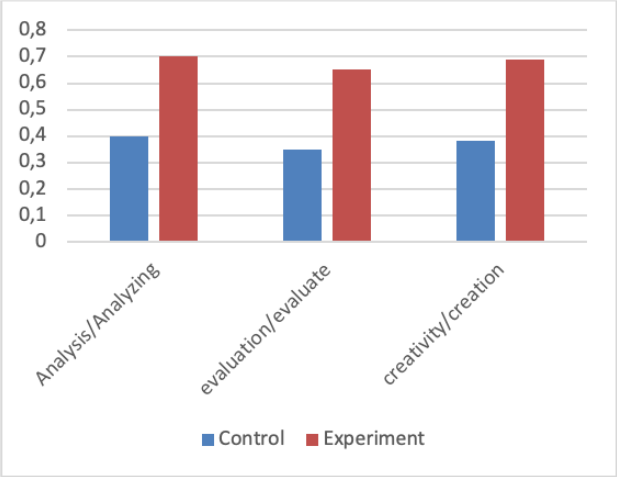


Figure 2 delineates the normalized gain (N-Gain) for each Higher-Order Thinking Skills (HOTS) indicator, providing a granular view of the experimental intervention's efficacy. The data reveals a consistent and superior performance by the experimental cohort across all measured cognitive domains compared to the control group. The most substantial improvement was recorded for the analysis indicator (N-Gain = 0.70), followed closely by creation, with the evaluation indicator showing a marginally lower, yet still robust, gain of 0.66. Crucially, all three indicators for the experimental group reside within the moderate-to-high effectiveness range. This stands in stark contrast to the control group, which demonstrated uniformly moderate gains (N-Gain 0.35–0.40) across the same indicators. This differential performance strongly suggests that the pedagogical approach employed in the experimental condition was particularly effective in fostering advanced cognitive processes, with a pronounced impact on analytical abilities.

Table 2.
Results of Observation of Learning Activities in the Experimental Group

Aspect	Average Score (1-4)	Category
Engagement	3.75	High
Collaboration	3.60	High
Problem Solving	3.45	Moderate
Use of E-Comics	3.80	High

The observational data from the experimental group, as detailed in Table 2, indicate a generally successful implementation of the instructional intervention. Student performance was particularly strong in the domains of Engagement (Average Score = 3.75) and Use of E-Comics (Average Score = 3.80), both categorized as 'High'. This suggests that the integration of the digital comic media was highly effective in capturing student interest and facilitating interaction with the learning material. Furthermore, the Collaboration aspect scored highly (Average Score = 3.60), implying that the learning environment successfully promoted productive group dynamics and cooperative tasks.

A more nuanced finding emerges in the Problem-Solving category, which received a 'Moderate' classification with an average score of 3.45. While this indicates a positive trajectory and demonstrates that students were actively engaged in solution-oriented activities, it also reveals a perceptible gap compared to the other metrics. This discrepancy suggests that while the learning design was successful in fostering engagement and collaboration, the translation of these activities into fully developed, independent problem-solving competencies may require further reinforcement or a longer intervention period to mature. The analysis of students' learning activities indicates that the integration of E-Comic within the PBL framework facilitated higher levels of student engagement and cognitive involvement, particularly during problem identification and solution formulation stages. These activities correspond to the HOTS dimensions of analysis, evaluation, and creation, thereby directly addressing the second research question

This pattern of results implies that the use of E-comics served as a powerful catalyst for motivation and collaborative work. However, the moderate score in problem-solving highlights a critical area for pedagogical refinement. It may be necessary to incorporate more explicit scaffolding techniques—such as structured brainstorming protocols, guided reflection on the problem-solving process, or direct instruction on specific heuristic strategies—within the E-comic narrative framework to more directly bridge

the gap between engagement and the advanced cognitive processes required for sophisticated problem-solving.

Figure 3.
Student Responses to Learning

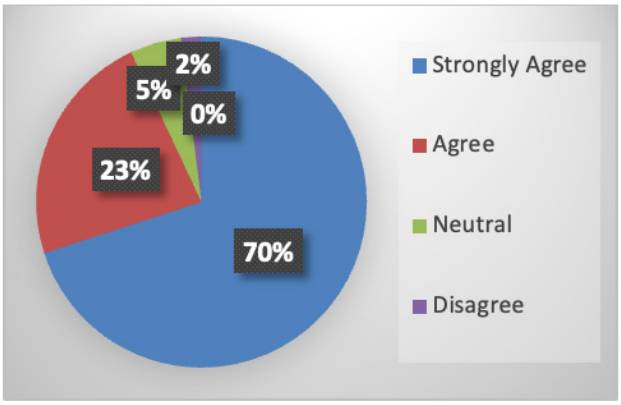


Figure 3 shows the results of a survey of student responses. The survey data reveals an overwhelmingly favorable reception of the integrative learning model among the student cohort. A commanding 93% of respondents expressed a positive stance, selecting either 'Agree' (70%) or 'Strongly Agree' (23%). This notable consensus indicates that the pedagogical approach successfully resonated with the vast majority of participants.

Qualitative feedback elucidates the reasons behind this strong endorsement. Students reported that the utilization of E-Comics significantly enhanced their engagement by presenting subject matter in a more captivating and accessible format, thereby facilitating improved comprehension of complex issues. Furthermore, the Problem-Based Learning (PBL) component was perceived as instrumental in developing their capacity for critical thinking, suggesting the model's efficacy in promoting higher-order cognitive skills. The findings related to student perceptions demonstrate a positive response toward the E-Comic–PBL integration, particularly in terms of learning motivation and conceptual understanding. These results provide analytical evidence that directly addresses the third research question, indicating that students perceive the learning model as supportive of HOTS-oriented learning.

This highly positive quantitative result, substantiated by student testimony, strongly suggests that the fusion of visual narrative media (E-Comics) with a constructivist pedagogical framework (PBL) creates a potent and effective learning environment. The data underscores the model's success not only in conveying information but also in actively training essential analytical competencies, marking it as a promising strategy for contemporary education. Future research could investigate the longitudinal effects of this model on specific cognitive gains and knowledge retention.

Overall, the findings consistently indicate that the proposed approach offers advantages over the traditional method, both in terms of measurable learning outcomes and the quality of the learning process.

Discussion

While the findings of this study corroborate previous research indicating that Problem-Based Learning (PBL) supported by digital learning materials enhances students' problem-solving skills and learning engagement, our results also reveal nuanced differences. Specifically, unlike prior studies that reported uniform improvements across cognitive domains, the present study found that the impact of PBL-based digital materials was more pronounced in higher-order thinking skills than in basic conceptual understanding. This divergence may be attributed to the contextual design of the digital materials, which emphasized authentic problem scenarios rather than content repetition.

Moreover, this study offers a new perspective by demonstrating that the effectiveness of digital PBL materials is influenced by students' prior experience with self-directed learning. This finding extends earlier research by suggesting that digital PBL environments may require differentiated scaffolding strategies to accommodate learners with varying levels of autonomy.

In addition to confirming the effectiveness of PBL in a digital context, this study contributes to the literature by highlighting how instructional design characteristics such as problem complexity and interactivity influence learning outcomes. These findings provide a deeper understanding of how digital learning materials can be optimized within the PBL framework.

The results of this study prove that the integration of E-Comics and PBL significantly improves students HOTS compared to conventional learning. These findings are in line with the research by Wu et al (2021), which shows that interactive visual media can improve the effectiveness of PBL. In this context, E-Comics act as scaffolding that helps students understand the context of the problem visually and narratively, thereby facilitating the process of analysis and problem solving (Þahan & AtlÝ, 2025) .

The highest increase in the analysis indicator (N-Gain=0.70) shows that presenting problems through E-Comics triggers students to identify the components of the problem systematically. This aligns with Mayer's theory that combining text and visuals facilitates deeper information processing. Additionally, the story

format in E-Comics makes problems more contextual, enabling students to connect them more easily with prior knowledge (Rasmet et al., 2025).

The observed learning activities also showed high levels of student engagement and collaboration. This indicates that this integrative model not only enhances cognitive skills but also social skills. These findings support (Hmelo-Silver, 2004) research that PBL is effective in creating a collaborative learning environment. E-Comics as a problem-presentation medium successfully served as a catalyst for productive discussions among students.

Students' positive responses to this learning model reinforce Hosler & Boomer's findings that comics can increase learning motivation. In this study, the interactive aspects of E-Comics, such as simple animations and easy navigation, made students more enthusiastic. This high motivation is suspected to be one of the driving factors behind the improvement in HOTS (Bijuklič, 2024; Hosler & Boomer, 2011).

However, the problem-solving aspect still has a slightly lower observation score (3.45) compared to other aspects. This may be due to the complexity of the problems, which require repeated practice. Therefore, it is recommended to implement this model continuously so that students become more skilled in developing innovative solutions (Farias et al., 2023).

Furthermore, the findings suggest that the narrative structure of E-Comics may serve as a metacognitive scaffold, guiding students to monitor and evaluate their problem-solving strategies more effectively. This is consistent with recent work, who demonstrated that digitally narrated scenarios prompt learners to engage in self-questioning and strategic planning, which are core components of metacognitive regulation essential for HOTS development (Berenji, 2021; Šterman Ivančič, 2024; Yuliani & Setiawan, 2024). The sequential panels in E-Comics inherently model a procedural approach to deconstructing complex issues, thereby making the abstract stages of problem-solving more tangible and accessible to students.

From a socio-constructivist perspective, the synergy between E-Comics and PBL effectively creates a shared referential framework for group discourse. The visual narrative provides a common ground for discussion, reducing ambiguities and aligning team members' understanding of the problem space. This aligns with contemporary studies on collaborative learning, which indicate that shared visual artifacts significantly improve the quality of group reasoning and co-construction of knowledge (Fitria et al., 2023; Tracey & Hutchinson, 2019). The E-Comic, therefore, is not merely a presentation tool but a boundary object that mediates social interaction and collective cognitive effort.

Regarding the slightly lower performance in problem-solving, this could be attributed to the cognitive load associated with transferring analytical insights into actionable, novel solutions. While E-Comics excel at framing problems and facilitating analysis, the act of synthesis and creation demands a distinct cognitive effort that may require more prolonged exposure. This observation finds support in a study, which noted that students often need multiple cycles of feedback and iteration within digital learning environments to transition comfortably from analysis to innovative solution generation (Bogataj, 2024; Lee & Hannafin, 2016; Ismiyanto et al., 2024) Future implementations could thus incorporate more iterative prototyping phases following the initial problem analysis facilitated by the E-Comics.

Although the findings indicate that the integration of E-Comics within PBL is associated with improved cognitive outcomes and learner motivation, it is important to consider alternative explanations. For instance, the observed effects may partly stem from a novelty effect or from increased instructional guidance provided during the implementation of PBL, rather than from the E-Comics alone. Empirically, the results demonstrate a statistically significant improvement in students' problem-solving performance and learning motivation. From an interpretative perspective, these outcomes suggest that E-Comics may function as cognitive and motivational scaffolds by externalizing problem representations and sustaining learner engagement during the PBL process.

Conclusion

Based on the research results, it can be concluded that the integration of E-Comics and PBL is effective in improving the higher-order thinking skills (HOTS) of elementary school students. This learning model not only significantly improves analytical, evaluative, and creative abilities but also encourages active engagement, collaboration, and motivation among students. E-Comics have proven to be an effective medium for presenting problems in PBL due to their visual, narrative, and interactive nature. Thus, this integration can be recommended as a pedagogical innovation for developing HOTS at the elementary education level. Despite the contributions of this study, several methodological limitations should be acknowledged. First, the sample was drawn from a single educational institution, which may limit the generalizability of the findings to other educational contexts or student populations. Second, the study employed a quasi-experimental design without random assignment, which may have introduced selection bias. Third, data collection relied partly on self-reported measures, which are subject to social desirability and response bias. Future studies are encouraged to employ longitudinal designs, multi-

institutional samples, and mixed-method approaches to further validate and extend the present findings.

These conclusions should be interpreted in light of several limitations, including the relatively small sample size and the short duration of the intervention. Consequently, while the findings support the potential of E-Comics as supportive scaffolding tools in PBL, further studies with broader contexts and longer implementation periods are required before making broader generalizations

Implications

Theoretically, this study reinforces the model of integrating digital media and the constructivist approach in developing HOTS. Practically, this study provides an alternative innovative learning model for elementary school teachers. Teachers can develop E-Comics with local content to increase the relevance of the problems. Schools are advised to provide supporting infrastructure such as digital devices and teacher training.

Research Limitations

This study has several limitations: 1) The sample is limited to two schools in one district, so generalization should be done with caution; 2) The research material is limited to the topic of science (reproduction of living things); 3) The development of E-Comics in this study still needs the use of augmented reality or advanced interactive features.

Further Research Recommendations

Based on these limitations, the following are recommended: 1) Further research with a broader and more diverse sample; 2) Experiments in other subjects such as Mathematics or Social Studies; 3) Development of E-Comics using more advanced technology (e.g., augmented reality-based) and testing its impact; 4) Longitudinal research to observe the long-term effects of this integrative model; 5) Studies on the factors mediating the effectiveness of the model, such as the role of teachers and parental support.

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The Model of Principal's Instructional Leadership Realizing Meaningful Learning in Primary Schools

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Abstract

This study aims to explore how a principal implements instructional leadership practices as the primary conceptual framework for realizing meaningful learning in an elementary school. The research employed a qualitative case study approach, with data collected through semi-structured interviews. The participants included the principal, four teachers, and four students. Data were analyzed qualitatively using the thematic analysis model developed by Naeem et al. (2023) , which involves selecting relevant statements, coding, identifying themes, and constructing a conceptual framework. The trustworthiness of the data was ensured through source triangulation. The findings indicate that the principal's instructional leadership plays a significant role in fostering meaningful learning in elementary schools. The conceptual framework of instructional leadership identified in this study highlights the interconnection between formulating a clear learning vision, empowering teachers and educational staff, openness to instructional innovation, conducting continuous supervision, and creating a positive learning environment as key factors supporting meaningful learning. This study contributes to the development of instructional leadership scholarship, particularly within the context of elementary education, and offers a practical model that can be utilized to support the implementation of meaningful learning in schools.

Keywords:

Teachers; Principals; Instructional Leadership; Meaningful Learning; Primary School

Introduction

Instructional leadership of school principals is a key factor in improving the quality of education (Acton, 2021). Principals hold a strategic role in promoting positive social change (Acton, 2021; Kurniawan & Hasanah, 2021) managing and directing instructional programs (Bada et al., 2024) and creating a school environment that is conducive to teaching and learning processes (Rincon-Flores et al., 2024). Through appropriate policies, instructional supervision, and sustained support for teachers, principals can directly influence the quality of classroom instruction (Bellibaş et al., 2021; Yu et al., 2022). The primary focus of instructional leadership is to build a positive academic climate and strengthen teachers' confidence in implementing instruction (Yu et al., 2022; Ma

& Marion, 2021). With such support, teachers are better positioned to deliver meaningful learning experiences that actively engage students, foster critical thinking skills, and connect subject matter to students' everyday lives (Mystakidis, 2021).

However, in practice, the implementation of instructional leadership in primary schools still faces various challenges. Weak communication and coordination between principals and teachers often hinder efforts to improve the quality of instruction and student learning outcomes (Hidayat et al., 2022). Several studies indicate that instructional leadership becomes less effective when it is not supported by strong synergy between principals and teachers (Datreni, 2022; Teguh et al., 2024). Moreover, in certain contexts, principals continue to prioritize administrative duties over the strengthening of instructional practices. This condition contributes to teachers' tendency to rely on rote-based teaching methods, which provide limited opportunities for students to experience meaningful learning (Kostiainen & Pöysä-Tarhonen, 2022).

Conceptually, the relationship between instructional leadership, instructional quality, and student learning outcomes has been widely examined in the international literature (Bellibaş et al., 2021; Liu et al., 2021; Berkovich & Hassan, 2024; Pietsch et al., 2025). However, most of these studies focus on educational contexts in Western countries, which differ from Indonesia in terms of educational systems, school organizational culture, and leadership dynamics. In-depth research examining how instructional leadership is effectively enacted within Indonesian primary schools characterized by distinctive cultural, social, and institutional complexities remains relatively limited. Therefore, contextual studies that portray the actual practice of instructional leadership are essential to enrich the current body of knowledge, which has largely been dominated by global perspectives.

This study was conducted at SD Inspiratif Al-Ilham Kota Banjar as a qualitative case study representing what is considered a successful practice of instructional leadership. The school demonstrates consistent student achievement and positive character development, such as discipline, responsibility, and social awareness, amid the dynamics and challenges of primary education in Indonesia. The instructional leadership practices implemented at SD Inspiratif Al-Ilham provide an empirical and contextual perspective on how school leadership can concretely support the realization of meaningful learning not only in terms of academic outcomes but also in strengthening character development and student engagement in the learning process. Accordingly, the novelty of this study lies in presenting an in-depth and contextual case study of a principal's instructional leadership practices in fostering meaningful learning within an Indonesian primary school. This research does not aim to propose a universal model; rather, it seeks to identify and formulate the key components of instructional leadership that are relevant to the local context and that may contribute to enriching the international literature, which has thus far provided limited representation of experiences from developing countries.

Based on this background, the present study aims to conduct an in-depth analysis of the principal's instructional leadership practices at SD Inspiratif Al-Ilham Kota Banjar and to identify the key components that shape this leadership model in supporting meaningful learning. Specifically, this study addresses the following research question: How do the principal's instructional leadership practices at SD Inspiratif Al-Ilham support the realization of meaningful learning in primary education, and what components constitute the instructional leadership model within this context?

Literature Review

Instructional Leadership as a Key to Realizing Meaningful Learning

Instructional leadership positions the school principal as a central actor in improving the quality of teaching and learning in schools (Liu et al., 2021). Unlike administrative leadership, which emphasizes operational management, instructional leadership focuses on the principal's direct involvement in instructional processes, teacher development, and the creation of a supportive learning climate (Berkovich & Hassan, 2024; Guo et al., 2025). In this role, the principal acts as a leader of learning, bridging the school's vision with classroom instructional practices.

This study adopts the instructional leadership framework proposed by dari Hompashe (2024) which consists of three dimensions: 1) setting the direction for learning, 2) managing instructional programs, and 3) developing a positive school learning climate. At the primary school level, this framework is particularly relevant, as principals are responsible not only for academic achievement but also for establishing students' foundational pedagogical experiences and early learning development achievement but also for establishing students' foundational pedagogical experiences and early learning development (Pietsch et al., 2025).

In this study, instructional leadership is conceptualized as a set of leadership practices that influence how teachers design, implement, and reflect on instruction. Accordingly, instructional leadership is employed as the primary theoretical lens for interpreting principals' practices and their impact on learning processes within the school.

Meaningful Learning as an Outcome of Instructional Leadership

Meaningful learning is a student-centered approach in which understanding is constructed through active engagement and authentic experiences, rather than through the passive reception of information (Tulak et al., 2024). Grounded in constructivist theory, meaningful learning emphasizes that knowledge is formed through students' interaction with their environment and learning context (Wibowo et al., 2025). Therefore, meaningful learning largely depends on teachers' pedagogical strategies and a classroom climate that supports participation and reflection.

At the primary school level, meaningful learning requires teachers to connect instructional content to students' everyday lives, provide opportunities for active participation, and foster the development of critical thinking skills and learning responsibility (Che Mat & Jamaludin, 2024; Conner et al., 2025; Kubsch et al., 2025). However, teachers' capacity to implement meaningful learning is strongly influenced by the support provided by the principal through instructional leadership practices. Accordingly, within the theoretical framework of this study, meaningful learning is positioned as an outcome of the principal's instructional leadership practices.

Teacher Capacity Development as a Connecting Mechanism

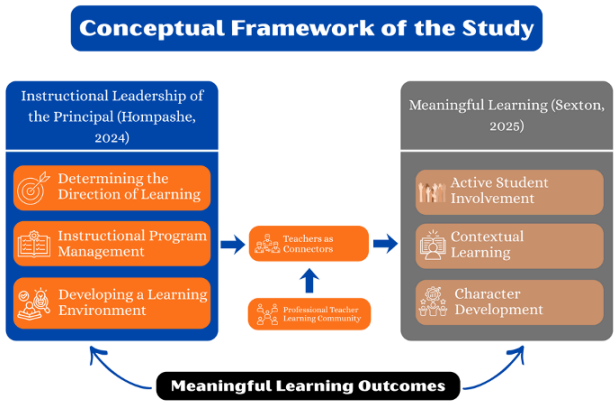
To explain the relationship between instructional leadership and meaningful learning, this study positions teacher capacity development as the linking mechanism. One of the key concepts employed is that of teachers as adaptive learners or fast learners (Li et al., 2023). In this study, fast learner is not understood merely as an individual cognitive ability, but as a professional characteristic demonstrated through openness to innovation, adaptability to curriculum changes, and a willingness to engage in continuous reflection on meaningful instructional practices (Kostiainen & Pöysä-Tarhonen, 2022). Teachers with these characteristics are better able to respond to the principal's guidance and translate the school's vision into meaningful classroom learning experiences.

Instructional leadership plays a significant role in developing teachers' capacity as adaptive learners through professional learning communities, collaborative supervision, and a culture of shared reflection (Hassan et al., 2019). Thus, the concept of fast learner is positioned as part of teachers' professional development, explaining how instructional leadership contributes to the quality of meaningful learning.

Conceptual Framework of the Study

Based on the above discussion, this study is grounded in a conceptual framework that positions instructional leadership as the primary factor influencing meaningful learning through the strengthening of teachers' capacity and adaptability. This framework serves as the theoretical foundation for analyzing and interpreting the research findings in a coherent and consistent manner.

Figure 1.
Conceptual Framework of the Study



Methods

Research Design

This study employed a qualitative approach with a case study design. This approach was selected to enable an in-depth exploration of the case (Hasanah, 2021; Lim, 2025) particularly concerning the model of instructional leadership in fostering meaningful learning based on real phenomena occurring in the field. Through this approach, the researcher was able to gain a comprehensive understanding of how the principal enacted their role in guiding and supporting instructional processes to ensure that learning was relevant and meaningful for students. The study emphasized depth of information rather than the quantity of data, thereby generating richer findings that are valuable for the development of educational practices in primary schools (Lim, 2025). Furthermore, the qualitative approach is inherently flexible, allowing the researcher to adjust the direction of the inquiry based on emerging findings during the data collection process. This flexibility makes the study more responsive to change and open to the emergence of new insights (Renjith et al., 2021).

Participant Selection

The research participants were selected using purposive sampling, a technique in which informants are intentionally chosen based on their involvement in and experience with the phenomenon under investigation, ensuring that the data obtained are relevant and information rich (Nyimbili & Nyimbili, 2024). The participants consisted of the principal, four teachers, and four students from SD Inspiratif Al-

Ilham Kota Banjar. The teachers were selected from Grades 3, 4, 5, and 6, as those grade levels are directly and continuously involved in the implementation of instructional policies, academic supervision activities, and instructional innovations directed by the principal. Including teachers from different grade levels enabled the study to obtain a more comprehensive and diverse understanding of instructional leadership practices within the school. Meanwhile, the student participants were specifically selected from Grade 5, based on the consideration that students at this level possess stronger communication and reflective abilities compared to those in lower grades. These abilities allowed them to articulate their learning experiences, interactions with teachers, and perceptions of meaningful learning more clearly. In addition, Grade 5 students have accumulated sufficient learning experience within the school but have not yet reached the final stage of primary education, making their perspectives representative of the sustained impact of instructional leadership practices.

Table 1.

Participant demographics

No	Participant	Gender	Position
1	Participant 1 (P1)	Female	Principal of Inspirational Elementary School Al-Ilham, Banjar City
2	Participant 2 (P2)	Male	Grade 3 Teacher of Inspirational Elementary School Al-Ilham, Banjar City
3	Participant 3 (P3)	Male	Grade 4 Teacher of Inspirational Elementary School Al-Ilham, Banjar City
4	Participant 4 (P4)	Female	Grade 5 Teacher of Inspirational Elementary School Al-Ilham, Banjar City
5	Participant 5 (P5)	Female	Grade 6 Teacher of Inspirational Elementary School Al-Ilham, Banjar City
6	Participant 6 (P6)	Female	5th Grade Student of Inspirational Elementary School Al-Ilham, Banjar City
7	Participant 7 (P7)	Female	5th Grade Student of Inspirational Elementary School Al-Ilham, Banjar City
8	Participant 8 (P8)	Female	5th Grade Student of Inspirational Elementary School Al-Ilham, Banjar City
9	Participant 9 (P9)	Female	5th Grade Student of Inspirational Elementary School Al-Ilham, Banjar City

Data Collection

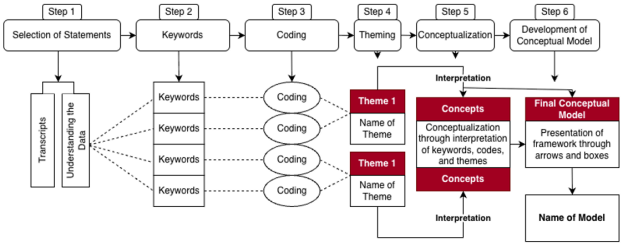
This study employed three data collection techniques: semi-structured interviews, observation, and documentation. Semi-structured interviews were conducted to explore participants' perspectives in depth using flexible open-ended questions guided by an interview protocol (Roberts, 2020). During the interviews, the researcher acted as the primary instrument, facilitating interaction and conducting preliminary interpretation of the data. Observation was carried out to obtain contextual and behavioral data directly from the field, enabling the researcher to capture actual practices beyond participants' verbal accounts (Chand, 2025). In addition, document analysis, including institutional policies, instructional documents, and related records, was used to support and verify the findings (Bowen, 2009). The use of these three instruments enabled data triangulation, thereby enhancing the credibility and trustworthiness of the study (Dahal, 2025).

Data Analysis

The data analysis in this study employed a thematic analysis approach based on the model proposed by Naeem et al. (2023) supported by the use of Atlas. ti version 9 software. The analytical process was not conducted in a linear manner; rather, it was iterative and reflective in nature. The researcher continuously moved back and forth between the raw data, the coding process, and the development of themes to ensure analytical rigor and depth.

Figure 2.

Data Analysis Process Naem et al. (2023)

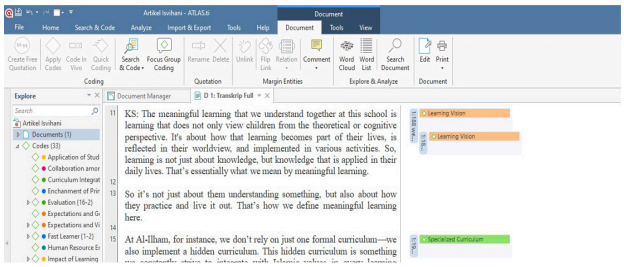


Based on the information presented in Figure 1, the data analysis process could be presented as follows:

1. The initial stage of analysis began with the verbatim transcription of all interview recordings to preserve the integrity of the context and meaning of participants' statements. The transcripts were then read repeatedly to gain a comprehensive understanding of participants' experiences regarding the implementation of instructional leadership in fostering meaningful learning. At this stage, the researcher wrote initial analytical memos to document impressions, emerging patterns, and reflections on the data.

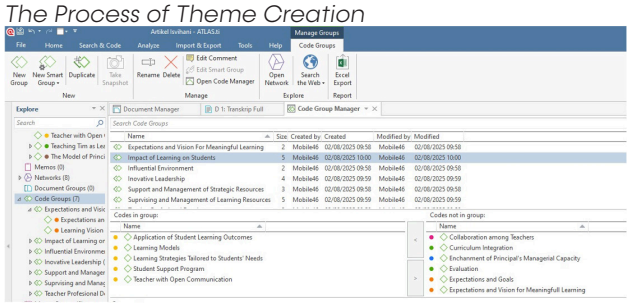
2. The coding process was conducted inductively by examining words, phrases, and sentences that represented participants' experiences and perspectives. The resulting codes were not treated as rigid categories; instead, they were continuously reviewed through a constant comparative process across transcripts. As the researcher's understanding evolved, several codes were revised, merged, or further refined. This process reflects an iterative movement between the raw data and the codes to ensure that each code was firmly grounded in the data.

Figure 3.
Coding Process



3. Through this iterative process, a total of 24 codes were generated, representing various aspects of instructional leadership roles in supporting meaningful learning in primary schools. These codes were then analyzed relationally by considering similarities in meaning, conceptual connections, and their relevance to the research objectives. The grouping of codes into themes was conducted interpretatively rather than mechanically, by continuously examining the alignment between the emerging themes and the original data.

Figure 4.
The Process of Theme Creation



4. The outcome of this process was the identification of six major themes: 1) expectations and vision for meaningful learning, 2) support and management of strategic resources, 3) supervision and management of instruction, 4) teacher professional development, 5) innovative leadership, and 6) the impact of learning on students. Each theme was constructed from several interrelated codes and supported by excerpts from multiple participants.

5. To enhance the transparency and rigor of the analysis, the relationships between codes and themes were visualized in the form of a thematic map. This thematic map illustrates how individual codes are interconnected and collectively form the major themes, as well as how these themes interact in explaining instructional leadership practices that support meaningful learning.

The final stage of analysis involved interpreting the themes holistically to develop key concepts that describe the principal's role in directing, facilitating, and sustaining meaningful learning within the school's social and educational context. These concepts were subsequently organized into a box-and-arrow diagram as a conceptual framework illustrating the interconnections among instructional leadership, teacher empowerment, contextual instructional strategies, school values, and student engagement.

Results

Figure 5.
Conceptual Conclusions

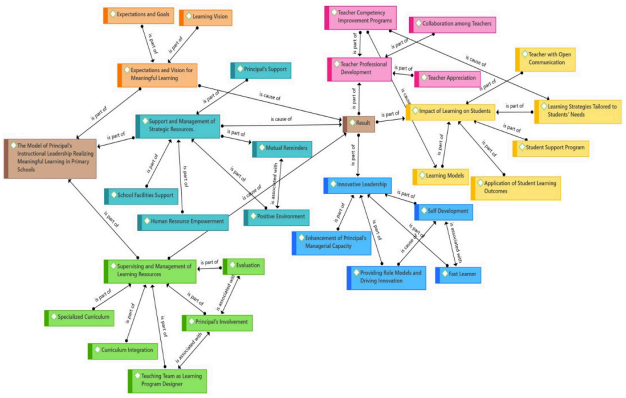


Figure 5 illustrates that the realization of meaningful learning in primary schools is the result of structured and interconnected instructional leadership enacted by the principal. The model explains that meaningful learning begins with the clarity of expectations and a shared vision for learning, which serve as the guiding direction for all school programs. This vision is subsequently supported by the strategic management of resources, including principal support, the provision of facilities, the empowerment of human resources, and the creation of a positive and collaborative learning environment. Furthermore, the successful implementation of instruction is reinforced through supervision and the effective management of learning resources, such as curriculum development and integration, the involvement of teacher teams as program designers, and ongoing evaluation. At the same time, teacher professional development through competence enhancement, teacher collaboration, and performance recognition emerges as a crucial factor that directly influences the quality of students' learning experiences. Collectively, these processes culminate in the development of innovative leadership that encourages the implementation of instructional strategies aligned with students' needs, the establishment of academic mentoring programs, and the optimization of learning outcomes. Thus, this model underscores that meaningful learning is created through the synergy of a clear vision, managerial support, academic supervision, and teacher professionalism oriented toward student development.

Theme 1: Expectations and Vision for Meaningful Learning

This theme was constructed from the grouping of several key codes, namely learning vision, expectations, and goals. These codes represent how

the principal formulates the direction of instruction and establishes standards for meaningful learning outcomes. The theme indicates that instructional leadership in fostering meaningful learning begins with the clarity of a shared vision and mutually agreed-upon expectations.

Figure 6.
Components of Meaningful Learning Vision



Figure 6 illustrates that the vision for meaningful learning is constructed from two main components: expectations and goals, and learning vision. Expectations and goals represent the targets the school aims to achieve in the instructional process, while the learning vision reflects the long-term direction that guides the implementation of education. These two components complement one another and form an integral part of shaping expectations and vision for meaningful learning. The findings indicate that meaningful learning does not emerge spontaneously; rather, it begins with clearly defined objectives and a well-articulated vision that is collectively understood by all members of the school community.

Subtheme 1.1: Learning Vision

The findings indicate that the learning vision is understood by participants as a strategic foundation underlying all educational planning and implementation within the school. This vision functions as a shared reference point for the principal and teachers, ensuring that instructional practices remain aligned with the school's long-term goals. The data reveal that the vision is not merely communicated verbally, but is also embodied in consistent policies and decision-making. The principal explained the essence of this vision as follows:

> *"...learning that does not view children solely from a theoretical or cognitive perspective, but also how learning becomes something that is applied in their lives, in their perspectives, and in various activities."*
> *(P1, Interview Transcript, page 1, lines 16-18)*

Conceptually, the learning vision reflects an instructional leadership orientation that emphasizes contextualized learning. This vision serves as a cognitive framework for teachers, guiding them to perceive students as individuals who need to be prepared for real-life challenges, rather than merely as recipients of academic content.

Subtheme 1.2: Expectations and Goals

In addition to the learning vision, the data reveal clearly articulated expectations and goals concerning the desired graduate profile. The code Expectations and Goals emerged from participants' statements regarding the academic, moral, and spiritual standards that the school seeks to achieve. These expectations serve as benchmarks for instructional quality as well as criteria for evaluating educational success. The principal expressed these expectations as follows:

> *"What we hope for is to have children who are aligned with our vision. Our vision is to produce scholars not only scholars, but also lovers of the Qur'an..." (P1, Interview Transcript, page. 3, lines 15-16)*

Conceptually, this subtheme suggests that meaningful learning is understood as a process of shaping students' identities. The integration of intellectual development and spiritual values indicates that the school views learning outcomes as part of students' character formation and life values, rather than merely as formal academic achievement.

Theme 2: Support and Management of Strategic Resources

This theme was developed from the grouping of several codes, namely principal support, school facility support, human resource empowerment, and a positive and mutually reinforcing environment. The theme indicates that meaningful learning does not rely solely on a clearly articulated vision, but also on the principal's tangible support in managing resources in a systematic and strategic manner. The effective management of teachers, facilities, and sustained professional support creates enabling conditions that allow teachers to implement instruction optimally and consistently.

Figure 7.
Support and Management of Strategic Resources

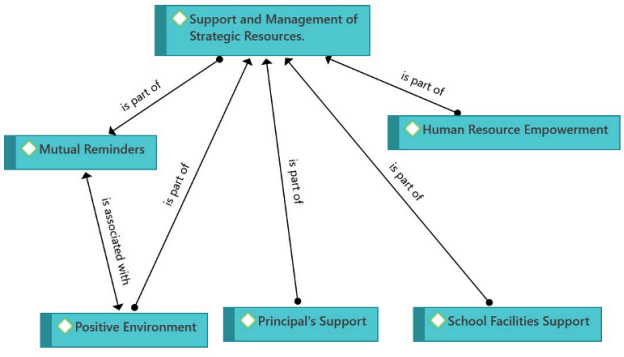


Figure 7 illustrates that support and the management of strategic resources for meaningful learning are constructed through several interrelated components: principal's support, school facilities support, human resource empowerment, a positive environment, and

mutual reminders. The principal's support serves as the primary driving force in coordinating the provision of facilities and the empowerment of human resources within the school. In addition, the establishment of a positive environment and the presence of mechanisms for mutual reminders among members of the school community reinforce the sustainability of instructional program implementation. These findings affirm that the success of meaningful learning is determined not only by pedagogical aspects, but also by the effectiveness of strategic resource management that supports the teaching and learning process.

Subtheme 2.1: Principal's Support

Participants emphasized that the principal's support serves as the driving force in maximizing instructional quality. This support is primarily directed toward fulfilling teachers' professional needs, enabling them to develop the confidence and skills necessary to innovate in the classroom. One participant stated:

> *"...The principal also provided training several times as a form of support from the school, so that teachers could further improve their quality." (P5, Interview Transcript, page 2, lines 18-21)*

These findings demonstrate that the principal plays an active role as a facilitator of educational quality improvement. Conceptually, the provision of training reflects that instructional leadership does not merely demand outcomes, but also assumes responsibility for developing human resource capacity to ensure that meaningful learning processes can be implemented effectively and sustainably.

Subtheme 2.2: School Facilities Support

In addition to personal support, the availability of physical facilities and information technology serves as an essential instrument that enables teachers to effectively perform their roles as instructional leaders. Adequate facilities allow teachers to explore various instructional media that are relevant to students' needs, both inside and outside the classroom. The principal explained the school's strategy in providing such facilities as follows:

> *"In terms of support from the school, perhaps from the aspect of facilities or supporting resources. For example, when it relates to IT or technology, we also strive to facilitate teachers whenever they need it." (P1, Interview Transcript, page 3, lines 25-27)*

The benefits of this infrastructural support are directly experienced by teachers in supporting their daily activities and fostering collaboration:

> *"Providing learning media such as projectors, facilitating Wi-Fi Alhamdulillah and a teachers' room for discussions in the administrative office, which allows sharing activities to take place." (P5, Interview Transcript, page 2, lines 22-23)*

Systematically, these findings indicate that school facilities function as enabling tools. With the availability of Wi-Fi, projectors, and collaborative spaces, the school transforms into a dynamic learning environment in which technology and physical spaces are utilized to enrich students' learning experiences and strengthen a culture of professional sharing among teachers.

Subtheme 2.3: Empowerment and Optimization of Human Resources

The management of strategic resources also encompasses both the quantity and quality of teaching staff. Participants indicated that a proportional number of teachers relative to the curricular workload is crucial for sustaining meaningful learning, particularly in schools implementing a full-day system. The principal described the teacher-to-program ratio at the school as follows:

> *"There are 41 teachers, because here, first, we implement a full-day system, and second, there are additional subjects that we also have to teach." (P1, Interview Transcript, page 4, lines 25-27)*

Conceptually, this finding suggests that human resource empowerment is a key factor in ensuring educational stability. By optimally managing the number of teachers, the school can maintain the quality of additional programs and the full-day system without imposing excessive workloads that might diminish teachers' creativity and instructional effectiveness.

Subtheme 2.4: A Positive Environment and Mutual Reminders

Participants revealed that the positive atmosphere within the school emerges from structured programs designed to encourage self-reflection and mutual support among teachers. The principal does not allow the work culture to develop naturally without direction; rather, it is intentionally shaped through activities that strengthen both the spiritual bonds and professional commitment of teachers. The principal explained one of the school's flagship programs as follows:

> *"To support one of the programs, teachers also participate in a group mentoring program, which we call Bina Pribadi Islami, and it is mandatory." (P1, Interview Transcript, page 5, lines 29-30)*

This positive culture extends beyond teachers and is translated into habits of mutual care and encouragement throughout the entire school community. One participant emphasized:

> *"There needs to be mutual feedback and advice among peers. Teachers encourage students to remind one another, where students are expected to provide input and advice to each other." (P5, Interview Transcript, page 5, lines 37-39)*

Conceptually, these findings indicate that the school has cultivated a collective value based culture. Coaching practices for teachers and a culture of mutual advice among students create a safe and supportive environment for all members of the school community. The key implication of this finding is that an environment characterized by reciprocal support facilitates the internalization of learning values. When teachers feel emotionally and spiritually supported, they are better prepared to create a comfortable classroom atmosphere, enabling knowledge to be more effectively understood and applied by students in their daily lives.

Theme 3: The Impact of Learning on Students

This theme illustrates how meaningful learning has a direct impact on students' experiences and development. It was constructed from various codes demonstrating the relationship between classroom instructional practices and the outcomes perceived by students. These codes include open teacher communication, the use of varied instructional models, the implementation of strategies tailored to students' needs, the availability of support programs for students, and students' ability to apply what they have learned. The analysis indicates that the impact of meaningful learning is reflected not only in students' understanding of subject matter, but also in their sense of comfort during learning, their level of engagement, and their ability to apply knowledge in everyday life.

Figure 8.
The Impact of Learning on Students

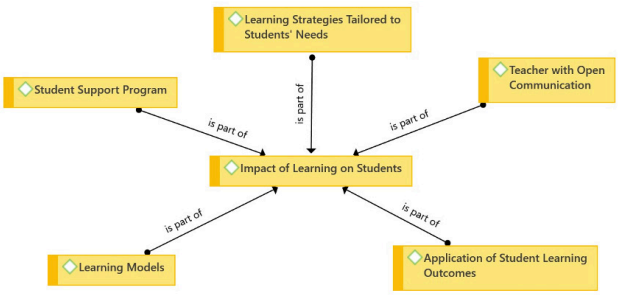


Figure 8 illustrates that the impact of learning on students is shaped by several key components: learning strategies tailored to students' needs, student support programs, teachers with open communication, learning models, and the application of student learning outcomes. Instructional strategies that are adapted to students' needs play a crucial role in ensuring that the learning process becomes more relevant and meaningful. Student mentoring programs and open teacher communication further strengthen student engagement and learning motivation. In addition, the implementation of appropriate learning models and students' ability to apply their learning outcomes serve as tangible indicators of successful meaningful learning. These findings suggest that the impact of learning extends beyond cognitive achievement to include the quality of support, interaction, and the practical application of students' competencies in real life contexts.

Subtheme 3.1: Teachers with Open Communication

The first impact perceived by students concerns teachers' open and warm communication patterns. Students noted that teachers who are approachable and willing to engage in discussion not only create an enjoyable learning atmosphere, but also enhance students' confidence to participate actively and ask questions, particularly in subjects considered difficult. One participant described the comfort experienced as follows:

> *"Learning feels easier because I use a different approach that I learned from my mother, especially in mathematics. The teacher accepts that approach, so the learning atmosphere becomes enjoyable and not angry. Also, during P5 activities or projects, the teacher especially the homeroom teacher is easy to discuss with and develop ideas." (P8, Interview Transcript, p. 5, lines 4-8)*

This sense of warmth also facilitates students' understanding of complex subject matter, as expressed by another participant:

> *"Everyone is easy to communicate with, both the principal and the teachers, especially the mathematics teacher, because it is difficult. Many students ask questions, and they answer immediately." (P9, Interview Transcript, page 5, lines 14-16)*

Conceptually, these findings indicate that the psychological safety established by teachers serves as a primary gateway to meaningful learning. When the distance between teachers and students is reduced through empathetic communication, students' intrinsic motivation to engage in academic exploration increases significantly.

Subtheme 3.2: Learning Models

Meaningful learning is implemented through instructional models that position students as the center of learning activities (student-centered learning). The use of problem-based learning and project-based approaches not only creates a dynamic classroom atmosphere but also fosters students' collaborative skills through group discussions. This was explained by one participant:

> *"...it is not only the teacher who is active, but also other models such as problem-based learning so that students can play a more active role. In addition, digital media are also facilitated." (P5, Interview Transcript, p. 6, lines 9-12)*

Discussion-based practices have become a common feature across various subjects, as expressed by another participant:

> *"Group work or discussions, like deliberation, are commonly carried out in P5 (Pancasila Student Profile Strengthening Program), Civics Education, and other projects." (P7, Interview Transcript, page 2, lines 8-9)*

In essence, these findings indicate that teachers have successfully transformed the classroom atmosphere from being monotonous to becoming more engaging and challenging. Conceptually, this reflects the development of learner autonomy. Students are no longer fully dependent on the teacher; instead, they are encouraged to think critically and seek answers independently. This demonstrates that the principal's strategy in promoting active teaching approaches has effectively empowered students within the classroom.

Subtheme 3.3: Learning Strategies Tailored to Students' Needs

Meaningful learning strategies in this school do not confine students' learning experiences solely to the classroom. Teachers encourage students to explore the external environment so they can understand that learning resources are not limited to textbooks or classroom settings. This strategy begins with a personal, "heart-to-heart" approach before engaging in academic content. One participant emphasized:

> *"Students are already accustomed to project-based learning because in our school, learning does not only take place inside the classroom, but also outside the classroom." (P2, Interview Transcript, page 7, lines 9-14)*

This approach is preceded by the development of emotional connection, as conveyed by another participant:

> *"First, we do not immediately deliver the material. We speak heart-to-heart with them." (P4, Interview Transcript, page 8, lines 12-16)*

These findings indicate that the school utilizes the real world as an extended learning resource. By learning outside the classroom, theoretical concepts that previously felt difficult become easier to understand because students can directly observe concrete examples. Furthermore, the heart-to-heart approach reflects the school's strong concern for students' emotional well-being. When students feel emotionally secure and connected to their teachers, the learning process becomes smoother and is no longer perceived as a burden.

Subtheme 3.4: Student Support Programs

The school provides various routine programs and diverse extracurricular activities to support students' interests and talents. Programs such as morning inspiration function as mental preparation before beginning academic activities, while extracurricular activities serve as platforms for self-development beyond the formal curriculum. The principal explained this routine as follows:

> *"...Routine activities from morning until afternoon... For example, in the morning we have morning inspiration from 7 to 8 a.m.; we do not immediately start formal lessons, right?" (P1, Interview Transcript, page 5, lines 19-24)*

Support for students' interests and talents is also extensive, covering sports, arts, and science, as mentioned by another participant:

> *"...the school has many extracurricular activities, such as cooking class, futsal, volleyball, badminton, karate, calligraphy, coloring, science art there are so many." (P2, Interview Transcript, page 7, lines 25-28)*

Conceptually, these programs demonstrate that the school values the uniqueness of each child. Meaningful learning is not solely about report card grades, but also about the balanced development of students' character and talents. Routine activities such as morning inspiration help students build positive mental readiness, ensuring that they develop not only intellectually but also in terms of personal maturity and social competence.

Subtheme 3.5: Application of Student Learning Outcomes

The ultimate impact of the entire learning process is reflected in students' ability to apply their knowledge in real-life contexts and achieve accomplishments at the global level. Meaningful learning has successfully transformed theoretical knowledge into practical life skills that are relevant to students' daily experiences. This application is evident in everyday subject practices:

> *"Civics Education involves cooperation or group work through deliberation, while mathematics may involve shopping activities using money in daily life." (P7, Interview Transcript, page. 3, lines 26-30)*

This success has even extended to the international level, as proudly shared by another participant:

> *"...there is also the International Kangaroo Mathematics Contest (IKMC), an international mathematics competition... I once won a gold medal..." (P8, Interview Transcript, page 1, lines 28-35)*

Conceptually, this theme leads to the conclusion that meaningful learning, when effectively managed by instructional leadership, produces holistic outcomes. Students not only excel academically but also develop mature character, strong deliberation skills, and independence in solving practical problems in their everyday lives.

Discussion

The findings of this study indicate that the principal's instructional leadership plays a crucial role in supporting the realization of meaningful learning in elementary schools. These results reinforce the perspective that the principal does not merely function as an administrative manager, but rather as a key actor who influences the quality of learning through policy direction, support for teachers, and the creation of a conducive learning climate. Thus, within the context of this study, instructional leadership operates indirectly yet systematically in enhancing the quality of students' learning processes.

Building a Shared Vision for Learning

The findings of this study indicate that the success of meaningful learning at SD Inspiratif Al-Ilham originates from a clear school vision that is collectively understood by all members of the school community. The vision does not remain merely a formal document, but is translated into daily instructional practices. This aligns with the literature emphasizing that setting a clear learning direction is a core dimension of instructional leadership (Hompashe, 2024), However, several studies have criticized that school visions often fail to influence instructional practices because they are not effectively communicated or internalized by teachers (McTigue et al., 2024; Yang & Xu, 2026). In contrast, the findings of this study demonstrate the opposite condition, where the principal consistently connects the school's vision with classroom learning objectives. This strengthens the argument that the effectiveness of instructional leadership lies not only in formulating a vision, but also in sustaining the processes of communication and guidance to ensure its implementation.

Principal Support for Teachers in Instructional Practices

The second theme of the research findings indicates that the principal provides tangible support to teachers through the provision of facilities, professional development opportunities, and spaces for collective reflection. These findings confirm the view that the influence of instructional leadership on student learning is generally mediated through teachers (Bellibaş et al., 2021; Yu et al., 2022). When teachers feel professionally supported, they are more confident in developing contextual and student-centered instructional strategies. However, research by Cansoy et al. (2025) suggests that instructional leadership is often constrained by the principal's administrative workload, resulting in less optimal support for teachers. The findings of this study add a new nuance by demonstrating that principals can continue to perform their instructional roles effectively when teacher support is positioned as a strategic priority rather than as an additional task. The results also show that the principal plays an active role in creating a safe, comfortable, and learning-supportive school environment. This environment not only impacts students but also enhances teachers' motivation and professional comfort in carrying out their duties. These findings are consistent with previous research highlighting that school climate is one of the primary pathways through which instructional leadership influences the quality of learning (Mayer, 2002). Nevertheless, not all studies agree that instructional leadership consistently succeeds in fostering a positive learning climate. Some research indicates that overly top-down leadership approaches may reduce teacher participation and generate resistance (Kostiainen & Pöysä-Tarhonen, 2022). In the context of this study, instructional leadership appears to be enacted collaboratively, thereby avoiding such negative consequences and instead strengthening the school's learning culture.

The Impact of Instructional Leadership on Student Learning

The ultimate impact of the instructional leadership practices identified in this study is reflected in increased student engagement in learning, as well as improved academic and non-academic achievement. Learning that is designed to be more contextual and interactive encourages students to become more active, confident, and capable of connecting subject matter with their everyday lives. These findings support the argument that effective instructional leadership contributes to the enhancement of learning quality, particularly when principals focus on the learning process rather than solely on outcomes (Shu & Gu, 2023). On the other hand, the literature also notes that the relationship between instructional leadership and student learning outcomes is not always direct or consistent (Papadakis et al., 2024). Therefore, the findings of this study enrich the discourse by demonstrating how the elementary school context and an adaptive leadership approach can strengthen this relationship.

Implications for Understanding Instructional Leadership

Overall, this discussion demonstrates that instructional leadership in elementary schools should be understood as a contextual and sustained practice. The findings not only confirm existing theories of instructional leadership, but also provide empirical insights into how such leadership can be enacted effectively to support meaningful learning. By focusing on a shared learning vision, providing continuous support for teachers, and fostering a conducive learning environment, principals can play a strategic role in enhancing the quality of learning in elementary schools.

Conclusion

This study demonstrates that the principal's instructional leadership plays a significant role in supporting the realization of meaningful learning in elementary schools. The findings at SD Inspiratif Al-Ilham, Banjar City, reveal that a principal who actively sets the direction for learning, supports teachers, and fosters a positive school climate can have a tangible impact on the quality of students' learning processes, particularly through strengthening teachers' roles and professionalism. Nevertheless, these findings should be interpreted with caution. This research is a qualitative case study conducted in a single private school grounded in religious values; therefore, the results are contextual in nature and are not intended for broad generalization. Accordingly, the instructional leadership model proposed in this study is more appropriately positioned as a preliminary model that is relevant for schools with similar characteristics. From an educational policy perspective, these findings highlight the importance of reinforcing the instructional role of principals not merely as administrative managers, but as learning facilitators and drivers of teachers' professional development. Future research is recommended to examine this model in more diverse school contexts using quantitative or mixed-method approaches. Finally, longitudinal studies would also be valuable to determine whether this type of instructional leadership leaves a lasting impact on students' character formation and development into adulthood.

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During the preparation of this manuscript, the authors utilized ChatGPT and Grammarly to improve the grammar and writing style of the text. Following the use of these tools, the authors reviewed and edited the results as necessary and maintain full responsibility for the content of the manuscript. The authors declare that artificial intelligence was not employed in the data collection process, data analysis, the formulation of scientific conclusions, or the drafting of the article's core intellectual content.

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Appendiks

Research Interview Blueprint

No	Research Concept	Sub-Concept	Indicators	Data Sources	Data Collection Techniques
1	Instructional Leadership	Expectations and Vision of Meaningful Learning	Principal's involvement in planning, implementing, and evaluating learning	Principal	Interview
		Resource Support	Frequency and forms of supervision	Principal, Teachers	Interview
			Follow-up actions from supervision results		
		Supervision and Management of Learning Programs	Facilitation of training	Principal, Teachers	Interview
			Provision of motivation		
			Provision of rewards		
		Positive Learning Environment	Intensity of communication	Principal, Teachers	Interview
			Teacher involvement in decision-making		
2	Meaningful Learning	Learning strategies used by teachers	Active and contextual learning methods	Teachers, Students	Interview, Observation
			Implementation of projects or group work		
		Student activities and engagement in learning	Student activeness, creativity, and understanding	Teachers, Students	Interview, Observation
		Supportive learning environment	Positive learning climate	Teachers, Principal, Students	Interview, Observation
			Emotional and social support		
3	Instructional Leadership Model	Best practices in reference schools (case study of SD Inspiratif Al-Ilham)	Unique strategies implemented	Principal, Teachers, Students	Interview, Documentation
			Impact on students and teachers		
		Potential replication of the model in other schools	Supporting and inhibiting factors	Principal	Interview
			Suitability with the characteristics of other elementary schools		

Interview Guidelines

For Principals

No	Aspect Explored	Interview Questions	Notes on Responses
1	Shared Vision and Expectations	How do you define meaningful learning in this school?	
		What are your expectations for teachers in realizing meaningful learning?	
		Do you communicate these expectations to the teachers?	
		How do you communicate them?	
2	Strategic Resource Management	What forms of support does the school provide to help teachers implement meaningful learning?	
		What is your strategy for allocating resources to support meaningful learning?	
3	Learning Program Management	How do you monitor the implementation of meaningful learning by teachers?	
		Are there any special programs developed to ensure that learning is relevant and meaningful for students?	
4	Positive Learning Environment	How do you create an environment that supports teachers in developing meaningful learning?	
		Does the school foster a collaborative culture among teachers in designing learning?	
5	Self-Development and Innovative Leadership	What efforts do you make to develop yourself as an instructional leader?	
		How do you encourage teachers to continuously develop themselves as instructional leaders?	

For Teachers

No	Aspect Explored	Interview Questions	Notes on Responses
1	Expectations and Vision for Meaningful Learning	How do you understand the concept of meaningful learning in this school?	
		Has the principal ever conveyed expectations or a vision related to meaningful learning?	
		How was it delivered?	
2	Resource Support	What kinds of support have you received from the principal to develop meaningful learning?	
		Has this support met your needs in teaching?	
3	Supervision and Learning Program Management	Has the principal ever provided feedback on the teaching strategies you use?	
		How is the principal involved in the planning, implementation, or evaluation of learning?	
4	Positive Learning Environment	How is the work atmosphere in the school regarding the development of meaningful learning?	
		Do you feel supported and motivated by the principal to try new methods in teaching?	
5	Role Modeling and Teacher Professional Development	Does the principal provide inspiration or concrete examples in learning innovation?	
		Does the principal encourage teachers to keep learning and developing?	
		Have you ever implemented project-based or collaborative learning?	
		What were the results?	
		What learning strategies do you usually use to produce meaningful learning? Why did you choose those methods? What were the results?	

For Students

No	Aspect Explored	Interview Questions	Notes on Responses
1	Engagement in Learning	Do you often get invited by the teacher to have discussions or work in groups during lessons?	
		What is your favorite subject and why?	
		Do you feel you can relate what you learn to everyday life?	
2	Learning Environment	Do you feel comfortable and motivated to learn at this school?	
		Are the teachers and principal easy to talk to when you have ideas or questions?	
		How is the classroom learning atmosphere exciting, boring, or enjoyable?	
3	Impact of Learning on Yourself	What learning activity do you think has made you more confident?	
		Have you ever been given the opportunity to lead a group task or project?	
		Do you feel that this school helps you become more creative and independent?	



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Gamifying Education: Trends, Networks, and Insights From 2014–2024

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Abstract

This study provides a comprehensive bibliometric analysis of research on gamification in education from 2014 to 2024, based on 4,784 publications indexed in Scopus. Using VOSviewer and R, the analysis maps global contributions, thematic clusters, and emerging trends. Results indicate a rapid annual growth rate of 23.1% and strong international collaboration, with the United States and Spain leading in productivity and impact, alongside growing contributions from Southeast Asia and Latin America. Keyword co-occurrence reveals eight thematic clusters, with "gamification," "engagement," and "motivation" as core concepts, while emerging topics include AI, adaptive learning, and virtual reality. The findings show a shift from short-term motivational applications toward sustainable, technology-integrated, and learner-centered models. Despite the progress, research gaps remain regarding long-term learning outcomes, cost-effectiveness, and cultural contexts. The study contributes to theory by mapping intellectual structures in gamification research and offers practical implications for policymakers, educators, and EdTech developers seeking to enhance engagement, personalization, and innovation in education.

Keywords:

Gamification, Education, Bibliometric, Engagement, Motivation

Introduction

Over the last four decades, educational technology has grown from a relatively specialized area into a well-recognized subfield of education. In response to increasing global pressure to innovate teaching methods and improve both engagement and learning effectiveness, digital technologies—particularly online learning—have opened new opportunities but also revealed challenges such as reduced learner motivation, higher dropout rates, and limited interaction. Against this backdrop, gamification—the incorporation of game elements into non-game contexts—has been proposed as a promising strategy to enhance participation, motivation, and learning performance (Li et al., 2023). It is essential to differentiate gamification from game-based learning: while gamification refers broadly to the use of game components in real-world situations, game-based learning relies on fully developed games to deliver content and skills (Wijaya et al., 2022). Within education, gamification involves integrating design features such as points, badges, leaderboards, quests, rewards, and instant

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feedback to create a gameful learning environment that stimulates both intrinsic and extrinsic motivation (Li et al., 2024).

A growing body of research has documented notable benefits of gamification. Li et al. (2023), for instance, conducted a meta-analysis of 41 studies with over 5,000 participants and reported a large effect size (Hedges' g ≈ 0.82) favoring gamified approaches over traditional methods, with moderating variables such as learner characteristics, subject area, design, duration, and learning environment shaping outcomes. Similarly, Gini (2025), in an analysis of 9,163 records and over 300,000 documents, found that gamification in education is expanding rapidly in both scale and scope, highlighting its application across primary, higher, and online learning. Likewise, Li et al. (2024) showed that students in gamified settings outperformed their peers in university-level mathematics courses.

Nevertheless, the impact of gamification on learning outcomes remains contested. Prior studies have yielded inconsistent findings: while many reported positive effects, others observed little or no measurable improvement (Bouchrika et al., 2019; Rachels & Rockinson-Szapkiw, 2017). Such discrepancies complicate efforts to draw firm conclusions about its effectiveness.

Moreover, existing research remains fragmented across learner groups (e.g., primary, higher, vocational education), contexts (online, blended, STEM, language learning), and evaluation criteria (motivation, achievement, soft skills). Comprehensive syntheses that systematically map key themes, leading contributors, research gaps, and future opportunities are still lacking (Al-Hafdi & Alhalafawy, 2024).

Although research on gamification in education has expanded rapidly, the existing literature remains fragmented across educational levels, contexts, and outcome measures, often leading to inconsistent and inconclusive findings. In the absence of a systematic bibliometric synthesis, it is difficult to identify dominant research streams, emerging themes, and underexplored gaps, thereby limiting both theoretical consolidation and evidence-based policy formulation. Accordingly, a bibliometric approach is essential to integrate existing knowledge, map the intellectual structure of the field, and guide future research and policy decisions related to gamification in education.

Addressing this gap, the present study offers several novel contributions to the gamification-in-education literature. First, it provides an updated and comprehensive bibliometric overview covering the period 2014–2024, capturing recent technological shifts such as AI-driven personalization and immersive learning environments. Second, by integrating VOSviewer with R-based science mapping techniques, the study not only identifies thematic clusters but also reveals their intellectual linkages and temporal evolution through bibliographic coupling. Third, unlike prior bibliometric reviews, the identified clusters are explicitly interpreted through established educational theories, including Self-Determination Theory, Flow Theory, and Constructivist Learning Theory, thereby strengthening the theoretical grounding and explanatory power of bibliometric findings.

To achieve these objectives, a transparent and replicable bibliometric analysis was conducted using a Scopus-indexed dataset spanning 2014–2024. The study addresses three main research questions: (i) which countries, institutions, authors, journals, and publications have made the most significant contributions to gamification research in education; (ii) which key concepts, themes, and dimensions are attracting scholarly attention and warrant deeper investigation; and (iii) what core research patterns, dominant themes, and emerging trends characterize the field. Overall, this approach provides a holistic view of the development and diffusion of gamification in education across time and space, offering empirically grounded and theoretically informed directions for future research.

Literature Review

The Concept of Gamification

Gamification is often described as distinct from entertainment games and serious games (Bai et al., 2020). Entertainment games are typically developed for leisure purposes (e.g., World of Warcraft), while serious games—also referred to as game-based learning (Boyle et al., 2016) - are designed to cultivate specific skills or deliver academic content (Annetta, 2010). Both types of games usually require substantial financial and technical resources for their development.

Although game elements form the foundation of gamification, there is no universally accepted classification of these elements (Bai et al., 2020). Riar et al. (2022) define gamification as the incorporation of game features into non-game contexts.

Gamification entails applying game elements across a variety of situations (Sanchez et al., 2020). These elements are purposefully designed to achieve certain objectives and are embedded within specific activities or tasks. It involves creating playful and game-like experiences by integrating elements, mechanics, and principles that make games engaging, challenging, enjoyable, and motivating into non-game environments, thereby enhancing user participation, motivation, and overall experience (Seaborn & Fels, 2015).

Gamification in Educational Contexts

Gamification can be implemented across diverse domains and has evolved into an interdisciplinary field of study (Nacke & Deterding, 2017). In recent years, game-based approaches to learning have drawn increasing attention from educators, practitioners, and researchers across different subjects and levels of education (Dahalan et al., 2023; Kaya & Ercag, 2023; Oliveira et al., 2022). Because active learning methodologies lie at the core of gamification, and game design draws upon psychological theories of learning, it has long been anticipated that integrating gamification into educational settings could improve outcomes, participation, and learner experience (Bai et al., 2020; Cechetti et al., 2019).

By its very nature, gamification can make learning experiences more interactive and engaging, while simultaneously boosting students' interest in subjects, participation, self-efficacy, persistence, focus, and motivation, ultimately supporting better academic performance (Bouchrika et al., 2019; Kim et al., 2017; Yildirim, 2017). Motivational elements embedded in gamification can foster desirable student behaviors and enhance psychological states (Hanus & Fox, 2015). However, some studies have reported opposite effects, where gamification discouraged learners or even hindered academic performance (Hanus & Fox, 2015; Kwon & Özpolat, 2020). The emotional and social dimensions of gamified learning are also noteworthy. Kuo and Chuang (2015), for example, emphasized the importance of collaborative gamified activities in strengthening peer interaction, thereby fostering more meaningful social relationships among students. Similarly, Zainuddin et al. (2017) highlighted how escalating challenges in gamified environments reinforce learners' confidence by cultivating a sense of accomplishment. According to Lampropoulos et al. (2024), learning environments that integrate virtual reality and game-based elements allow students to experience contexts, scenarios, and conditions both individually and collaboratively, engaging in educational activities that would otherwise be impossible. Nevertheless, as Ryan and Deci (2000) cautioned, an overreliance on extrinsic motivators may undermine intrinsic motivation, particularly when gamified applications are misaligned with clear pedagogical objectives. To overcome these challenges, stronger collaboration among educators, policymakers, and developers is necessary to design gamification solutions that are both pedagogically sound and holistically effective.

Theoretical Foundations Commonly Used to Explain the Effects of Gamification

These theoretical perspectives provide an important lens for interpreting bibliometric clusters. For instance, themes related to engagement, motivation, and autonomy can be understood through Self-Determination Theory, which emphasizes intrinsic motivation and psychological needs. Clusters focusing on challenge, immersion, and enjoyment align closely with Flow Theory, highlighting optimal learning experiences. Meanwhile, themes such as active learning, collaboration, and problem-solving resonate with Constructivist Learning Theory, which views knowledge as actively constructed through meaningful interaction. This theoretical integration enhances the interpretive depth of the bibliometric results.

Self-Determination Theory

Self-Determination Theory (SDT) is considered one of the most influential frameworks in contemporary behavioral science and is widely recognized as one of the most comprehensive and practical motivation theories in the social sciences (Proulx et al., 2016). SDT has played a crucial role in the study and application of gamification, particularly in explaining psychological and motivational processes in gaming contexts (Ryan et al., 2006). Hsia et al. (2024) describe SDT as a psychological theory that explores human motivation and behavior through the lens of psychological needs. According to SDT, three basic psychological needs must be satisfied for individuals to thrive and achieve success: autonomy, competence, and relatedness. When individuals operate within rigid structures, intrinsic motivation may be undermined due to limited autonomy (Ryan & Deci, 2000). Conversely, environments that provide choice and opportunities for self-direction can enhance intrinsic motivation by reinforcing a sense of autonomy, thereby fostering continuous personal growth (Ryan & Deci, 2020).

Empirical studies have shown that when gamification elements meet learners' basic psychological needs, improvements are observed in motor skills, learning behaviors, and classroom engagement (Fernandez-Rio et al., 2020; Quintas et al., 2020). Gao (2024) emphasizes that SDT is particularly suited to examining when and how gamification is effective, as it reveals the underlying psychological and motivational mechanisms. Within SDT, competence refers to the sense of effectiveness and mastery when individuals face challenges that align with their current abilities, enabling them to maintain and enhance their skills (Deci & Ryan, 2000). Moreover, SDT distinguishes between different forms of motivational regulation along a continuum from controlled to autonomous: external and introjected regulation are more controlling, whereas identified, integrated, and intrinsic regulation are more autonomous, contributing to stronger engagement and optimal learning outcomes (Manganelli et al., 2019; Niemiec & Ryan, 2009).

Through gamification elements, students' psychological needs—autonomy, competence, and relatedness—can be effectively addressed, supporting them in achieving their learning goals (Grabner-Hagen & Kingsley, 2023). This application of SDT has been endorsed by several scholars as a theoretical lens to explain the positive impacts of gamified learning environments in education (Dehghanzadeh et al., 2024).

Flow Theory

One of the most frequently cited theoretical foundations in gamification research is Flow Theory, also known as the theory of optimal experience (Guo et al., 2016). Flow represents an optimal state of intrinsic motivation in which learners perceive challenges as well matched to their skills and capabilities. According to Wong and Csikszentmihalyi (1991), learning experiences can be classified into three main channels: the boredom channel, the frustration (or overload) channel, and the flow channel. When challenges are too low compared to a learner's abilities, boredom quickly emerges, leading to disengagement. Conversely, when tasks are excessively difficult, learners may experience frustration and ultimately withdraw. Flow occurs only when task difficulty is properly aligned with learners' skill development, enabling them to sustain engagement and maximize intrinsic motivation (Sharek & Wiebe, 2011).In educational contexts, gamification has been identified as an effective mechanism for fostering flow states. Game elements such as clear goals, immediate feedback, progressive challenges, and a sense of control help create the conditions necessary for flow (Hamari & Koivisto, 2014; Högberg et al., 2019). These factors play a critical role in maintaining motivation and engagement, which in turn are closely tied to learning outcomes (Oliveira et al., 2019).

For example, Wan et al. (2021) developed a flow-based model to examine the antecedents of flow in game-based learning environments. Their findings showed that learners highly valued conditions supporting flow—particularly concentration and challenge. The model concluded that when courses were designed with clear objectives and high levels of autonomy, learners tended to report stronger motivation and improved academic performance. Similarly, Kaya and Ercag (2023) conducted an experimental study with 60 university students, incorporating challenge-based gamification into a course. The results indicated significant improvements in both learning outcomes and learner motivation. Although the increase in flow experiences among gamified groups did not reach statistical significance, the findings still suggested that gamification strategies centered on challenge and competition can support conditions for flow by enhancing perceived competence and enjoyment. While several studies have confirmed the positive influence of gamification on flow in learning contexts (Hamari et al., 2016; Xi & Hamari, 2019), there remains a shortage of research investigating how individual differences—such as learning styles, technological proficiency, or initial motivation levels—moderate this relationship. Addressing this gap offers promising opportunities for future research to explore how gamification can be more effectively designed to personalize learning, optimize flow states, and improve educational outcomes.

Constructivist Learning Theory

One of the key pioneers of constructivist learning theory was Lev Vygotsky, a Russian psychologist and educator who emphasized the inherently social nature of learning (Tilak & Glassman, 2022). He argued that children's cognitive and linguistic development does not occur in isolation from their social environment (Rochat, 2023; Tilak & Glassman, 2022). More than half a century ago, Vygotsky highlighted the importance of social interaction in shaping the child's mind. Vygotsky's ideas gained increasing attention in the late 20th century. He maintained that every individual develops within a social context, and that intellectual processes—such as meaning-making, memory, reasoning, and perception—evolve from interpersonal interactions before being internalized. From this perspective, all higher-order cognitive functions originate in social interactions situated within specific cultural contexts. Cognition, therefore, can be seen as the internalization of social exchanges. This socio-cultural theory underscores the need for a social foundation to better understand educational processes (Alkhudiry, 2022).

In this sense, constructivist learning refers to the process by which learners generate knowledge and ideas through personal exploration, experience, and reflection. As Wibowo et al. (2024) argue, constructivism emphasizes the search for knowledge and ideas rather than focusing solely on the "correct" answers. Learning is viewed as an active process in which students build their own understanding. Knowledge cannot simply be transmitted; instead, it must be co-constructed through the dynamic interaction between teachers and learners (Moşteanu, 2021). Within this framework, gamification functions as a pedagogical tool that helps put constructivist principles into practice. Game elements such as challenges, instant feedback, rewards, and task progression encourage learners to engage actively rather than passively absorb information (Grover & Pea, 2013). By experimenting, tackling appropriately designed challenges, collaborating with peers, and adjusting strategies in response to feedback, learners construct knowledge through experience.

Constructivist learning theory also stresses the importance of social interaction and collaboration. Gamification mechanisms such as leaderboards, group systems, or team-based missions create opportunities for students to communicate, share, and solve problems together. This not only strengthens their understanding of content but also enhances critical thinking, creativity, and problem-solving skills in educational settings (Liu et al., 2021). Furthermore, constructivism highlights the necessity of contextualizing learning within real-world situations and practical applications. Gamification supports this by simulating authentic scenarios and designing tasks that mirror real-life or professional contexts, enabling learners to see the relevance and applicability of their knowledge (Kale et al., 2018).

These theoretical perspectives provide an important lens for interpreting bibliometric clusters. For instance, themes related to engagement, motivation, and autonomy can be understood through Self-Determination Theory, which emphasizes intrinsic motivation and psychological needs. Clusters focusing on challenge, immersion, and enjoyment align closely with Flow Theory, highlighting optimal learning experiences. Meanwhile, themes such as active learning, collaboration, and problem-solving resonate with Constructivist Learning Theory, which views knowledge as actively constructed through meaningful interaction. This theoretical integration enhances the interpretive depth of the bibliometric results.

Research Methodology

Scopus and Web of Science (WoS) are widely recognized as two of the most reputable academic databases globally, and numerous comparative studies have been conducted to highlight their respective strengths and limitations (Mongeon & Paul-Hus, 2016). Although both systems have certain constraints, Pranckute (2021) notes that Scopus demonstrates several advantages over WoS: (i) broader content coverage; (ii) provision of author and institutional profiles along with publication abstracts, facilitating easier access and exploration; (iii) more comprehensive and less manipulable impact metrics that are applicable across disciplines and publication types; and (iv) a unified database structure, in contrast to WoS, which is divided into multiple collections (e.g., SCIE, SSCI, ESCI), often causing confusion for new users. In this study, the authors combined quantitative bibliometric analysis with a comprehensive literature review, focusing on works published in journals indexed by Scopus. This database is considered reputable, particularly for its capacity to assess research impact, measure influence, and reflect the quality of published studies (Baas et al., 2020). The search strategy was developed based on the keywords "gamification" and "education", carefully selected to ensure both relevance and coverage. The specific query used was: TITLE-ABS-KEY(("gamification") AND ("education")). The search was limited to the period 2014–2024, yielding a total of 4,784 scientific publications, which served as the primary dataset for subsequent analyses.

Bibliometric Analysis

Bibliometric analysis is widely regarded as a rigorous and systematic quantitative method for examining large volumes of scientific data (Aria & Cuccurullo, 2017). This approach enables researchers to trace the development of a field, identify emerging research themes, and uncover potential knowledge gaps. In this study, bibliometric techniques are applied to investigate the prevailing topics and directions within the domains of educational gamification research.

At its core, bibliometric analysis quantitatively examines scholarly outputs such as books, journals, and other academic publications. By employing indicators such as citation counts, co-authorship networks, and keyword co-occurrence, the method helps evaluate both the impact and relevance of scientific contributions within a particular domain (Donthu et al., 2021).

The importance of bibliometric analysis lies in several aspects: (i) it offers a systematic and objective framework to assess the current state of research, pinpoint knowledge gaps, and track trends over time; (ii) it facilitates mapping of collaboration networks among scholars and institutions; and (iii) it guides researchers toward emerging research areas and potential partnerships (Kumar et al., 2021).

To maximize its strengths, this study integrates bibliometric analysis with a comprehensive literature review. A key technique employed is co-occurrence analysis, which identifies when two or more terms appear together in the same context, thereby revealing thematic or semantic relationships. This helps illustrate the intellectual structure of the field and highlight its core topics (Allahbakhshian Farsani et al., 2024; Zhou et al., 2022). Moreover, citation frequency continues to serve as an essential indicator, reflecting both the visibility and the scholarly contribution of individual works in advancing the field (Allahbakhshian Farsani et al., 2024; Donthu et al., 2021).

Data Characteristics

The dataset employed in this study covers publications from 2014 to 2024, comprising a total of 4,784 articles. These works were authored by 13,511 researchers, with only 415 being single-authored papers, while the vast majority involved multiple contributors. This highlights the high level of international collaboration in the field and suggests that the research provides

a global perspective on strategies for enhancing user engagement in digital environments.

Data Processing

Two specialized bibliometric tools were used for data analysis: VOSviewer and R (Moral-Muñoz et al., 2020; Aria & Cuccurullo, 2017). Both were selected for their ability to visualize and map scientific networks and trends over time. VOSviewer was applied to construct co-occurrence networks, intellectual structures, and developmental trajectories within the field (Moral-Muñoz et al., 2020). Meanwhile, R was used to perform statistical analysis and generate visualizations that illustrate research trends, interrelationships, and contributions at the author, journal, and country levels. This dual approach enabled a comprehensive and dynamic assessment of the field's evolution and emerging directions (Moral-Muñoz et al., 2020).

Data Extraction

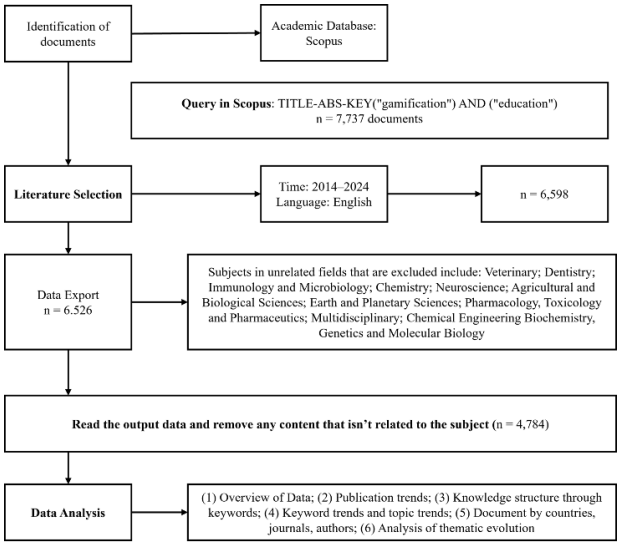
The Scopus database was selected for data retrieval on the topic of education and gamification, as it is widely used in the social sciences for large-scale bibliometric and systematic reviews (Naeem et al., 2022; Rabbani et al., 2022). The search process followed the PRISMA framework (Preferred Reporting Items for Systematic Reviews and Meta-Analyses), as illustrated in Figure 1. The PRISMA process consists of four main stages. In the identification stage, records were retrieved from the Scopus database using predefined keywords. During screening, duplicate and irrelevant records were removed based on titles and abstracts. The eligibility stage involved full-text assessment to ensure alignment with the study's scope. Finally, the included stage resulted in the final dataset used for bibliometric analysis.

Using Boolean combinations of the keywords "gamification" AND "education", the search initially yielded 7,737 documents, which were exported in .CSV format for further screening.

The extracted records were carefully examined to ensure relevance to the study's scope. Several inclusion and exclusion criteria were applied. Publications outside the 2014–2024 period, non-English documents, and non-academic items such as books, short notes, and editorials were excluded, removing 1,139 records. The inclusion criteria were limited to journal articles, book reviews, book chapters, and conference papers. Importantly, only studies with a clear focus on gamification in education were retained. Titles and abstracts were manually screened, leading to the exclusion of an additional 1,814 records.

As a result, a final dataset of 4,784 documents was compiled for synthesis and bibliometric analysis. This dataset was used to explore both past and emerging research trends in gamification and education. Bibliometric analysis served as a systematic technique to examine publication patterns, citation impact, leading authors and journals, co-authorship networks, and keyword co-occurrence (Hassan et al., 2023; Wasiq et al., 2023). The analysis was conducted using the Biblioshiny interface in R, which supports the processing of large bibliographic datasets and provides advanced visualization tools tailored for bibliometric research (Hassan et al., 2023).

Figure 1.
The actual process of conducting bibliographic analysis



Several limitations should be acknowledged. First, the analysis is limited to English-language publications indexed in the Scopus database, which may exclude relevant studies published in other languages or databases. Second, regional research output may be unevenly represented. These limitations should be considered when interpreting the findings.

Results

This chapter presents a comprehensive bibliometric analysis of research on gamification in education published between 2014 and 2024, structured explicitly around three core research objectives. First, the chapter aims to identify the countries, institutions, authors, journals, and publications that have made the most significant scholarly contributions to the field, based on analyses of research output and citation impact. Second, through keyword co-occurrence analysis and thematic trend examination, the chapter elucidates the key concepts, research themes, and analytical dimensions that are currently attracting scholarly attention and warrant further investigation. Third, the chapter seeks to uncover the dominant research patterns, core thematic structures, and emerging trends that characterize the evolution

and intellectual positioning of gamification research in education over time. Accordingly, the chapter is organized into six interrelated sections: (i) an overview of the dataset, (ii) publication and citation trends, (iii) scholarly contributions by countries, institutions, authors, and publication sources, (iv) the knowledge structure based on keyword analysis, (v) keyword and thematic trends, and (vi) the evolution and thematic positioning of research topics.

Overview of the dataset

Table 1 illustrates that between 2014 and 2024, the field produced 4,784 publications from 1,856 sources, with an annual growth rate of 23.1%, reflecting its rapid and dynamic expansion. On average, the publications are 4.37 years old and have received 15.63 citations per paper, indicating both currency and a relatively strong academic impact. In terms of content, the field demonstrates substantial diversity, with more than 11,000 Keywords Plus and 8,400 author keywords, highlighting the breadth of research coverage. The author community consists of 13,511 researchers, with most works being collaborative in nature—averaging 3.52 co-authors per paper and showing 16.22% international collaboration. Regarding document types, journal articles (2,135) and conference papers (2,318) dominate the dataset, while reviews (213) and other categories represent only a minor share. Overall, the data suggest that this is a young and rapidly expanding field, characterized by strong international collaboration and a predominant focus on articles and conference proceedings. To assess the development and thematic diversification of the gamification research field, we examined the ratio between the number of keywords and the number of documents, a descriptive measure commonly used in bibliometric and co-word analyses (Callon et al., 1983; Cobo et al., 2011). This ratio, hereafter denoted as K, was calculated as:

$$K = \frac{Number\ of\ keywords}{Number\ of\ documents} = \frac{8429}{4784} = 1.76$$

A value of K = 1.76 indicates a high level of thematic diversity, suggesting that gamification research in education has evolved into a conceptually rich, interdisciplinary, and multi-dimensional research field rather than remaining focused on a narrow set of topics. To provide a clearer overview, this chapter is organized into four sections: (i) publication trends, (ii) keyword and content analysis, (iii) authors, countries, and journals, and (iv) thematic evolution of the research field.

Table 1.

Descriptive Statistics of the Dataset (2014–2024)

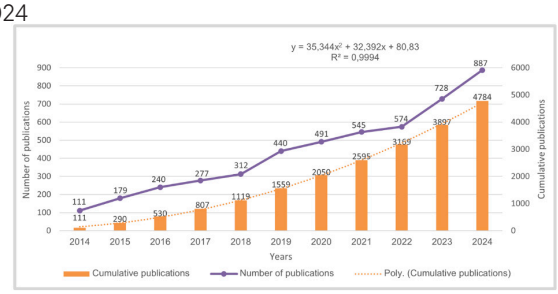
Description	Results
MAIN INFORMATION ABOUT DATA	
Timespan	2014:2024
Sources (Journals, Books, etc)	1856
Documents	4784
Annual Growth Rate %	23,1
Document Average Age	4,37
Average citations per doc	15,63
References	146499
DOCUMENT CONTENTS	
Keywords Plus (ID)	11114
Author's Keywords (DE)	8429
AUTHORS	
Authors	13511
Authors of single-authored docs	415
AUTHORS COLLABORATION	
Single-authored docs	459
Co-Authors per Doc	3,52
International co-authorships %	16,22
DOCUMENT TYPES	
article	2135
book chapter	2
conference paper	2318
conference review	116
review	213

Publication Trends

As the figure 2, the results indicate a pronounced and sustained growth in scholarly publications on gamification in education over the period 2014–2024. In the early stage of the field, only 111 documents were published in 2014. However, this number increased steadily over the following decade, reaching 887 publications in 2024 and resulting in a cumulative total of 4,784 documents. A clear turning point emerged in 2018, when annual publications exceeded 300 for the first time, marking the transition from an emerging to a rapidly expanding research domain. From 2019 onward, the growth trajectory accelerated considerably, reflecting the escalating academic recognition of gamification as a pivotal pedagogical approach and a mainstream topic within educational research.

Figure 2.

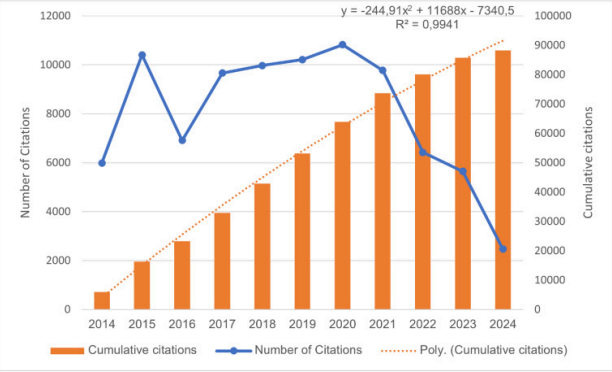
Annual number of scientific publications on the topic of gamification in education during the period 2014–2024



Further insights into the scholarly impact of this field in figure 3 are provided by the analysis of annual and cumulative citations. Overall, cumulative citations exhibit a strong and uninterrupted upward trend throughout the decade, increasing from fewer than 10,000 citations in 2014 to more than 90,000 citations by 2024. The polynomial trend line fitted to cumulative citations shows an excellent goodness of fit ($R^2 = 0.9941$), underscoring the robustness and consistency of long-term scholarly attention to gamification in education.

In contrast, annual citation counts display a more fluctuating pattern. Following a sharp increase from approximately 6,000 citations in 2014 to over 10,000 citations in 2015, a temporary decline occurred in 2016. This was followed by a renewed and steady rise, culminating in a peak around 2020. However, from 2021 onward, annual citations show a gradual decline, despite the continued accumulation of total citations. This divergence suggests that the field may have entered a phase of relative maturity, characterized by a well-established and highly cited knowledge base, while the marginal growth in new citation activity has begun to stabilize. Taken together, these publication and citation trends highlight both the historical consolidation of the field and the evolving dynamics of its scholarly influence.

Figure 3.
Annual number of scientific citations on the topic of gamification in education during the period 2014–2024

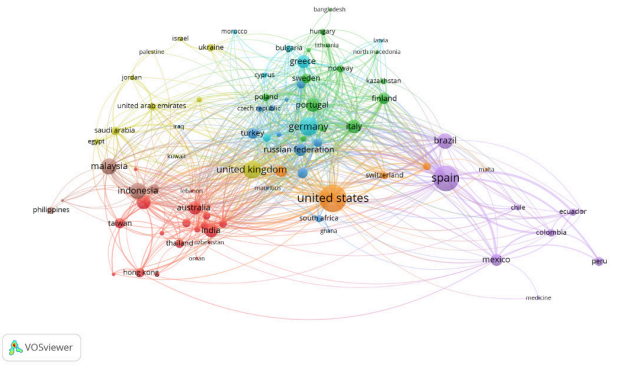


Academic Contributions by Countries, Journals, and Authors

Countries

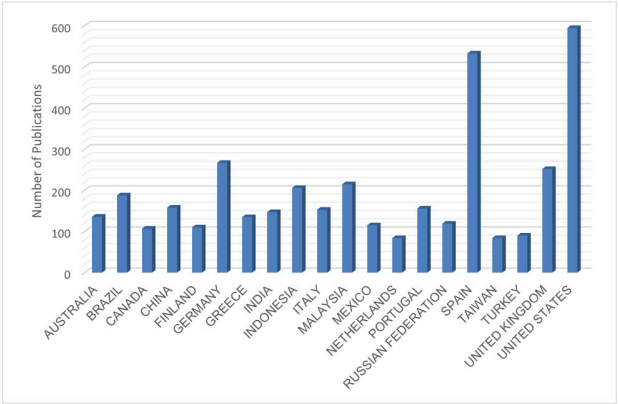
The data analysis presented in Figure 4 reveals that 168 countries and territories have contributed publications related to gamification in education during the period 2014–2024. While the topic demonstrates a global scope, its distribution remains uneven. The top 20 most productive countries are listed in Figure 5, with the United States leading decisively with 595 publications, highlighting its pioneering role in the field of education and research. Spain follows closely with 533 publications, underscoring Europe's strong engagement, further supported by significant contributions from Germany (267), the United Kingdom (252), Italy (153), Portugal (156), Greece (135), Finland (110), and the Netherlands (84). This confirms Europe as a major research hub for gamification. In Asia, notable contributions come from Malaysia (215), Indonesia (206), China (158), India (147), Turkey (90), and Taiwan (84), with Malaysia and Indonesia standing out for their relatively high publication output, reflecting the dynamism of Southeast Asia in adopting and advancing gamification. In Latin America, Brazil (188) and Mexico (115) reinforce the global expansion of this research field, while Canada (107) and Australia (136) highlight the involvement of North America and Oceania. Russia (119), although moderate in output, affirms Eastern Europe's presence in the broader research landscape. Overall, as illustrated in Figure 5, the United States and Spain dominate the field, yet the growing contributions from Asian and Latin American countries demonstrate that gamification research has expanded beyond developed nations, evolving into a global trend closely tied to educational innovation.

Figure 4.
Country Collaboration Network



Source: Visual map extracted from VOSviewer

Figure 5.
Leading countries in publications on gamification in education (2014–2024).

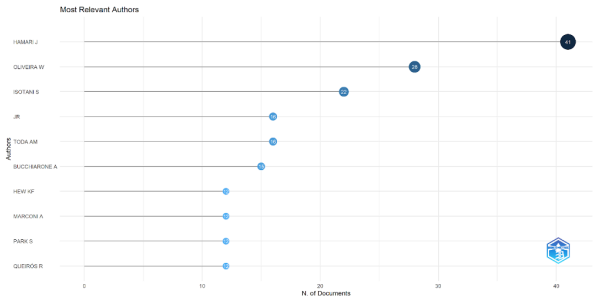


Source: Visual map extracted from Rstudio

Authors

The analysis in Figure 6 indicates that among 13,989 authors, there exists a notable disparity between publication volume and scholarly impact. Within this landscape, the top 10 most productive authors can be identified. Hamari J. leads with 41 publications, highlighting his prominent role and substantial academic contributions to the field. He is followed by Oliveira W. (28) and Isotani S. (22), both of whom demonstrate sustained and active engagement in gamification research.Subsequently, JR and Toda A.M. each contributed 16 papers, while Bucchiarone A. authored 15 publications, underscoring their significance within the scholarly community. Additionally, authors such as Hew K.F., Marconi A., Park S., and Queirós R., each with 12 publications, further illustrate the diversity of research contributions. This distribution reflects a broad and collaborative academic community rather than dominance by a single individual or a small group of scholars.

Figure 6.
Most Relevant Authors.

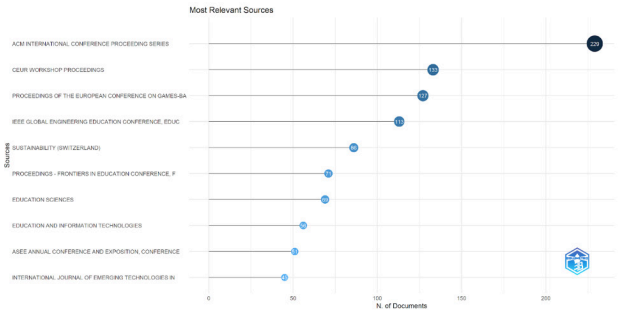


Source: Visual map extracted from Rstudio

Journals and Conferences

In terms of publication sources, the most prominent outlets are concentrated in international conference proceedings. As shown in Figure 7, the ACM International Conference Proceeding Series leads with 229 publications, underscoring ACM's role as a major forum for research at the intersection of technology and education. This is followed by CEUR Workshop Proceedings (133) and the Proceedings of the European Conference on Games-Based Learning (127), reflecting the strong academic interest in gamification and game-based learning within educational contexts. In addition, conferences under the IEEE network such as IEEE EDUCON (113) and the Frontiers in Education Conference (71) play a vital role in disseminating research. On the journal side, scholarly outlets including Sustainability (Switzerland) (86), Education Sciences (69), and Education and Information Technologies (56) provide significant contributions to the academic foundation of the field. Notably, the International Journal of Emerging Technologies in Learning (45) highlights the growing attention toward innovative technologies in education.

Figure 7.
Most Relevant Sources.



Source: Visual map extracted from Rstudio

Knowledge Structure through Keywords

Keyword co-occurrence analysis was conducted to examine the intellectual structure of research on gamification in education and to identify dominant thematic patterns within the field. Based on 4,784 Scopus-indexed documents, a total of 8,444 unique keywords were extracted, among which 106 met the minimum occurrence threshold of 20. The resulting keyword network in figure 8 reflects both the frequency of key concepts and the strength of their conceptual relationships, thereby revealing the knowledge structure of the domain.

The analysis identifies eight interrelated thematic clusters: education, e-learning, gamification, higher education, engagement, game-based learning, active learning, and educational technology. Together, these themes form a coherent structure in which education represents the foundational context, supported by technological enablers such as e-learning and educational technology, while gamification occupies a central integrative role connecting pedagogical approaches, learning environments, and educational outcomes.

The education theme serves as a core foundation, closely linked with gamification, e-learning, STEM education, online learning, and serious games. It acts as a conceptual bridge between technology-oriented topics (e.g., artificial intelligence, augmented reality, and blockchain) and pedagogical concerns such as motivation, flipped classrooms, and higher education.

Closely associated with this foundation, e-learning emerges as a key technological driver, reflecting strong scholarly interest in digital and distance learning environments. Research in this theme emphasizes the integration of gamification with emerging technologies such as MOOCs, adaptive learning systems, artificial intelligence, and digital badges.

At the center of the knowledge structure lies gamification, which exhibits strong connections with education, e-learning, engagement, motivation, serious games, and game-based learning. This central

positioning underscores its role as the primary research focus that integrates pedagogical innovation with technological advancement.

The higher education theme reflects a strong concentration of gamification research within university settings, particularly in relation to motivation, academic performance, flipped classrooms, and professional training, including medical education. Existing studies report positive effects on engagement and learning outcomes.

Engagement appears as a key outcome-oriented theme, strongly associated with gamification, motivation, educational technology, and game elements. Most studies conceptualize engagement as an immediate or short-term effect of gamified learning environments, with limited attention given to sustained engagement or its influence beyond the classroom.

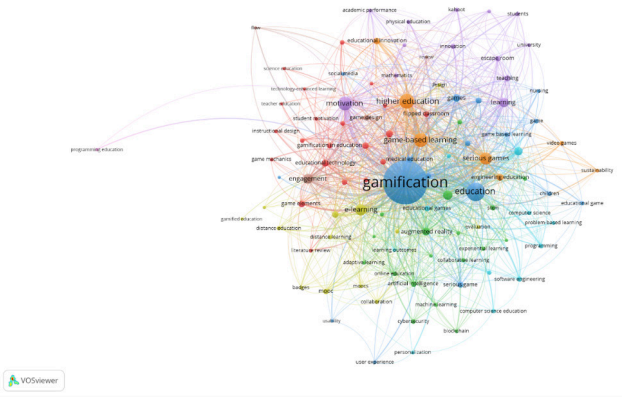
In parallel, game-based learning constitutes a closely related yet distinct research stream, emphasizing the design and implementation of educational games to achieve specific learning objectives. It is frequently linked to assessment, simulation, and specialized training contexts.

The active learning theme highlights the integration of gamification with student-centered pedagogies such as problem-based learning, collaborative learning, and experiential learning. Although widely applied in engineering and STEM education, its adoption in the social sciences, humanities, and vocational education remains limited.

Finally, educational technology functions as an enabling framework that supports the implementation of gamification through instructional design, mobile learning, and social media integration. While prior studies emphasize its role in enhancing learning experiences, challenges related to large-scale adoption, cost-effectiveness, and educational quality have not been systematically addressed.

Overall, the keyword-based knowledge structure reveals a mature yet evolving research domain, characterized by strong conceptual integration around gamification but limited attention to long-term effectiveness and sustainability. These gaps highlight important directions for future research and provide a foundation for advancing theory and practice in gamified education.

Figure 8.
Cluster network illustrating the relationship between Gamification and other keywords

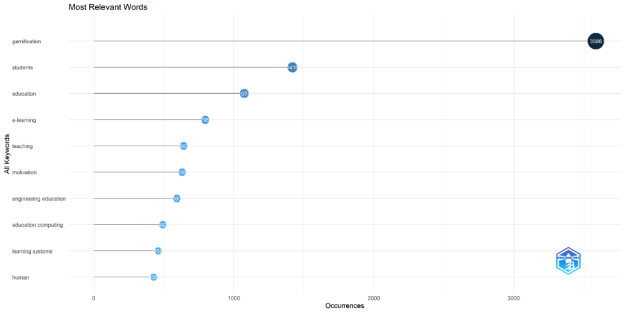


Keyword and Thematic Trends

Most Frequently Used Keywords

Based on the analysis of the most frequently occurring keywords shown in Figure 9, gamification emerges as the central term with 3,586 occurrences, underscoring its dominant role in this research domain. Closely related keywords such as students (1,418), education (1,074), e-learning (795), and teaching (642) highlight that gamification is primarily applied within educational contexts, focusing on learners and online learning environments. Additionally, the presence of terms like motivation (630) and engineering education (593) emphasizes gamification's contribution to enhancing learning motivation and its growing adoption in technical training. Keywords such as education computing (492), learning systems (459), and human (426) further indicate the field's expansion toward educational technologies, learning infrastructures, and human-centered aspects. Overall, these findings reaffirm that gamification stands as a prominent research trend, closely associated with improving learning quality and enriching educational experiences in modern contexts.

Figure 9.
Most Relevant Keywords

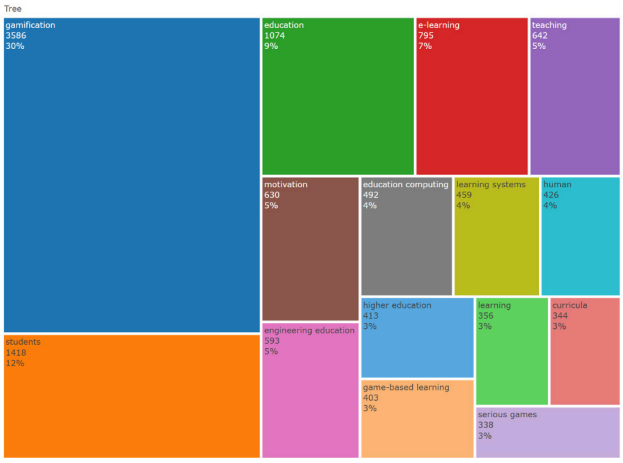


Source: Visual map extracted from Rstudio

In addition, the treemap in Figure 10 illustrates that gamification accounts for the largest proportion (30%), reaffirming its position as the core axis of this research field. The keyword students (12%) highlights learners as the primary focus of most studies, while education (9%), e-learning (7%), and teaching (5%) reflect the educational settings and pedagogical environments where gamification is most frequently applied. Keywords with medium frequencies, such as motivation, engineering education, education computing, and learning systems (4–5%), indicate that gamification research extends beyond general theoretical discussions to more specialized applications and supporting learning technologies. The presence of the keyword human further demonstrates an emphasis on individual factors and learner experiences. Moreover, smaller clusters of keywords—including higher education, game-based learning, curricula, and serious games (around 3%)—showcase the diversification of the field, with trends pointing toward applications in higher education, game-based pedagogies, and integration into formal curricula. Overall, the treemap portrays a multidimensional landscape in which gamification remains the central hub, closely interlinked with pedagogical, technological, and learner-centered perspectives.

Figure 10.

Treemap of the Top 15 Most Frequently Occurring Keywords



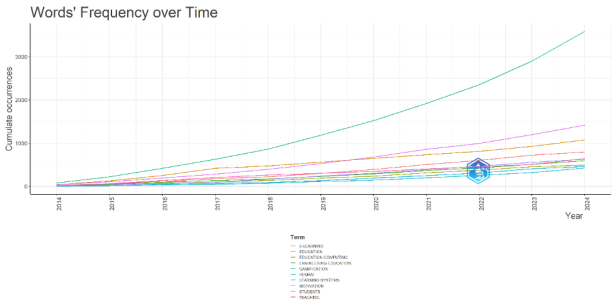
Source: Visual map extracted from Rstudio

Keyword Frequency Over Time

As shown in Figure 11, the temporal analysis of keyword frequency indicates that gamification has experienced exceptional growth, particularly after 2018, reaching more than 3,000 cumulative occurrences by 2024. This trend confirms its role as the central theme of the field. The keywords students and education also display steady growth, reflecting that both the educational context and the learner remain at the core of gamification research. In addition, e-learning, teaching, and motivation maintain consistent upward trends, underscoring the role of gamification in supporting online learning, enhancing teaching practices, and fostering learner motivation. Meanwhile, topics such as education computing, learning systems, and engineering education have developed more gradually yet steadily, highlighting the complementary role of technology and specialized training applications. Overall, the longitudinal analysis demonstrates that gamification has become a sustainable research trend in modern education.

Figure 11.

Words'Frequency over Time.



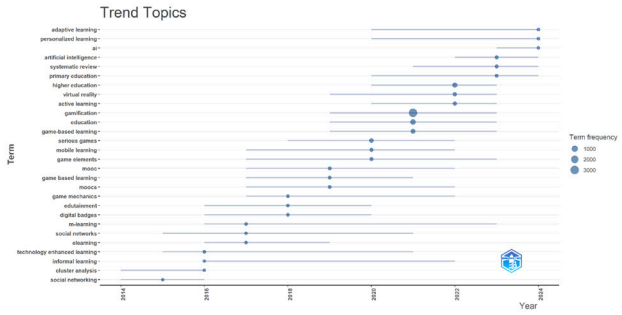
Source: Visual map extracted from Rstudio

Trend Topics

As illustrated in Figure 12, the trend analysis indicates that "gamification" and "education" have consistently maintained their central positions throughout 2014–2024, underscoring their foundational role in the field. Topics such as "game-based learning," "MOOCs," and "mobile learning" experienced significant growth between 2016 and 2020 but gradually declined in prominence in subsequent years. Conversely, emerging keywords including "AI," "personalized learning," "adaptive learning," and "virtual reality" have gained momentum since 2020, highlighting a shift toward the integration of advanced technologies. Overall, these thematic trends reflect the evolution of the field—from the early application of traditional gamification approaches to the adoption of intelligent technologies and personalized learning within modern education.

Figure 12.

Trend Topics



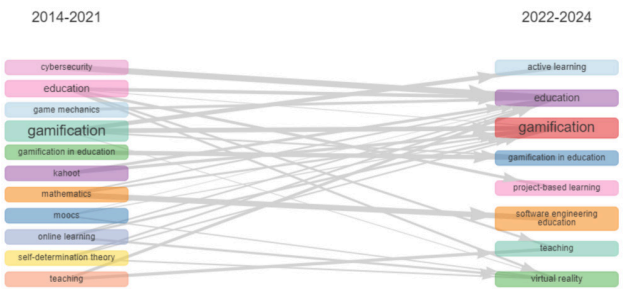
Source: Visual map extracted from Rstudio

Analysis of thematic evolution

As shown in figure 13 depicts the longitudinal evolution of research themes in gamification in education from 2014 to 2024, revealing a clear shift from conceptual foundations toward more applied and technology-driven pedagogical approaches. In the early phase (2014–2021), research was primarily anchored in core theoretical and methodological themes, including gamification, education, game mechanics, online learning, MOOCs, self-determination theory, and platform-based tools such as Kahoot. These themes played a foundational role in establishing the conceptual legitimacy of gamification and in exploring how game elements could be systematically integrated into digital learning environments.

In contrast, the more recent period (2022–2024) is characterized by the emergence and consolidation of application-oriented themes such as active learning, project-based learning, software engineering education, and virtual reality. This transition signals a growing emphasis on experiential, learner-centered pedagogies supported by advanced technologies. Rather than focusing solely on motivational mechanisms or isolated digital tools, recent studies increasingly investigate how gamification can be embedded within broader instructional designs and immersive learning environments. Notably, gamification and education persist as stable and central themes across both periods, indicating their enduring relevance. Meanwhile, earlier topics such as MOOCs, online learning, and Kahoot appear to have been progressively integrated into more complex pedagogical and technological frameworks. Overall, the thematic evolution reflects a natural maturation of the field—from establishing theoretical and technological foundations to advancing innovative, experience-driven educational practices aimed at enhancing learning effectiveness and engagement.

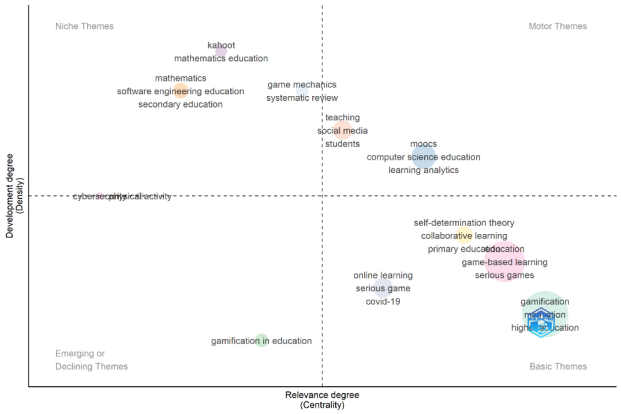
Figure 13.
Thematic Evolution.



Source: Visual map extracted from Rstudio

As shown in figure 14 illustrates the thematic structure of gamification in education research based on centrality and density, revealing a differentiated yet coherent knowledge landscape. In the Motor Themes quadrant, topics such as MOOCs, learning analytics, computer science education, game mechanics, and systematic review exhibit both high relevance and strong internal development, indicating that they actively drive the field. Their prominence reflects a shift toward data-driven, large-scale digital learning environments and methodological consolidation in gamification research. The Basic Themes quadrant contains gamification, education, higher education, game-based learning, serious games, and self-determination theory. These themes are highly central but less dense, suggesting that they form the conceptual backbone of the field while still offering room for further theoretical refinement and empirical expansion. In contrast, the Niche Themes quadrant—comprising Kahoot, mathematics education, software engineering education, and secondary education—represents well-developed but context-specific applications that remain weakly connected to the broader research structure. Finally, the Emerging or Declining Themes quadrant includes gamification in education and cyber–physical activity, indicating themes that are either in an early stage of development or gradually losing prominence. Overall, the map confirms that while foundational gamification concepts remain central, the field is increasingly shaped by technologically advanced and analytically oriented research directions.

Figure 14.
Thematic Map illustrating the position of research themes in the field of gamification in education based on centrality and density.



Source: Visual map extracted from Rstudio

Discussion

This study provides a comprehensive bibliometric overview of gamification research in education during the period 2014–2024, revealing a rapidly expanding and increasingly diversified research field. The findings indicate a sustained annual growth rate of 23.1%, strong international collaboration, and a clear thematic evolution from foundational motivational applications toward technology-integrated and learner-centered pedagogical models. These results suggest that gamification has progressed beyond a short-term

engagement strategy and is now positioned as a core component of the digital education ecosystem.

From a theoretical perspective, the dominance of keywords such as motivation, engagement, and learning can be effectively interpreted through Self-Determination Theory (SDT). SDT posits that learning environments fostering autonomy, competence, and relatedness are more likely to support intrinsic motivation and sustained engagement (Ryan & Deci, 2020). The bibliometric evidence shows that gamification research consistently emphasizes motivational constructs, aligning with prior meta-analyses demonstrating that gamified learning environments significantly enhance students' motivation and engagement (Li et al., 2023; Li et al., 2024). This confirms SDT as a dominant explanatory framework underpinning the effectiveness of gamification in education. However, the persistence of motivation as a core theme over a decade also suggests that research has largely focused on short-term psychological outcomes, while the sustainability of motivation remains insufficiently explored.

In addition, the emergence of themes related to challenge, immersion, virtual reality, and adaptive learning reflects the growing relevance of Flow Theory in contemporary gamification research. Flow Theory emphasizes the importance of balancing challenge and skill to create optimal learning experiences characterized by deep concentration and enjoyment (Wong & Csikszentmihalyi, 1991). The increasing integration of immersive technologies such as VR and AI-driven adaptive systems indicates a shift toward designing gamified environments that can dynamically adjust task difficulty and feedback, thereby facilitating flow states. This trend extends earlier empirical findings that gamification can enhance engagement and learning when flow conditions are met (Hamari et al., 2016; Oliveira et al., 2019), and suggests a maturation of the field toward more sophisticated, experience-driven learning designs.

Furthermore, the growing prominence of themes such as active learning, project-based learning, and collaborative learning resonates strongly with Constructivist Learning Theory. Constructivism views learning as an active process in which learners construct knowledge through experience, reflection, and social interaction (Sanchez et al., 2019). The bibliometric clusters indicate that gamification is increasingly embedded within constructivist pedagogical approaches, particularly in STEM, engineering, and professional education. This finding is consistent with prior studies showing that gamified learning environments can support problem-solving, collaboration, and higher-order thinking skills when aligned with constructivist principles (Grover & Pea, 2013; Kale et al., 2018). Importantly, this shift reflects a transition from reward-based gamification toward experience-based and competence-oriented learning designs.

Beyond theoretical integration, the results also highlight several critical research gaps. First, despite the rapid growth of publications, there remains a lack of longitudinal studies examining the long-term effects of gamification on learning outcomes and skill development. Second, relatively little attention has been paid to the cost-effectiveness and scalability of gamified educational solutions, particularly in resource-constrained contexts. Third, although the geographical distribution of research is becoming more global, socio-cultural influences on gamification design and effectiveness remain underexplored. These gaps suggest that while the field has achieved conceptual maturity, further empirical consolidation is required to inform sustainable educational practice and policy.

Overall, the discussion reveals that gamification research in education is theoretically grounded, technologically evolving, and pedagogically diversifying. By integrating SDT, Flow Theory, and Constructivist Learning Theory, this study demonstrates that gamification functions not merely as a motivational tool but as a comprehensive educational strategy that bridges psychology, technology, and pedagogy in the digital era.

Conclusion

This bibliometric study analyzed 4,784 publications on gamification in education from 2014 to 2024. The findings confirm that gamification has evolved into a global research frontier, characterized by rapid growth, strong international collaboration, and increasing sophistication in research themes. As a central node in the knowledge network, gamification now intersects with multiple fields of education and technology, highlighting its dual role as both a driver of innovation and a foundation of modern pedagogy. Bibliometric evidence also indicates that gamification research is increasingly connected with AI, e-learning, personalized learning, immersive learning, and educational management, while issues related to transferability, long-term impact, and cost-effectiveness remain underexplored. This trend reflects a shift from short-term motivational studies toward the pursuit of more sustainable and interdisciplinary educational models.

Theoretical Contributions

Theoretically, this study enriches the academic body of knowledge on education and digital technology by providing the first comprehensive quantitative analysis focusing on gamification in education. The

results demonstrate that gamification has become a central theme, bridging domains such as e-learning, game-based learning, learner motivation, and digital skill development.

The study also identifies six core thematic clusters, reflecting the diversity of gamification applications: (i) gamification and e-learning; (ii) learner motivation and engagement; (iii) game-based learning and STEM; (iv) gamification in professional training (e.g., healthcare, engineering); (v) applications of emerging technologies (AI, VR/AR, blockchain); (vi) impact assessment and sustainable development in education.

Keyword analysis shows that gamification, engagement, motivation, and game-based learning remain foundational, while new topics such as adaptive learning, personalized education, virtual reality, and AI indicate a strong integration of gamification with Industry 4.0 in education.

Furthermore, the results contribute to behavioral and psychological theory by revealing a research gap: while short-term motivation has been extensively studied, sustainability of motivation and its effects on critical thinking, collaboration, and creativity remain underexplored. This study helps highlight that gap, paving the way for future research integrating gamification with experiential learning theories and 21st-century skill development.

Practical Implications

The findings of this study provide concrete implications for educators, policymakers, EdTech developers and learners.

For educators, the prominence of themes related to engagement, motivation, and active learning suggests that gamification should be embedded systematically into curriculum design rather than applied as an isolated instructional add-on. For example, learning objectives can be aligned with progressive game mechanics such as levels, challenges, and feedback loops to support mastery learning, while collaborative game elements (e.g., team-based missions or quests) can be used to foster peer interaction and problem-solving skills.

For policymakers, the growing integration of gamification with digital platforms, AI, and immersive technologies highlights the need for supportive policy frameworks that promote pedagogically grounded innovation. This includes investing in teacher training on gamified instructional design, developing quality standards for gamified learning tools, and incorporating gamification into national digital education strategies to reduce learner disengagement and online dropout rates.

For EdTech developers, the emergence of adaptive learning, AI, and personalized education as key research trends indicates strong opportunities to design intelligent gamified systems that adjust content difficulty, feedback, and learning pathways based on learner behavior and performance. Such systems can support scalable and data-informed curriculum development while ensuring that game elements remain aligned with educational objectives rather than purely entertainment-oriented features.

For learners: Gamification can foster enthusiasm, build intrinsic motivation, and enhance soft skills through mechanisms of feedback, rewards, and healthy competition.

Limitations and Future Research

This study has several limitations. First, the dataset was collected from Scopus, which may not fully capture all publications on gamification, particularly non-English sources or "grey literature" (e.g., project reports, policy documents). Second, the study focuses on bibliometric analysis and therefore does not assess the content or quality of individual works. Third, the timeframe was limited to 2024, potentially omitting emerging trends beyond this point.

Future research should address these limitations by combining bibliometric analysis with systematic reviews or meta-analyses to assess research quality and effect sizes. More importantly, future studies should adopt longitudinal research designs to examine the long-term impacts of gamification on learning outcomes and skill development. Expanding research into diverse cultural and educational contexts would also enhance the generalizability of findings. Finally, greater attention should be paid to cost-effectiveness and AI-driven personalization in gamified learning systems to support sustainable and equitable implementation at scale.

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Errorless Compliance Training (ECT) in Cooperative Skills in a Preschool Child with Autism

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Abstract

This single-case study examined the effects and maintenance of cooperative skill training using Errorless Compliance Training (ECT) in a four-year-old boy diagnosed with autism (F84.0) attending a Norwegian kindergarten. A pre–post design with an 11-week follow-up period was implemented. The dependent variable was the percentage of adult instructions followed within 10 seconds without avoidance or resistance. Results indicated a clear increase in cooperative behavior across all levels of task difficulty, with the greatest improvement for low-probability instructions (from 25% at baseline to 75% at follow-up). The findings align with previous research supporting ECT as an effective and socially valid method for increasing cooperation in children with autism. Skills were maintained and partially generalized to natural settings 11 weeks after training. Implications for Early Intensive Behavioral Intervention (EIBI) and early childhood education are discussed.

Keywords:

Autism, Cooperation, Compliance Training, Applied Behavior Analysis, Generalization, Early Intervention

Introduction

Early and targeted instruction in social, communicative, and cooperative skills is essential for children with autism spectrum disorder (ASD). Such skills are a prerequisite for learning, social inclusion, and later academic functioning (Isaksen & Holth, 2009). Children with autism often experience difficulties following instructions, sharing attention, and responding to adult-initiated prompts (Ingersoll, & Schreibman, 2006). These abilities constitute what is commonly referred to as cooperative behaviors, a core component of children's capacity to participate in learning activities and engage in social interactions in preschool and school settings. Limited cooperative behavior may reduce learning outcomes and increase the risk of social isolation (Kløfta et al., 2020).

Within applied behavior analysis (ABA), numerous studies have documented the effectiveness of systematic instructional procedures based on precise measurement, arrangement of reinforcement contingencies, and the use of prompting and prompt-fading procedures. Such methods have been shown to produce rapid, stable, and generalizable learning of both basic and complex

skills (Leaf et al., 2022). ABA offers a theoretical and methodological framework for analyzing and modifying behavior in a structured, individualized, and empirically grounded manner.

One well-documented intervention in this field is Errorless Compliance Training (ECT), developed by Ducharme and colleagues (Ducharme, 1996; Ducharme & Drain, 2004). ECT is based on gradual exposure and errorless learning, training the child to respond correctly to instructions of increasing complexity while minimizing the likelihood of errors. This is achieved through differential reinforcement, most-to-least prompting, and systematic fading. ECT differs from traditional compliance training by focusing on preventing avoidance and resistance through early establishment of successful responding (Davis & Axe, 2021; Ducharme, 2007).

International studies show that ECT can significantly improve children's cooperative skills and facilitate generalization of new individuals and settings (Ducharme & Drain, 2004; Ducharme & Ng, 2012). Cavell et al. (2018) demonstrated effective parent-implemented ECT in home and school settings for young children with autism. Similarly, Rames-LaPointe et al. (2014) found that ECT improved compliance in a special education classroom, with improvements in generalizing novel instructions.

ECT shares goals with other interventions targeting cooperation and social competence in children with autism. Pivotal Response Training (PRT), for example, focuses on pivotal skills and employs natural reinforcement procedures (Park, 2013). Both PRT and ECT are sensitive to children's needs and preferences and aim to increase motivation for appropriate interaction with the environment. Within the broader literature on behavioral interventions, Errorless Compliance Training (ECT) and Pivotal Response Training (PRT) share common roots in applied behavior analysis but differ in both conceptual focus and procedural implementation. PRT emphasizes child-initiated interactions and targets pivotal behaviors to promote widespread developmental gains (Koegel & Koegel, 1995), whereas ECT is structured around systematically reducing errors during instruction to establish high rates of successful responding and compliance (Ducharme & Ng, 2012). Procedurally, ECT relies on carefully sequenced prompts and immediate reinforcement to minimize task failure, making it particularly well suited for preschool settings where instructional tolerance and sustained engagement may be limited. This distinction highlights ECT as a complementary approach within early intervention, especially when rapid acquisition of cooperative behavior is a primary instructional goal.

Findings across ECT studies indicate high social validity—parents, teachers, and children typically perceive the intervention as meaningful, feasible, and positive. The method aligns with non-aversive behavior change practices (Wolf, 1978).

Recent research highlights the importance of planned generalization and maintenance to ensure lasting change. If learned skills are not maintained by natural reinforcement contingencies, intervention effects may diminish over time. Combining structured instruction with systematic transfer to natural settings is critical for long-term outcomes (Stokes & Baer, 1977). The use of an ECT protocol to preschool settings improved cooperation in young children with autism after targeted, level-based instruction. Staff reported the intervention as feasible, suggesting high social validity in preschool contexts (Cavell et al., 2018). However, limited research has examined long-term maintenance of cooperative behavior in such environments.

The present study seeks to address this gap by examining how a tailored ECT procedure influences and maintains cooperative skills in a preschool child with autism. The study follows ABA principles and prior research by Ducharme (1996, 2004, 2007), Ducharme and Ng (2012), and Kløfta et al. (2020), with emphasis on social validity, generalization, and skill maintenance.

The guiding research question is: To what extent does ECT-based instruction increase and maintain cooperation, measured as the child's ability to follow adult instructions in everyday preschool routines?

Method

Participant

The participant was a four-year-old boy diagnosed with childhood autism (F84.0; WHO, 2019). The child attended a regular municipal preschool and received approximately 25 hours of 1:1 instruction weekly as part of an EIBI program.

Setting

The intervention was conducted in the preschool, both in a designated training room and in natural environments (classroom, circle time, meals, outdoor play). Transfer to natural settings was planned and gradual. All sessions were delivered by the same special educator, with observation and supervision from the researcher.

Design

A single-case experimental design with an 11-week follow-up was employed. The study used a within-subject design; behavior changes were evaluated through visual analysis of graphed data.

Table 1
Design Overview

Phase	Description	Duration
Baseline (A)	Assessment without intervention	One week
Intervention (B)	ECT training, three–five sessions/week	Four weeks
Posttest	Measurement after final training phase	Immediate
Follow-up	Assessment 11 weeks after intervention	Two days

Note. The table contains an overview of the four phases in this present study. Each phase is explained with a short description and the duration of the phase.

Dependent Variable

The dependent variable was compliance with adult instructions, defined as following a given instruction within 10 seconds without resistance, avoidance, or off-task behavior.

A response was coded as correct if the child:

1. initiated the action within 10 seconds,
2. completed it without protest, and
3. executed the task correctly.

Correct responses were marked (+); incorrect responses were marked (–). Data were calculated as the percentage of correct responses per task per session.

Independent Variable: Errorless Compliance Training

The intervention was based on ECT as described by Ducharme (1996), Ducharme and Drain (2004), and Durcharme and Ng (2012), and adapted for Norwegian settings by Kløfta et al. (2020).

Table 2
Instruction Probability Levels

Level	Description	Examples
1	High probability	"Point to...", "Find the picture..."
2	Medium	"Flush the toilet", "Sing with the music"
3	Low	"Put away the toys", "Wash your face"

Note. The table shows the three levels of instruction probability from high to low, with examples of instructions.

Procedures

Assessment

Cooperative behavior was assessed using the Compliance Probability Questionnaire (CPQ) (Ducharme & Drain, 2004), completed by the special educator, the pedagogical leader, and an assistant. Six tasks were selected for training, all reported as occurring with low likelihood.

Training Phase

Instruction began in a structured 1:1 format. Each task was introduced individually to ensure clarity and optimal learning conditions. A task was considered mastered after three consecutive correct responses without prompts.

Tasks were then transferred to natural preschool routines to promote generalization. Later, mastered tasks were intermixed with other known tasks in a semi-random sequence to strengthen discrimination and flexibility. The mastery criterion for mixed trials was five consecutive correct responses.

Prompting Procedures

A most-to-least prompting strategy was used, beginning with modeling, physical guidance, or verbal cues, which were systematically faded as independence increased. This minimized errors and promoted successful performance.

Reinforcement

Reinforcement was delivered contingent on each correct response and served as a central mechanism for establishing and strengthening cooperative behavior. Following accurate task completion, the child received one of several forms of positive reinforcement, including enthusiastic social praise, access to a preferred activity, or a small tangible item. These reinforcers were selected based on the child's demonstrated preferences and were adjusted across sessions to maintain engagement and prevent satiation.

The deliberate variability in reinforcement types was essential for sustaining the child's motivation throughout the intervention, as diverse reinforcers are known to enhance the reinforcing value of instructional contexts and promote more robust acquisition and maintenance of target behaviors. This approach is consistent with established principles in applied behavior analysis, which emphasize the importance of individualized, dynamic reinforcement systems to support skill development and generalization.

Tests

Posttest

A standardized posttest was conducted without prompting, using low-probability tasks to assess transfer of cooperative behavior to new conditions.

Follow-Up

A follow-up assessment 11 weeks later evaluated maintenance and generalization across adults and natural contexts.

Data Collection and Analysis

Data were collected through direct, manual observation, and graphed as percentage of compliant responses across sessions. Visual analysis was conducted in accordance with established guidelines for single-case experimental designs, with systematic evaluation of level, trend, variability, immediacy of effect following phase changes, degree of overlap between baseline and intervention phases, and consistency of data patterns within and across phases.

Ongoing visual inspection of data informed data-based decision making throughout the study. Intervention procedures were adjusted responsively when patterns indicated insufficient level change, delayed immediacy of effect, or excessive variability, while core intervention components were maintained to preserve treatment integrity.

Reliability, Validity, and Treatment Integrity

Reliability and validity considerations are essential when interpreting findings from single-case designs (Byiers et al., 2012). In the present study, all data was collected by a single observer, which means that interobserver agreement (IOA) could not be calculated. The absence of IOA limits the ability to verify the consistency and objectivity of recorded measurements. To mitigate this limitation, the study employed clearly articulated operational definitions of the target behaviors, thereby enhancing measurement precision and reducing ambiguity in coding.

Treatment integrity was systematically supported using a standardized intervention protocol, detailed procedural checklists, and a comprehensive treatment manual. These elements ensured that the Errorless Compliance Training procedures were implemented consistently across sessions and aligned with established guidelines in the literature. Additionally, adherence to the protocol was monitored through regular supervision, which further strengthened procedural fidelity (Bergmann et al, 2023).

Social validity was evaluated through brief interviews and informal observations involving staff members familiar with the child. These assessments provided insight into how the intervention was perceived by practitioners and whether it aligned with the ecological demands and values of the preschool context. Together, these components contribute to the methodological rigor of the study, while also highlighting areas where future research could incorporate additional reliability measures.

Ethical Considerations

Parental consent was obtained prior to data collection. Child assent was ensured by allowing the child to select reinforcers and activities during each training session.

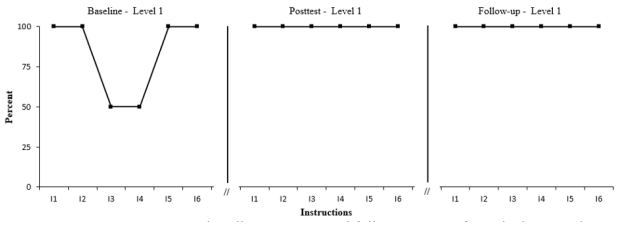
Results

Results showed clear increases in compliance across all levels. At Level 1, compliance demonstrated a marked increase in level from a stable baseline mean of 83% to 100% at follow-up, indicating a strong and sustained improvement. A similar, though more moderate, level change was observed at Level 2, where compliance increased from 83% at baseline to 91% at follow-up. The most pronounced level change occurred at Level 3, with compliance increasing from a low baseline level of 25% to 75% at follow-up, representing the largest absolute and relative improvement across conditions

With respect to trend, baseline data across levels were either stable or showed no systematically increasing pattern, whereas posttest and follow-up data reflected clear upward shifts in performance. Variability within baseline phases was limited, supporting confidence in phase comparisons, while post-intervention data showed reduced variability at higher levels of compliance, particularly for Level 1. Although the intervention phase is not graphically presented, the observed posttest data indicate a clear immediacy of effect, reflected in abrupt level changes between baseline and posttest measurements. The degree of overlap between baseline and post-intervention data was minimal for Levels 1 and 3, and limited for Level 2, further supporting a functional relation between the intervention and observed behavior change.

Figure 1

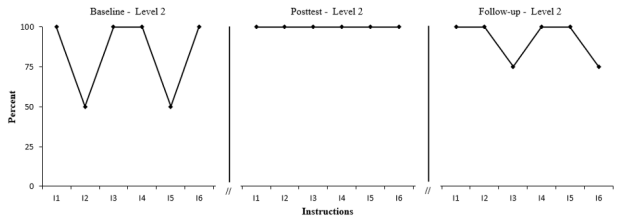
Percent compliance during Level 1.



Note. The figure shows data from baseline, posttest, and follow-up. Data from the intervention phase is not shown, since this study focuses on compliance at posttest and follow-up

Figure 2

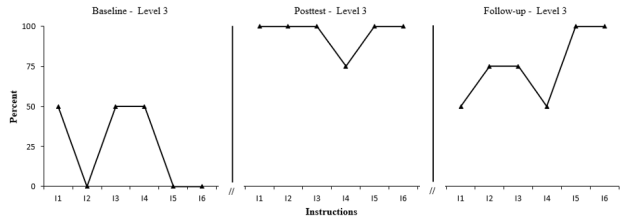
Percent compliance during Level 2.



Note. The figure shows data from baseline, posttest, and follow-up. Data from the intervention phase is not shown, since this study focuses on compliance at posttest and follow-up.

Figure 3

Percent compliance during Level 3.



Note. The figure shows data from baseline, posttest, and follow-up. Data from the intervention phase is not shown, since this study focuses on compliance at posttest and follow-up.

Across tasks and instructional levels, data patterns demonstrated a high degree of consistency, with all levels showing improvements in compliance and evidence of maintenance at follow-up. Two low-probability tasks ("pick up ... at mealtime" and "wash your face") demonstrated complete maintenance (100%), while remaining tasks showed partial maintenance ranging from 50% to 75%. Collectively, these data indicate robust acquisition of cooperative behavior and partial maintenance over time.

Discussion

The findings of this study corroborate a growing body of research demonstrating that Errorless Compliance Training (ECT) is an effective approach for strengthening cooperative behavior in children with autism spectrum disorder. In particular, the marked improvements observed in low-probability instructions are consistent with the results reported by Ducharme and Drain (2004), who showed that ECT reliably produces rapid gains in compliance and facilitates generalization across tasks and settings. These parallels reinforce the notion that errorless learning procedures, when combined with systematic prompting and differential reinforcement, can meaningfully reduce avoidance and resistance even for tasks that initially function as aversive or low likelihood demands.

The present study contributes to novel insights by demonstrating that ECT can be implemented effectively within a preschool context, a setting characterized by dynamic routines, variable environmental stimuli, and high levels of peer and adult interaction. These contextual properties often present challenges for structured behavioral interventions; nevertheless, the successful outcomes observed here align closely with those reported by Kløfta et al. (2020), who documented similar improvements when applying ECT in Norwegian early childhood education environments. Together, these studies suggest that ECT is sufficiently flexible and adaptable to be embedded within play-based, socially rich preschool settings without compromising treatment integrity.

The observed generalization of cooperative responding provides further support for the robustness of the training procedures. Planned transitions from the structured training room to naturalistic preschool routines, combined with the involvement of multiple adult implementers during follow-up, appear to have facilitated the transfer of skills across contexts and personnel. This is consistent with Schreibman et al. (2015), who emphasize that skills acquired through systematic and positively reinforced teaching procedures are more likely to generalize and be maintained when they are embedded within varied and natural learning contexts. Importantly, the maintenance of improved performance 11 weeks after the cessation of formal training indicates that cooperative behavior may have become naturally reinforced through everyday interactions with preschool staff and peers. Such sustained responding suggests that the target behaviors had acquired functional relevance within the child's daily routines, a critical objective in applied behavior analysis, and a key determinant of long-term treatment success.

Maintenance and Resistance to Extinction

The sustained occurrence of cooperative behavior may be explained by the continued availability of reinforcement across multiple natural contexts, which strengthened the response class and enhanced its stability over time. When behaviors contact reinforcement in varied and naturally occurring environments, they become less dependent on formal teaching procedures and more resilient to fluctuations in adult attention or programmed consequences (Cooper et al., 2020). This pattern reflects increased resistance to extinction—a central objective within applied behavior analysis (ABA), as it suggests that the behavior has acquired functional significance in the child's everyday routines and is maintained by naturally occurring contingencies rather than contrived intervention conditions (Nevin, 2012).

Social Validity

Staff reported that the intervention was both feasible to implement within the existing preschool routines and meaningful in relation to the child's

developmental goals. They observed that the child showed increased engagement, more consistent participation in activities, and a notably more positive effect during instructional interactions. Such qualitative impressions from practitioners are essential indicators of an intervention's practicality and social relevance. Together, these observations provide strong support for the social validity of the procedures employed, in line with Wolf's (1978) conceptualization of social validity as the degree to which intervention goals, methods, and outcomes are perceived as acceptable, important, and beneficial by those directly involved.

Limitations

This study is subject to several methodological limitations that should be considered when interpreting the findings. First, the use of a single-case design with only one participant restricts the generalizability of the results. Although single-case methodology allows for detailed, individualized analysis of behavior change, it does not permit inferences about broader populations of children with autism. Replication across multiple participants and settings is therefore necessary to strengthen external validity (Kazdin, 2011).

Second, interobserver agreement (IOA) was not calculated. The absence of IOA data reduces confidence in the reliability of behavioral measurements, as it is not possible to determine the extent to which observations were consistently recorded. Although clearly defined operational definitions and structured recording procedures were used to enhance measurement precision, future studies should include independent observers to ensure objectivity and replicability.

Third, the follow-up period of 11 weeks, while demonstrating promising maintenance, is short for assessing long-term durability of behavior change. Cooperative responding may fluctuate over longer intervals due to developmental changes, contextual shifts, or variations in reinforcement contingencies. Extended follow-up assessments, at six months, one year, or beyond, would provide a more robust evaluation of the persistence of ECT effects.

Finally, the broader literature on Errorless Compliance Training and related interventions may be influenced by publication bias. Studies demonstrating strong or positive outcomes are more likely to be published, whereas null or negative findings may be underreported. This trend can inflate perceptions of the intervention's effectiveness and limits the ability to evaluate its true impact across diverse populations and contexts. Comprehensive reporting and registration of single-case studies would contribute to a more balanced evidence base.

Future Research

Future research should address several avenues to strengthen the evidence base for Errorless Compliance Training and its application in early childhood settings. First, studies should include larger and more diverse samples to improve the generalizability of findings beyond single-case designs. Replication across multiple participants, settings, and implementers will help clarify the extent to which ECT is effective across variations in child characteristics, instructional environments, and staff backgrounds.

Second, research should incorporate extended follow-up periods. Although short-term maintenance was demonstrated in the present study, long-term evaluations are necessary to determine whether cooperative behavior remains stable over time and under naturally occurring reinforcement contingencies. Follow-up assessments conducted at six months, one year, and beyond would yield more robust evidence regarding the durability of treatment effects.

Third, future studies should analyze the active components of ECT to determine which aspects of the intervention are primarily responsible for behavior change. Component analyses examining the relative contributions of prompting procedures, reinforcement strategies, task sequencing, and errorless learning techniques would enhance theoretical understanding and improve the efficiency of clinical implementation.

Fourth, researchers should explore how ECT can be integrated with complementary interventions such as Functional Communication Training (FCT) or Pivotal Response Treatment (PRT). Combining ECT with interventions targeting communication, motivation, or broader social engagement may yield synergistic effects and support more comprehensive skill development for children with autism.

Last, there is also a need for systematic investigation of organizational and implementation variables, including staff training, treatment fidelity, supervision structures, and contextual factors within preschools and early education settings. Understanding how these variables influence treatment outcomes will be essential for scaling ECT in real-world environments and ensuring sustainable, high-quality implementation.

Conclusion

This study demonstrates that ECT can effectively increase and maintain cooperative behaviors in a preschool child with autism. ECT appears flexible enough for integration into daily routines while remaining structured and empirically grounded. The findings support ECT as a socially valid, ethically

sound, and practical intervention for early childhood educational settings.

Despite its empirical support, ECT remains relatively underexplored at a theoretical level. Further research is needed on protocol standardization, motivational operations, and mechanisms underlying maintenance and generalization.

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Augmented Reality Edu-tourism for Literacy and Numeracy: Analysis of the Learning Behavior Patterns of Elementary Students.

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Abstract

This research analyzes the learning behavior patterns of elementary school students in literacy and numeracy through Augmented Reality (AR) edu-tourism. Using a qualitative case study involving 53 fourth-and fifth-grade students in Bangka Belitung, Indonesia, data were gathered through direct observations, semi-structured interviews, and documentation. The results indicate that AR-based edu-tourism consistently fosters high engagement and active exploration across all learning sessions, with younger students demonstrating higher physical expressiveness. Collaborative patterns were particularly prominent, necessitated by shared device ratios which triggered natural peer-scaffolding and joint problem-solving among students. Furthermore, 3D visualizations of local tourism landmarks, such as Tanjung Kalian lighthouse and Jembatan Emas, acted as cognitive scaffolds that reduced extraneous load and facilitated embodied meaning-making by bridging abstract concepts with physical reality. While technical constraints and varying digital proficiencies were identified as challenges, these obstacles inadvertently promoted social constructivist behaviors through collective navigation and peer assistance. This study concludes that AR-based edu-tourism provides a situated learning environment that effectively contextualizes literacy and numeracy learning, offering significant implications for the implementation of the "Merdeka Belajar" curriculum in digital-age primary education.

Keywords:

Edu-Tourism, Augmented Reality, Learning Behavior Patterns, Literacy, Numeracy

Introduction

Elementary education is the foundation for the development of children's academic and life skills. At this stage, basic skills such as literacy and numeracy are taught, which serve as the groundwork for further abilities in various subjects (Bonifacci et al., 2021; Muliantara & Suarni, 2022). Literacy encompasses not only the ability to read and write but also skills in interpreting and understanding information in various forms of media. Similarly, numeracy involves more

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than just counting; it includes the ability to understand and apply mathematical concepts in everyday life contexts (Rakhmawati & Mustadi, 2022). These two skills are a top priority in the elementary education curriculum because they influence nearly all other aspects of learning (Mudzanatun, 2017)

Although literacy and numeracy are critically important aspects of elementary education, many students struggle to grasp the concepts being taught, especially when the material is abstract and not directly applicable to their lives. The results of the Indonesia National Assessment Program, which measured reading, math, and science skills for elementary school children, showed that students' reading ability is at 46.83% in the low category (Puspendik, 2018). In literacy, many students find it difficult to connect reading and writing lessons with their real-life experiences. Meanwhile, in numeracy, many students struggle to understand mathematical concepts such as basic operations, geometry, and algebra, which are often perceived as too abstract and disconnected from their real-world experiences.

This challenge drives the search for more engaging and effective learning methods. One of the solutions that has emerged in recent years is the use of technology in education (Grinshkun & Osipovskaya, 2020), one of which is Augmented Reality (AR). AR is a technology that combines elements of the real world with digital elements, creating an immersive experience that can interact with the real environment (Al-Ansi et al., 2023; Çetin, 2022). By using devices such as smartphones or tablets, students can directly interact with virtual objects displayed in the real world, enriching their learning experience (Bacca et al., 2014).

The use of AR in education not only changes how students learn but also how they interact with the subject matter. The results suggest that one of the most fundamental advantages of AR in education lies in its ability to support kinesthetic learning (Alzahrani, 2020). AR allows students to see and interact with information that previously existed only in text or two-dimensional images, making it more vivid and easier to understand (Ding, 2017). In literacy learning, AR can help students connect words with images or sounds, deepening their understanding of the texts they read. Meanwhile, in numeracy learning, AR can transform abstract mathematical concepts into more concrete visualizations, for example by displaying three-dimensional objects representing specific mathematical operations (İslim et al., 2024). Furthermore, research by Cao (2023) indicates that AR and VR technologies have strong potential as effective tools for visualizing mathematical concepts and models, which can significantly improve students' understanding.

One increasingly explored instructional approach is AR-based edu-tourism, which integrates learning activities with contextual exploration of environments relevant to students' everyday experiences. When combined with augmented reality technology, learning is no longer limited to textbooks or direct instruction but extends to interactive experiences that allow students to engage with digital content embedded in their physical or visual surroundings. Through AR-based edu-tourism, students can virtually explore places, objects, or representations related to lesson content and interact with three-dimensional models or informational overlays. In literacy learning, this approach enables students to engage with authentic texts in real or simulated environments, supported by AR-enhanced explanations and visual cues. In numeracy learning, students can explore mathematical concepts by observing and manipulating three-dimensional representations that support conceptual understanding (İslim et al., 2024; Koreňová & Gunčaga, 2018).

In this study, AR-based edu-tourism is conceptualized as a learning approach that integrates local tourism, cultural, or environmental contexts with augmented reality technology to create interactive and context-rich learning experiences (Dede, 2014; Radianti et al., 2020). Through AR, students engage with digital overlays such as three-dimensional objects, visual narratives, and interactive prompts embedded in representations of local sites, enabling them to explore literacy and numeracy content in authentic learning situations. Unlike conventional educational tourism, which primarily emphasizes experiential exposure through physical visits, AR-based edu-tourism facilitates active exploration, conceptual interaction, and collaborative learning through digitally augmented environments. It is also distinct from generic AR-based learning, as learning activities are deliberately anchored in place-based and locally meaningful contexts rather than decontextualized classroom materials.

The use of AR-based edu-tourism in this study is theoretically grounded in situated learning theory (Lave & Wenger, 1991), embodied learning (Wilson, 2002), and social constructivism (Vygotsky, 1978). Situated learning theory posits that knowledge is constructed more effectively when learning occurs within meaningful and authentic contexts, while embodied learning emphasizes the role of physical interaction and spatial experience in supporting cognitive processes. From a social constructivist perspective, shared AR artifacts function as mediating tools that stimulate peer discussion, explanation, and collaborative problem-solving. Together, these theoretical perspectives explain why AR-based edu-tourism is expected to influence students' learning behavior patterns. Based on these theoretical foundations, the affordances of AR-based edu-

tourism were operationalized into observable learning behavior patterns, including students' engagement in learning activities, peer collaboration and verbal interaction, and strategies for linking textual, visual, and numerical information during literacy and numeracy learning.

The AR-based Edu-tourism approach offers several advantages, including increased motivation and student engagement. Abdullah et al. (2022) highlight that augmented reality has attracted significant attention in educational research due to its ability to increase interactivity with learning content and to visualize scientific phenomena, thereby reducing cognitive load and enabling more personalized learning experiences. Learning experiences involving technology allow students to be in a highly interactive and immersive learning environment, both mentally and physically. This learning involves presence-based technology that immerses students into a virtual learning environment capable of delivering material through narratives or challenges (Beck et al., 2024). Additionally, AR enables students to learn in a more contextualized and practical manner, making the material taught feel closer to their everyday lives. This not only enhances their understanding of the material but also helps them develop critical thinking and problem-solving skills in real contexts.

Although the use of AR in education has much potential, there are still challenges in its implementation, particularly related to students' learning behavior patterns. Students may struggle to adapt to new technologies or may become too focused on technological elements at the expense of concentrating on the subject matter itself. Therefore, it is important to understand how AR affects students' learning behavior patterns in the context of literacy and numeracy and how this technology can be utilized to create optimal learning experiences (Cadavieco et al., 2018).

Literacy and Numeracy Learning in Elementary Schools

In the context of elementary education, literacy and numeracy learning play a crucial role in equipping students with the basic skills needed for everyday life and their academic development. Literacy and numeracy are two core skills that serve as the foundation for accessing and understanding various information and solving mathematical problems encountered in their environment. In this study, literacy and numeracy learning refers to two interrelated fields, each with distinct characteristics and methods (Wood, 2017).

Literacy Learning

Literacy is not limited to the ability to read and write; it also encompasses understanding, analyzing, and applying information found in various forms of text. According to Febriyanto, (2016) and Parmini et al. (2023), 21st-century literacy involves the ability to use various media and sources of information, whether written texts, images, or videos, often requiring critical thinking and problem-solving skills. Effective literacy requires skills in filtering relevant information, understanding its context, and being able to communicate that understanding clearly. Therefore, literacy learning in elementary schools aims not only to introduce students to reading and writing skills but also to help them develop critical thinking abilities, analyze information, and communicate effectively.

In this context, Augmented Reality (AR) can enhance literacy learning by presenting information visually and interactively, allowing students to explore texts in a more engaging and contextual manner. The use of AR in literacy learning enables students to engage in a more immersive learning experience by connecting texts with images or virtual objects that provide deeper explanations (Familoni & Onyebuchi, 2024; Masneri et al., 2022). AR can also improve students' comprehension and interpretation of texts by giving them opportunities to see how information can be applied in various real-world contexts (Grinshkun & Osipovskaya, 2020).

Numeracy Learning

Numeracy refers to the ability to understand and use mathematical concepts in everyday life. According to Iswara et al. (2022), numeracy is more than just counting; it also includes skills in solving mathematical problems, applying numerical concepts in various situations, and making decisions based on mathematical understanding. Numeracy is a vital skill for addressing challenges related to an increasingly complex world and can be found in many aspects of life, from personal financial management to planning and decision-making in broader contexts.

Effective numeracy learning must include an understanding of basic mathematical concepts such as addition, subtraction, multiplication, division, as well as problem-solving skills. Similar to literacy learning, technology can also enhance the quality of numeracy education. AR can help students understand abstract mathematical concepts in a more concrete and visual way. For example, AR can be used to display three-dimensional objects representing mathematical operations or allow students to interact with virtual objects that help them understand the relationship between numbers and mathematical concepts. AR can enhance students' understanding of mathematical concepts by enabling them to see and manipulate objects that they would not physically be able to see or touch in the real world (Ahmad, 2021).

AR-based numeracy learning gives students the opportunity to experience mathematical concepts directly and more enjoyably, which can subsequently increase their motivation and engagement. With a more immersive and contextual learning experience, students are expected to develop a better understanding of the material taught while feeling more confident in facing mathematical challenges in everyday life (Nafi'an, 2024).

The Ministry of Education and Culture has proposed several indicators of numeracy skills: (1) The ability to use various numbers and symbols related to basic mathematics to solve problems in various everyday contexts; (2) The ability to analyze information presented in various forms (graphs, tables, charts, diagrams); (3) The ability to interpret analysis results for predictions and decision-making; and (4) aspects of life (Muniri et al., 2023).

Literacy and Numeracy Learning through AR Edu-tourism

In this study, literacy and numeracy are studied integratively using AR-based Edu-tourism, which allows students to learn while exploring their environment and interacting with virtual objects related to the subject matter. AR-based Edu-tourism provides experiences that are not only instructional but also contextual and enjoyable, thereby enhancing student engagement. In this regard, literacy and numeracy learning involves not only teaching theories or concepts but also understanding gained through direct experiences and active exploration supported by AR elements that present deeper visualizations and interactions (Karakus et al., 2019).

Literacy and numeracy are fundamental competencies that support children's academic development and life skills in the twenty-first century. At the elementary school level, these competencies form the foundation for students' ability to understand information, solve problems, and participate meaningfully in social and learning contexts. However, national assessment data in Indonesia continue to indicate that a significant proportion of elementary students demonstrate low proficiency in reading comprehension and basic mathematical reasoning, highlighting persistent learning challenges in literacy and numeracy education.

To address these challenges, recent educational research has increasingly explored the use of digital technologies, particularly Augmented Reality (AR), as innovative learning media. AR enables the integration of virtual objects into real-world environments, allowing abstract concepts to be visualized in concrete and interactive forms. Previous studies have shown that AR can enhance students' motivation, engagement, and conceptual understanding across various subjects, including literacy and numeracy. Nevertheless, much of this research has focused primarily on learning outcomes or performance gains, with limited attention to students' learning processes and behaviors during AR-supported activities.

Despite the burgeoning literature on Augmented Reality (AR) in education, a critical synthesis of recent international studies reveals a disproportionate focus on quantitative academic achievement and system usability (AlGerafi et al., 2023; Alzahrani, 2020). While scholars have extensively documented the 'what' (learning outcomes), there is a profound scarcity of research addressing the 'how' specifically the micro-longitudinal behavioral patterns that manifest when AR is situated within place-based edu-tourism (Beck et al., 2024; Cadavieco et al., 2018). Current global trends in immersive learning often overlook the socio-pedagogical friction, such as peer-scaffolding and joint attention, that occurs under resource-constrained environments (Abdelmonem & Karawia, 2024).

Furthermore, existing AR-based learning studies are often conducted in decontextualized classroom settings, with learning content detached from students' local environments and lived experiences. In contrast, edu-tourism based learning, which utilizes local cultural, environmental, or tourism resources as learning contexts, has the potential to support situated and embodied learning by connecting academic content with authentic and meaningful experiences (Lave & Wenger, 1991; Wilson, 2002). Despite this potential, empirical research that integrates AR with edu-tourism contexts at the elementary school level particularly for literacy and numeracy learning remains scarce.

Consequently, few studies have qualitatively examined learning behavior patterns such as students' engagement, collaboration, verbal interaction, and meaning-making strategies when AR is implemented in these authentic settings. As a result, there is still insufficient empirical evidence explaining how and why AR-based edu-tourism influences elementary students' learning behaviors beyond measurable achievement outcomes.

To address these multifaceted research gaps, the present study investigates elementary students' learning behavior patterns during AR-based edu-tourism activities designed to support literacy and numeracy learning in Bangka Belitung, Indonesia. By employing a qualitative case study approach, this study aims to provide an in-depth understanding of students' engagement, interaction, and conceptual meaning-making processes within an authentic, context-rich learning environment. Specifically, this research seeks to map these behavioral dynamics to theoretical lenses of cognitive load, embodied learning, and social constructivism, offering a

nuanced perspective on how AR reconfigures the learning trajectory in primary education.

Accordingly, this study aims to examine how elementary students demonstrate learning behavior patterns, including engagement, collaboration, and meaning-making, during AR-based edu-tourism activities for literacy and numeracy learning. Based on the research gaps identified above, this study is guided by the following research questions:

1. How do elementary students demonstrate learning behavior patterns during AR-based edu-tourism activities for literacy and numeracy learning?

2. What forms of engagement, collaboration, and meaning-making emerge when students interact with AR edu-tourism content?

3. What challenges do students and teachers encounter during the implementation of AR-based edu-tourism learning?

In this study, learning behavior patterns refer to observable and recurring student behaviors during learning activities, including engagement, peer collaboration, verbal interaction, and strategies used to link textual and visual information when interacting with AR media. Literacy is defined as students' ability to interpret and communicate meaning from written and multimodal texts, while numeracy refers to students' capacity to apply mathematical concepts and reasoning in contextualized situations. AR edu-tourism is conceptualized as the use of augmented reality technology to present local tourism and environmental content as interactive learning resources that support situated and embodied learning.

Method

Research Design

This study employs a qualitative research method with a case study design to analyze the learning behavior patterns of elementary school students in literacy and numeracy learning through Augmented Reality (AR) Edu-tourism. This approach was chosen because it allows the researcher to explore students' experiences, perspectives, and interactions in a more natural and contextual setting. The researcher observes, documents, and analyzes students' learning behavior patterns during the learning process involving AR-based Edu-tourism for literacy and numeracy content (Abdelmonem & Karawia, 2024; Daniel, 2016; Morgan et al., 2017).

Participants and Research Setting

The participants in this study consisted of 53 students (28 males and 25 females) from the fourth and fifth-grade cohorts of a public elementary school in Bangka Belitung, Indonesia. This specific age group (10–11 years) was selected through a purposive sampling strategy, as it represents a 'digital native' transition phase where students possess sufficient motor skills for mobile AR manipulation but are still developing abstract reasoning in literacy and numeracy. The school was selected as the research site due to its strategic implementation of AR-based learning activities and its role as a representative micro-context of the region, characterized by moderate digital access and a curriculum emphasis on local cultural heritage.

The inclusion of students from both grade levels aimed to capture variations in learning behavior patterns across upper elementary classrooms. In addition, two classroom teachers (one fourth-grade and one fifth-grade teacher) were involved as key informants to provide pedagogical context during the observation and interview processes.

Regarding the adequacy of the sample, N=53 is significantly larger than the typical threshold for qualitative case studies, which often prioritize a smaller number of units for depth. However, this sample size was determined by the principle of data saturation through group-level dynamics. By dividing students into 13 small groups, the researchers were able to observe repeated behavioral patterns across multiple units, thereby ensuring the internal validity of the findings. The adequacy is further reinforced by data triangulation, where observational data were cross-validated with semi-structured interviews from 10 selected students and the 2 lead teachers, providing a 360-degree view of the learning behavior patterns that a smaller sample might not capture.

Data Collection Techniques

Data were collected through several methods:

Participatory Observation: The researcher directly observes the learning process using AR. Observations are conducted to identify student behaviors, such as levels of engagement, interactions with AR media, and their understanding of the learning material.

Semi-Structured Interviews: Interviews were conducted with students and teachers to gain deeper insights into students' learning experiences, responses to the use of AR, and changes in their learning behavior patterns.

Documentation: The researcher collects documentation of student work, field notes during observations, and video recordings capturing student interactions with AR technology.

To ensure the validity and reliability of the observations, students' learning behavior patterns were operationalized into specific, observable

indicators. This operationalization served as the primary observation protocol to categorize field data into four dimensions: Engagement, Collaboration, Meaning-Making, and Technical Challenges. Table 1 presents the codebook used, including the indicators and data exemplars that guided the evidence-gathering process.

Table 1.
Codebook for Operationalizing Students' Learning Behavior Patterns in AR Environments

Dimension	Observable Indicators	Exemplars (Data Excerpts)
Engagement	Sustained attention to AR content, active manipulation of digital objects, and verbal expressions of interest.	"I like learning this way because I can see the objects directly, not just imagine them. I want to try all the AR features" (S12).
Collaboration	Peer-scaffolding, device sharing, joint problem-solving.	"We took turns using the tablet. If my friend didn't understand, I explained it to him." (S19).
Meaning-making	Connecting digital visualizations with literacy/numeracy concepts and real-world contexts.	"Oh, I see! The 1:100 scale in this AR model means the real lighthouse is much taller than our school building!" (S22)
Technical Challenges	Experiencing 'technological friction' or requiring assistance with device operation.	"Sometimes the AR didn't appear, and I didn't know what to do." (S14)

Procedure

Research Preparation

Selection of Location and Participants: This research was conducted at SD STKIP Muhammadiyah Bangka Belitung based on specific criteria, such as having access to and infrastructure supporting AR technology, using AR in their curriculum, particularly in literacy and numeracy learning, and allowing the researcher to conduct observations and interviews.

Ethical Approval: Before commencing the research, the researcher sought permission from the school authorities for participation in the study. All data obtained were kept confidential, and participants' identities were protected to avoid potential bias.

Learning Intervention: AR-based Edu-tourism Activities

To ensure intervention fidelity and allow for replication, the AR-based edu-tourism learning activities were implemented with a structured protocol. The key components of the intervention are detailed as follows:

1. Intervention Dose: The study consisted of four learning sessions, with each session lasting 70 minutes (totaling 280 minutes of exposure), integrated into regular literacy and numeracy lessons.
2. Task Sequence: Each session followed a standardized four-stage sequence:
    a. Introduction (10 mins): Teacher orientation to the learning objectives.
    b. Guided Exploration (30 mins): Direct interaction with AR-based edu-tourism content.
    c. Collaborative Task (20 mins): Small-group discussion and numeracy/literacy problem-solving.
    d. Consolidation (10 mins): Reflection and sharing of findings.
3. AR Assets & Platform: Activities were developed using the Assemblr Edu platform. Assets featured 3D models and informational overlays of local heritage sites (e.g., Jembatan Emas, Tanjung Kalian Port, and the Indonesian Tin Museum).
4. Technical Specifications: The learning activities were accessed via Android-based tablets and smartphones (Minimum specs: 3GB RAM, Android OS 9.0) using the school's wireless network.
5. Grouping & Collaboration: Students worked in heterogeneous groups of 3–4. This setup promoted device sharing, turn-taking, and peer discussion.
6. Teacher Orchestration: The teacher acted as a facilitator using pedagogical prompts (e.g., "Which geometric shapes stabilize this bridge?") rather than direct instruction, providing support for both content understanding and technical friction.

Development of Research Instruments

Research instruments were developed to support data collection. These instruments include:

Observation Guide: This contains aspects observed in student learning behavior, such as levels of engagement, interactions with AR technology, and understanding of literacy and numeracy concepts.

Interview Guidelines: These consist of open-ended questions for interviews with students and teachers. The interviews explore their experiences and perceptions regarding the use of AR in learning.

Documentation Sheets: These contain formats for recording student work results, photos, and relevant interaction videos.

Data Collection Phase

Learning Observations: The researcher actively participates in the learning process while observing during classroom activities involving AR Edu-tourism. This observation aims to identify students' behavior patterns, levels of engagement, and their reactions

to using AR in literacy and numeracy learning. Observations were conducted over four learning sessions.

Interviews

Interviews were conducted after the learning sessions to delve into the experiences of students and teachers regarding the use of AR in education.

- Students: Interviews with students asked about their experiences using AR, how AR helped them understand the material, and how they felt about their engagement in learning.
- Teachers: Interviews with teachers focused on how they used AR to teach literacy and numeracy, challenges faced, and observed changes in students' learning behavior patterns.

Documentation

The researcher collected various student work results, including written assignments, tasks completed with the help of AR, and photos or videos documenting student interactions with AR media. This documentation supports findings from observations and interviews.

Data Analysis

The collected data were analyzed using thematic analysis. The steps involved in data analysis include:

- Coding: Data from interviews, observations, and documentation were scanned to identify themes or categories relevant to students' learning behaviors, such as levels of engagement, understanding of literacy and numeracy concepts, and interactions with AR.
- Theme Grouping: Themes emerging from coding were grouped to address the research focus related to students' learning behavior patterns.
- Interpretation: The researcher interpreted data within the context of using AR for literacy and numeracy education and how AR played a role in enhancing student engagement and understanding.

Data Validity

To ensure the validity and credibility of research findings, the researcher employed triangulation techniques by comparing data from various sources (observations, interviews, and documentation) and seeking feedback from participants on initial findings through member checking. Additionally, peer debriefing was conducted by discussing the research process with colleagues to ensure objectivity and accuracy of findings.

Findings

This section presents the findings of the study based on classroom observations, interviews with students and teachers, and documentation of AR-based edu-tourism learning activities. The findings are organized according to recurring learning behavior patterns that emerged during data analysis, namely student engagement, collaboration, meaning-making, and implementation challenges.

Student Engagement during AR-based Edu-tourism

Consistently across all observed sessions, classroom observations indicated high levels of student engagement during AR-based edu-tourism activities, as reflected in sustained attention, active manipulation of AR content, and voluntary participation in learning tasks. Observations revealed that this high engagement was uniform across both fourth and fifth-grade groups, although the intensity of interaction varied; younger students tended to be more physically expressive, while older students displayed more sustained focus. Students appeared focused and motivated while interacting with AR materials integrated into literacy and numeracy lessons.

During AR-supported literacy activities, students studied a text about Tanjung Kalian Beach, Muntok, while simultaneously viewing three-dimensional representations of the beach and its lighthouse an iconic local landmark on their device screens. Through the Assemblr Edu application, students were able to virtually "visit" Tanjung Kalian Beach, which enabled them to engage with the text in a more contextual and visually supported manner. Figure 1 illustrates students exploring Tanjung Kalian Beach through AR-based edu-tourism activities.

Verbatim data further illustrate students' engagement with AR-based learning. A fifth-grade student expressed enthusiasm for the interactive features:

> *""I like learning this way because I can see the objects directly, not just imagine them. I want to try all the AR features." (S12, Grade 5, ENG)*

Similarly, a fourth-grade student described increased focus during numeracy learning:

> *"Usually I get bored when learning math, but when the AR appeared, I kept focusing because it felt like playing and learning at the same time." (S7, Grade 4, ENG)*

Despite generally high engagement, variations were observed depending on technical stability and device familiarity. A teacher noted that technical

constraints occasionally disrupted the focus of groups that experienced lag or those less accustomed to the interface:

> *"Some students were very engaged, but a few lost focus when the device was slow or when they had to wait their turn." (T1, ENG)*

Figure 1.
Students exploring Tanjung Kalian Beach through Augmented Reality Edu-tourism



Collaboration Patterns in AR-supported Learning

Classroom observations indicated that AR-based edu-tourism activities consistently fostered collaborative learning behaviors among students. This pattern was largely necessitated by the device-to-student ratio (approximately 1:4), which naturally encouraged shared device use, peer explanation, and joint problem-solving. During AR-supported literacy tasks, students frequently negotiated turns when using the devices and supported one another in understanding the learning content.

Figure 2.
Students collaborating to find out about tourist objects



As illustrated in a group activity exploring historical stories from the Indonesian Tin Museum, students worked collaboratively to identify key information about the museum and its history. Using AR, they virtually examined three-dimensional representations of historical artifacts, which encouraged discussion, information sharing, and collective problem-solving within their groups. Figure 2 illustrates students collaborating to explore tourism-related objects through AR-based edu-tourism activities. Figure 2. Students collaborating to find out about tourist objects.

Verbatim data further demonstrate these collaborative patterns. A fourth-grade student stated:

> *"We took turns using the tablet. If my friend didn't understand, I explained it to him." (S19, Grade 4, COL)*

Similarly, a fifth-grade student explained:

> *"We discussed the answer together because the AR object showed many details." (S3, Grade 5, COL)*

Despite these positive interactions, variations in participation equality were observed. In some groups where roles were not clearly defined, one student tended to dominate the device, while others participated more passively unless guided by the teacher:

> *"Some students dominated the device, so others participated more as observers unless guided by the teacher." (T2, COL)*

Conceptual Linkage and Meaning-Making

Students demonstrated meaning-making strategies by connecting AR visualizations with textual and numerical concepts. AR visuals supported students in interpreting abstract content and relating it to real-world contexts.

Figure 3.
Students exploring various flat shapes at observed tourist sites.



In numeracy activities, for example, observations showed students applying geometric concepts to local tourism contexts. As shown in Figure 3, students actively identified characteristics of flat shapes such as triangles and rectangles embedded in the architecture of Jembatan Emas (Golden Bridge) and Tanjung Kalian Port. Instead of memorizing definitions, they pointed out the physical angles and sides of the

AR structures to solve problems.

> *"The numbers made sense after I saw how they worked in the AR model." (S9, Grade 5, MM)*

Teachers noted that AR supported conceptual understanding, although scaffolding remained necessary.

> *"Oh, I see! The 1:100 scale in this AR model means the real lighthouse is much taller than our school building!" (S7, Grade 4, MM)*

Challenges in Implementing AR-based Edu-tourism

Although AR-based edu-tourism positively influenced learning behaviors, the implementation process was not without obstacles. Classroom observations and interview data highlighted several challenges, primarily related to technical constraints and variations in students' digital proficiency, which occasionally disrupted the flow of learning.

Technical Constraints Technical issues were the most frequently observed challenge. This included internet latency (lag), particularly caused by high bandwidth requirements for rendering complex 3D objects, difficulties in scanning AR markers due to lighting conditions, and device responsiveness. When these technical glitches occurred, some students experienced a temporary loss of focus or frustration.

> *"Sometimes the AR didn't appear, and I didn't know what to do." (S14, Grade 4, CH)*

> *"I had to wait because only one phone was working well." (S21, Grade 5, CH)*

These technical interruptions often required the teacher to shift from a facilitator role to a technical support role, momentarily pausing the instructional momentum to resolve device issues. Digital Skill Disparities and Variation Another significant challenge was the gap in digital skills among students. While some students intuitively navigated the AR interface, others required constant guidance to perform basic gestures like rotating or zooming in on the 3D objects for instance, when exploring the detailed architecture of Jembatan Emas.

The frequency of these disruptions varied significantly by group composition. Observations showed that groups containing at least one 'tech-savvy' student resolved navigation issues independently, whereas groups with uniformly low digital familiarity experienced prolonged pauses. This disparity affected group dynamics, as students with lower digital confidence tended to become passive observers.

> *"Differences in digital skills meant some students needed constant assistance, which slowed down group work." (T2, CH)*

Positive Behavioral Adaptation However, it is worth noting that these challenges often triggered peer-scaffolding behaviors, where more digitally skilled students assisted their peers. This dynamic inadvertently fostered a deeper level of collaboration and collective problem-solving.

Frequency and Variations in Learning Behavior Patterns

The study identified significant variations in how students interacted with the AR content, with behaviors appearing at different frequencies across the four sessions. Engagement was the most consistent behavior, observed in over 85% of students throughout all sessions. However, the nature of this interaction was primarily mediated by prior digital fluency. While students with high smartphone familiarity navigated the AR interface with minimal hesitation, students with lower digital exposure (approximately 30% of the participants) initially exhibited 'technological friction' during the first two sessions, requiring more direct scaffolding from teachers or tech-savvy peers.

Furthermore, variations were observed in social dynamics across the groups. In the majority of groups (10 out of 13 groups), a 'distributed leadership' pattern emerged where students successfully engaged in turn-taking and peer-scaffolding. However, in three specific groups, a 'dominant driver' behavior was observed, where one student controlled the device for the duration of the task while others remained as passive observers. These frequencies and variations highlight that the impact of AR edu-tourism is not monolithic but is significantly influenced by the learner's technical readiness and the social structure of the peer group.

To synthesize the observational and interview data presented in the previous sections, Table 2 provides a comprehensive summary of the key behavioral indicators and representative responses across the four identified themes.

Table 2.
Summary of Observational Findings on Students' Learning Behaviors in Literacy and Numeracy through AR Edu-tourism

Observed Aspect	Behavioral Indicators	Observation Notes
Engagement	Enthusiasm in following instructions, persistence in using AR applications	Most students immediately attempted to scan AR objects without being prompted; some expressed excitement when the 3D objects appeared on their screens.
Collaboration/ social interaction	Peer discussion, collaboration within groups	While observing the Golden Bridge in AR, groups of 4–5 students discussed and compared triangular structures on the pillars. Some students helped peers who struggled with operating the application.

Observed Aspect	Behavioral Indicators	Observation Notes
Content Understanding (meaning-making)	Ability to link AR visuals with literacy/numeracy concepts	In geometry tasks, students successfully identified triangles and rectangles in the bridge structure. During the Tanjung Kalian text activity, students connected the 3D visualization of the lighthouse with the written description.
Motivation and Confidence	Willingness to ask/answer questions, initiative to explore	Several students confidently demonstrated how to rotate 3D objects for their peers. Others initiated questions such as, "Why does the bridge use triangles, Miss?"
Technical Challenges	Difficulties in navigating the app, device limitations	Six students struggled to focus their cameras to display AR objects. Teachers provided direct assistance to prevent disruption to the learning flow.

Discussion

The findings of this study demonstrate that AR-based edu-tourism significantly alters student learning behavior patterns by transforming abstract literacy and numeracy tasks into interactive, multi-sensory experiences. This discussion maps these observed behaviors to three primary theoretical mechanisms: the optimization of cognitive load, the facilitation of embodied and situated learning, and the reinforcement of social constructivism through peer interaction.

The high levels of engagement and improved meaning-making observed in Sections Engagement and Conceptual Linkage and Meaning-Making can be explained through Cognitive Load Theory. Traditional literacy and numeracy instruction often impose a high extraneous cognitive load, as students must use significant mental effort to visualize abstract concepts, such as the scale of historical landmarks or geometric properties (Ahmad, 2021; AlGerafi et al., 2023).

In this study, AR acted as a cognitive scaffold. By providing three-dimensional visualizations of the Tanjung Kalian lighthouse and Jembatan Emas, the technology reduced the mental "imagination gap" for students. This allows working memory to focus on higher-order tasks like analysis and problem-solving (Abdullah et al., 2022; Alzahrani, 2020). The enthusiasm expressed by students (e.g., S12 and S7) confirms that when the visual "concreteness" of a lesson is increased, satisfaction and focus naturally follow, echoing the systematic benefits of AR in primary education (Basumatary & Maity, 2023; Çetin, 2022).

The physical behaviors observed such as students rotating their devices and moving their bodies to explore AR markers highlight the role of Embodied Cognition (Wilson, 2002). Unlike traditional desktop learning, AR edu-tourism requires physical interaction, which grounds abstract numeracy concepts in a concrete, place-based context (Cadavieco et al., 2018). When students identified flat shapes on the architecture of Jembatan Emas, they were not merely observing; they were engaging in situated learning (Lave & Wenger, 1991).

This "place-based" approach is particularly vital in the Indonesian context, where there is a recognized gap between theoretical literacy and its practical application in real-world environments (Muliantara & Suarni, 2022; Rakhmawati & Mustadi, 2022). By "visiting" local tourism sites through AR, students moved beyond rote memorization toward authentic meaning-making, a process essential for developing 21st-century competencies (Parmini et al., 2023; Febriyanto, 2016).

The collaborative patterns identified in Section Collaboration Patterns in AR-supported Learning, characterized by peer explanation and joint problem-solving, strongly resonate with Social Constructivism (Vygotsky, 1978). Interestingly, the technical challenges and limited device access (1:4 ratio) identified in this study did not solely hinder learning; they acted as catalysts for social interaction.

These constraints forced students into a "shared attention" state, where more digitally proficient students acted as the "More Knowledgeable Other" (MKO). This created a Zone of Proximal Development where technical navigation and conceptual understanding were co-constructed (Abdelmonem & Karawia, 2024; Masneri et al., 2022). This peer-scaffolding behavior proves that AR-based learning is inherently social, promoting communication skills that are foundational to modern literacy (Mudzanatun, 2017; Wood, 2017).

While AR provides significant benefits, the variation in digital proficiency and infrastructure remains a challenge. For AR-based edu-tourism to effectively address the numeracy literacy gap identified by the Indonesian Ministry of Education (Badan Penelitian dan Pengembangan, 2019), teachers must balance their roles as facilitators of technology and mentors of conceptual understanding (Iswara et al., 2022; Nafi'an, 2024). The transition to "Education 4.0" in Indonesia requires not just the presence of AR tools, but a pedagogical shift toward student-centered, collaborative environments that mitigate digital disparities (Al-Ansi et al., 2023; Grinshkun & Osipovskaya, 2020).

This interaction demonstrates that the teacher's role remains central in an AR-supported environment.

The observed variations in student behavior highlight the role of Digital Readiness and Social Mediation in AR environments. The 'technological friction' experienced by low-fluency students aligns with the Cognitive Load Theory, where limited prior technical knowledge increases the intrinsic load, momentarily diverting focus from the pedagogical content. Conversely, the transition from 'dominant driver' to 'distributed leadership' in some groups suggests that AR-based edu-tourism can serve as a catalyst for Social Constructivism, provided that teacher scaffolding is present to balance group dynamics. This study thus suggests that pedagogical design must account for these individual differences to optimize learning outcomes.

Conclusion

This study concludes that AR-based edu-tourism serves as a powerful bridge between abstract academic concepts and real-world contexts in primary literacy and numeracy. The findings highlight a significant shift in student learning behavior moving from passive reception to active, embodied exploration. By reducing extraneous cognitive load through 3D visualizations and fostering social constructivism through shared digital artifacts, AR technology enables students to engage with local tourism heritage in a way that is both intellectually stimulating and emotionally engaging.

While technical constraints and digital skill disparities remain as challenges, they inadvertently foster peer-scaffolding and collaborative problem-solving. Ultimately, the integration of AR in edu-tourism does not just modernize the classroom; it recontextualizes learning as a situated, social, and physically active process.

Pedagogical Implications

Based on the findings, several pedagogical implications for educators and policy-makers are proposed:

1. Strategic Grouping for Peer Scaffolding: Since digital proficiency varies, teachers should intentionally form heterogeneous groups where "tech-savvy" students can assist their peers. This minimizes the burden on the teacher for technical support and maximizes collaborative learning opportunities.

2. Contextual Content Design: Educational content should prioritize local landmarks and tourism sites. Grounding lessons in familiar environments (situated learning) significantly reduces the cognitive effort required to process new literacy and numeracy information.

3. Balanced Teacher Roles: Teachers must be prepared to oscillate between being a pedagogical facilitator and technical troubleshooter. Training programs should focus not just on how to use AR applications, but on how to integrate them into inquiry-based lesson plans.

4. Addressing the Digital Divide: For AR-based edu-tourism to be inclusive, schools must address infrastructure readiness, particularly device compatibility and high-bandwidth internet access. Hybrid models where AR is used in turns or through shared screens can be a temporary solution to resource scarcity.

Limitations and Future Research

While this study provides valuable insights into student behavior in AR-based edu-tourism, it acknowledges several limitations that should be considered.

1. Sample and Generalizability: First, the scope was limited to a single elementary school in Bangka Belitung with a relatively small sample size (N=53). Thus, the findings may not be fully generalizable to diverse geographical or socio-economic contexts across Indonesia.

2. Novelty Effect: Second, as the AR intervention was conducted over a specific period, the high levels of engagement observed might partially stem from a "novelty effect," where students are excited by the newness of the technology rather than the pedagogical content itself.

3. Qualitative Boundaries: Finally, this research relied heavily on qualitative observations and interviews. While rich in detail, it does not quantify the direct impact of these behaviors on measurable learning outcomes (e.g., standardized test scores).

4. To address these limitations, we propose the following follow-up research:

5. Mixed-Methods Approach: Future studies should employ a mixed-methods design, combining qualitative behavioral analysis with quantitative pre-test and post-test measures to statistically correlate specific AR interactions with literacy and numeracy score improvements.

6. Comparative Studies: We recommend comparative research to evaluate the effectiveness of AR edu-tourism against traditional field trips or non-AR digital learning. Additionally, comparing different grade levels or urban versus rural school settings would provide a more nuanced understanding of how digital proficiency variations influence learning trajectories.

7. Longitudinal Tracking: Longer-term longitudinal studies are needed to determine if student engagement and collaborative behaviors persist after the initial novelty of AR technology has diminished.

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Ethical Statement

This study has been conducted in accordance with ethical research standards. All participants were informed about the purpose of the study, and consent was obtained prior to data collection. Any images used in this study have been published with appropriate permission.

AI Disclosure Statement

The authors used AI-based tools to assist with language editing and paraphrasing to improve the clarity and readability of the manuscript. All ideas, data analysis, and interpretations presented in this study are the original work of the authors.

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Supportive Classroom Relationships as Protective Factors Against Bullying Among Slovenian Primary School Students

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Abstract

This study investigated how individual and contextual classroom factors contribute to bullying perpetration and victimization among Slovenian primary school students. While most research focuses on adolescence, this study targeted 4th and 5th-grade students to explore predictors during a critical transitional period. A total of 1,303 students (aged 9–11) participated in the study. Using self-report measures, we assessed peer relationships, teacher–student relationship closeness and conflict, classroom belonging, and experiences of bullying. Structural equation modeling was used to examine the associations between these variables. Results showed that lower classroom belonging, more conflictual teacher–student relationships, and poorer peer relationships were associated with higher victimization. Bullying perpetration was predicted by lower teacher–student closeness, higher teacher-student conflict, and poorer peer relationships. Notably, classroom belonging was associated with victimization but not perpetration, suggesting that the pathways to these roles may differ. Gender differences were also observed, with boys reporting higher involvement in both perpetration and victimization. These findings support the importance of classroom relationships in bullying prevention. Peer and teacher–student dynamics shape students' social experiences and may reinforce or buffer bullying involvement. The results highlight the need for interventions that strengthen supportive peer interactions, enhance teacher–student closeness, and reduce conflict. Fostering a sense of classroom belonging may also serve as a protective factor, particularly for victims. The study contributes to the understanding of bullying during late childhood and offers evidence for early, relationship-centered prevention strategies.

Keywords:

Bullying, Victimization, Peer Relationships, Teacher-Student Relationships, School Belonging, Early Adolescence

Introduction

Peer bullying is a widespread public health concern that significantly affects children's social and emotional development. It is defined as "aggressive, goal-directed behavior that aims to harm another individual within the

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context of a power imbalance" (Volk et al., 2014, p. 328). We will use the term "bullying" from this point on referring to interactions among peers. Bullying is a subtype of aggression (Salmivalli, 2010) and it is distinguished from general aggressive behavior by its repetitive nature, intentional harm, and power imbalance. The term bullying encompasses different forms of repetitive aggressive behaviors among peers, which are commonly categorized as verbal (saying hurtful things, calling hurtful names etc.), physical (kicking, hitting, tripping someone over, damaging someone's property etc.), relational (ignoring or excluding the person, spreading rumors, telling lies about someone etc.) and cyber bullying (using social media to harm or hurt someone) (e.g., Chapell et al., 2006).

Prevalence rates of peer bullying vary considerably depending on methodological approaches and contextual factors. A cross-national study by Johansson et al. (2022) confirmed its widespread occurrence, with monthly victimization reported by 18% to 60% of 10-year-old students across 50 countries, and weekly victimization by 4% to 35%. A recent meta-analysis by Ariani et al. (2025) estimated that globally, 25% of children and adolescents have experienced peer victimization, 16% have engaged in bullying, and another 16% have been both victims and perpetrators. Comparable national data from Slovenia indicate that 14% of students reported being victims of traditional peer bullying, 7.3% reported perpetrating it, and 3.2% were involved in both roles (Pirc et al., 2019).

Bullying victimization during childhood and adolescence has long-term effects on psychological adjustment later in life, as it is associated with higher risk for developing depression, anxiety, psychosomatic disorders, eating disorders and substance abuse in adulthood (McDougall & Vaillancourt, 2015). Bullying perpetration is similarly linked to negative outcomes, as individuals who perpetrate bullying during their formative years are more prone to participate in delinquent and risky behaviors in adulthood (Lebar et al., 2017).

Given the numerous adverse outcomes associated with bullying, it is imperative to understand the factors that may reduce students' involvement in such behaviors. Bullying occurs within a social context and is best understood through Bronfenbrenner's socio-ecological framework (1977, 1989), which highlights the dynamic interplay between individual and environmental influences. This model has proven especially useful in identifying risk and protective factors across ecological levels, enabling more targeted and context-sensitive interventions (Huang et al., 2024).

In selecting predictors for this study, we drew on findings from meta-analyses and systematic reviews identifying individual characteristics and relational contexts within the classroom microsystem as key correlates of bullying (ten Bokkel et al., 2022; Zych et al., 2015). Specifically, we focused on students' sense of classroom belonging and gender as individual-level variables, and on peer relationships and teacher–student relationships quality (operationalized as closeness and conflict as contextual factors. These variables were not chosen as a complete list of predictors, but because they are well-supported by theory and can be influenced through interventions in the classroom setting (Hong & Espelage, 2012; Thornberg et al., 2017; Wang & Degol, 2016). Gender was included as a substantive predictor, given consistent evidence linking it to differences in bullying involvement, although the direction and magnitude of these associations may vary across forms of bullying and developmental stages (Smith et al., 2019).

Individual Factors

Sense of Belonging to the Classroom

The sense of belonging to the classroom refers to an individual's perception of the extent to which they feel supported, accepted, respected, and included within the classroom (Goodenow, 1993). It encompasses students' perception of their social status in the classroom as well as their emotional connection to it (Allen et al., 2016). The sense of belonging is strongly influenced by individual characteristics, including personality, experiences, culture, identity, and other perceptions (Allen et al., 2021).

A lower sense of belonging is considered a risk factor for both bullying perpetrating and victimization (Hong & Espelage, 2012). Students involved in bullying as victims or perpetrators often perceive diminished sense of belonging to the school, coupled with lower academic adjustment (Kashy-Rosenbaum & Aizenkot, 2020; Pečjak & Pirc, 2017).

Gender

Research findings regarding the role of gender in bullying remain inconsistent. While some studies have found that boys are more likely to engage in physical bullying and girls are more likely to engage in relational bullying (e.g., Dane et al., 2016; Gloppen et al., 2018), others do not report gender differences (Kljakovic & Hunt, 2016). However, more recently, Smith et al. (2019) overviewed five large cross-national data bases, and suggested that boys are more likely to be perpetrators than girls and that both genders are about equally at risk of being victimized. Researchers commonly explain differences in gender with different gender socialization and expectations for each gender (Felix & Green, 2010) and with theories of greater empathy in girls (Topcu & Erdur-Baker, 2012).

Contextual Factors

Peer Relationships

Adolescence represents a developmental period in which primary family takes on a less important role and peers become the most influential in shaping adolescents' behavior and values (Tajfel & Turner, 1979). Thornberg et al. (2017) found that positive and supportive relationships among students are associated with lower prevalence of bullying perpetration and victimization and Bollmer et al. (2005) reported that supportive relationships among peers can serve as buffers against victimization. On the other hand, students who are frequently victimized report lower quality of peer relationships and lower perceived acceptance and support in peer relationships (Perren and Hornung, 2005). Given the central role of peer dynamics in bullying processes, some authors emphasize that effective prevention requires interventions aimed specifically at improving the quality of peer relationships (e.g., Dietrich & Cohen, 2021).

Teacher–Student Relationships

Teacher–student relationships are foundational to students' academic, social, and emotional development. Conceptually, teacher–student relationships are typically described along two dimensions: closeness, reflecting warmth, open communication, and support, and conflict, reflecting distrust, coercion, and emotional distance (Pianta & Nimetz, 1991).

Recent evidence further emphasizes that teachers' positive perceptions of students foster supportive teacher–student relationships and are associated with a lower risk of bullying victimization. In contrast, negative perceptions were linked to conflictual teacher–student relationships and an increased likelihood of student victimization (Longobardi et al., 2023).

In contemporary developmental theory, teachers are increasingly understood as attachment figures, providing a secure base and emotional support that influence students' socio-emotional and academic adjustment across all school levels (Fabris et al., 2022). Teacher-student relationships marked by warmth, closeness, and mutual respect are consistently associated with favorable developmental outcomes and smoother adjustment to the school environment (Lin et al., 2024; Roorda et al., 2011, 2017;). Students who enjoy supportive teacher–student relationships tend to exhibit lower levels of oppositional behavior, are less likely to engage in bullying, and achieve higher peer social status, which may protect them from victimization (Bru et al., 2002; Longobardi et al., 2023; Maldonado-Carreño & Votruba-Drzal, 2011).

In contrast, conflictual teacher–student relationships are linked to an increased likelihood of both bullying perpetration and victimization (Huang et al., 2018; Longobardi et al., 2018; Marengo et al., 2021; ten Bokkel et al., 2022). In this way, teacher–student relationships serve as a relational context through which peers evaluate an individual's position within the group, potentially reinforcing inclusion or exclusion patterns.

Purpose of the Current Study

The purpose of this study was to identify the contribution of the selected factors to perpetration and victimization among 4th and 5th-grade students. While most studies focus on students at the peak of bullying, our study targets an often-overlooked age group just before bullying peaks, therefore addressing a critical developmental period (Espelage & Holt, 2013; Volk et al., 2014).

Drawing on previously mentioned findings (e.g. Bollmer et al., 2005; Huang et al., 2018; Smith et al., 2019), we included key classroom-level factors that contribute to bullying and victimization, including peer relationships and teacher–student relationships. By simultaneously examining both closeness and conflict in teacher–student relationships, our approach further explores the nuanced associations between teacher–student relationships and bullying involvement, as recommended by recent studies (ten Bokkel et al., 2022).

In addition, we included students' sense of classroom belonging and gender as individual-level factors. Although all relational variables reflect students' perceptions of their social environment, they were selected based on their distinct theoretical foundations and their relevance to designing classroom-based interventions. Together, these predictors offer a socially embedded perspective on bullying involvement that aligns with socio-ecological theory and reflects the interdependence of individual adjustment and relational dynamics in the classroom (Hong & Espelage, 2012; Roorda et al., 2011; Wang & Degol, 2016).

Based on previous research, we hypothesized the model presented in Figure 1, in which peer relationships, teacher–student closeness and teacher–student conflict, sense of belonging to classroom and gender are associated with bullying victimization and perpetration. We hypothesize that:

1. Lower classroom belonging, more conflictual teacher–student relationships, and poorer peer relationships will be associated with higher victimization.

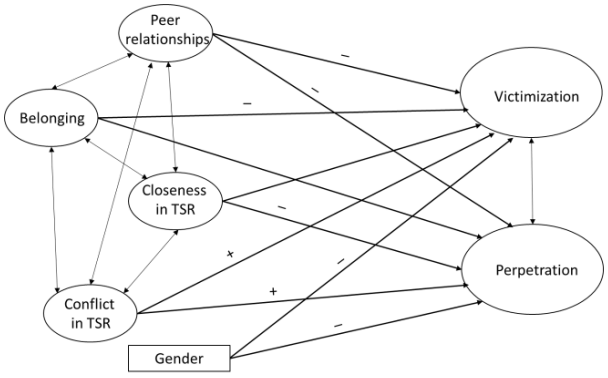
2. Lower teacher–student closeness, higher teacher–student conflict, and poor peer relationships will predict higher perpetration.

3. Girls will report less victimization and perpetration.

The outcomes of this study will enhance the understanding of the interrelationships among the studied variables and provide another perspective for developing practical implications aimed at preventing bullying in classroom settings. The age group of students included in our research is of particular interest to researchers and practitioners because bullying prevention programs tend to show greater efficacy up to the 7th grade (Yeager et al., 2015).

Figure 1

The Tested Model for Relationship Between Studied Variables and Bullying Perpetration and Victimization



Note. TSR – Teacher-Student Relationships

Method

Research Design

This study employed a cross-sectional quantitative research design, aimed at examining the associations between individual and classroom-level relational factors and students' involvement in bullying. Given the nested structure of the data (students within classrooms), the study used multilevel structural equation modeling (SEM) to simultaneously estimate measurement and structural parameters while appropriately accounting for clustering. The design is correlational in nature and does not allow for causal inferences, but it enables a comprehensive analysis of the predictive interplay between peer relationships, teacher–student relationships, classroom belonging, gender, and bullying perpetration and victimization.

Participants

Our sample comprised 1,303 4th- and 5th-grade students[1], with 674 (51.7%) of them being girls. The mean age of participants was 9.91 years (min = 9, max = 12). Of the total sample, 527 (40.5%) students attended 4th grade and 776 (59.5%) attended 5th grade. Participants were drawn from 26 public primary schools located in urban, suburban, and rural areas, representing all Slovenian regions except one, as no school from this region agreed to participate. All participating schools followed the national curriculum, and participation was voluntary for both schools and students. The final dataset included 80 classrooms, with an average of 16 students per classroom completing the survey. No cases were excluded due to missing responses, as the online survey required completion of all items. Altogether, the sample is considered broadly representative of Slovenian primary school students in this age group.

Instruments

To assess bullying, two scales from the School Bullying Scale (Cheng et al., 2011; Jaklin & Pečjak, 2013, as cited in Jaklin, 2013) were employed. One scale measured the frequency of experiencing bullying – Victimization (15 items, e.g. "In the last school year, someone intentionally damaged or destroyed my belongings."), while the other measured the frequency of perpetrating such behavior - Perpetration (14 items). An additional item addressing severe forms of bullying, such as physical aggression, was included in the Perpetration scale, since a similar item was in the original version of the Victimization scale.

Participants responded on a 6-point scale: 0 (never), 1 (once or twice), 2 (two to three times a month), 3 (once a week), 4 (several times a week), and 5 (every day). In the Slovenian sample, the victimization scale exhibited a Cronbach's α of 0.86, and the perpetration scale demonstrated an α of 0.88 (Jaklin, 2013). From the Perpetration scale, we omitted 5 items related to cyberbullying, coercion and destroying friendships due to low factor loadings and high modification indexes. We also permitted the covariances between the residuals of three pairs of content related items. A one-factor latent structure was confirmed with robust fit indicators (CFI = 0.965, TLI = 0.951, RMSEA = 0.059, SRMR = 0.038). We omitted 4 items from the Victimization scale (considering cyberbullying and speaking badly about someone in front of others) and permitted the covariance between the residuals of one pair of contentrelated items. The robust indicators (CFI = 0.968, TLI = 0.958, RMSEA = 0.056, SRMR = 0.033) suggested a good fit.

The Sense of Belonging at School scale (OECD, 2019) was administered, comprising six items designed to assess students' sense of belonging to their class. Students responded to items on a 5-point Likert scale, ranging from 0 (strongly disagree) to 4 (strongly agree), with a higher score indicating a stronger sense of class belonging. The scale's 6 items were adapted for better comprehension by the participants' age group (e.g., "I feel like my classmates like me."). In the acquired data, a one-factor latent structure of the scale (Belonging) was confirmed, allowing for covariance between the residuals of two content related items. The robust fit indicators (CFI = 0.989, TLI = 0.979, RMSEA = 0.059, SRMR =

0.020) suggested overall good fit. The reliability of the scale for our sample was $\alpha = 0.86$.

To assess peer relationships, we applied the Delaware School Climate Survey–Teacher/Staff (Bear et al., 2014; Slovenian adaptation by Roczen et al., 2020), which is a scale that originally measures teachers' perceptions of students' relationships within their respective classrooms. The original and Slovenian-adapted versions demonstrate robust internal reliability (α = 0.83–0.92, Bear et al., 2014; $\alpha = 0.94$, Roczen et al., 2020, respectively). To align with the study objectives, we prepared a parallel version of the scale tailored for students' responses, utilizing a 5-point Likert scale (ranging from 1 - strongly disagree to 5 - strongly agree). Our scale comprised of 8 items (e.g., "Students care about each other."). Confirmatory factor analysis in our sample confirmed a one-factor latent structure – peer relationships. The robust fit indicators (CFI = 0.977, TLI = 0.967, RMSEA = 0.059, SRMR = 0.024) suggested an overall satisfactory fit.

Two scales from the Inclusive Classroom Climate Questionnaire (Fischer et al., 2017; OECD, 2019) were utilized to assess perceived Closeness and Conflict in teacher–student relationships. Translated and adapted within the Slovenian project "Hand in Hand – Social and Emotional Skills for Tolerant and Non-discriminative Societies" (Roczen et al., 2020), the scales exhibited good reliability, with $\alpha = 0.87$ for the scale measuring Closeness in teacher–student relationships and $\alpha = 0.77$ for the scale measuring Conflict in teacher–student relationships (Roczen et al., 2020). Closeness in teacher–student relationships Scale included 8 items (e.g., "I can trust my teacher."), and the Conflict in teacher–student relationships Scale included 7 items (e.g., "The teacher humiliated me in front of other students."). Both scales were originally assessed on a 4-point scale. To maintain consistency and offer a neutral option, we transformed both scales into 5-point scales (ranging from 1 - not at all true to 5 - completely true). Instructions for both scales were adjusted to focus on the relationship with the homeroom teacher in the current school year. Additionally, age-appropriate modifications were made to the items, and an item ("When I'm in trouble or distress, I ask the teacher for help.") was added to the Closeness in teacher–student relationships Scale, since actively seeking help from a teacher is also an indicator of closeness in teacher–student relationships. Confirmatory factor analysis confirmed a one-factor structure for both scales. For the Closeness in teacher–student relationships Scale robust fit indicators (CFI = 0.966, TLI = 0.955, RMSEA = 0.063, SRMR = 0.034) suggested overall good fit. After we omitted one item from the Conflict in teacher–student relationships Scale due to low factor loading and a high modification index, the robust indicators (CFI = 0.966, TLI = 0.953, RMSEA = 0.070, SRMR = 0.035) supported a good fit.

Complete factor loadings for all questionnaire items used in this study are reported in Appendix A (Table 3).

Data Collection

After obtaining ethical approval, we began collecting data. Invitations for research participation were extended via email to primary school staff who had previously provided consent to collaborating institute to receive information about research activities.

In these emails, schools were briefed about the research, and those expressing interest were further invited to an online meeting. During this meeting, the data collection process was explained in detail. Following this session, detailed instructions, parental consent forms, instructions for students, the web link to the online survey, and a recording of the online meeting were provided to school counselling services.

Subsequently, school counselling services and homeroom teachers secured parental consent for student participation. Online questionnaires were then administered to 4th and 5th-grade students. Prior to commencement, students were briefed on the data collection purpose, with age-appropriate information. They were assured of the voluntary nature of participation and the confidentiality of their responses.

To maintain consistency, researchers crafted instructions for students, ensuring uniform information dissemination. The initial section of the online questionnaire captured demographic details before students proceeded to complete the survey, which included five psychometric instruments described in detail in the Measures section. Students could not skip items in the digital survey interface; thus, no item-level missing data were recorded. However, data on partial completions and drop-outs were not collected, which limits our ability to assess full participation rates and possible attrition bias.

Data Analysis

Statistical analyses were executed using SPSS 28.0 IBM for descriptive statistics, reliability analyses and calculating intraclass correlation coefficients (ICCs), the R lavaan package (Rosseel, 2012) for confirmatory factor analyses and Mplus Version 8.10 (Muthén & Muthén, 2017) for Structural equation modeling.

To account for the nested structure of the data (students within classrooms), we employed a multilevel modeling approach using the TYPE = COMPLEX option in Mplus. This method adjusts for the non-independence of observations within classrooms by correcting the standard errors for clustering (Muthén & Muthén, 2017). Individual-level (Level 1) included all the measured variables (gender, sense of belonging,

peer relationships, closeness in teacher–student relationships, conflict in teacher–student relationships, victimization, perpetration), while the classroom variable served as the clustering factor (Level 2), allowing us to account for between-classroom variability in the analysis. This approach ensures robust estimates and appropriate statistical inferences. The MLR estimator was used since some of the constructs were non-normally distributed (Muthén & Muthén, 2017). Factor loadings and reliabilities are presented in Table 3.

The intraclass correlation coefficient (ICC) was calculated to evaluate the proportion of variance in student scores attributable to differences between classrooms, indicating the extent to which classroom-level factors influenced student outcomes.

Results

We first present descriptive statistics (Table 1) and correlations among the investigated variables (Table 2) and then proceed to the results of structural equation modelling for bullying perpetration and victimization.

Table 1

Descriptive Statistics, Reliability Indices, and ICCs for Study Variables

	M	SD	Mdn	min	max	Skew.	Kurt.	α	ICC
Victimization	1.79	0.78	1.54	1.00	5.73	1.60	2.78	0.89	0.07
Perpetration	1.33	0.47	1.20	1.00	4.60	2.66	9.21	0.86	0.06
Belonging	4.08	0.80	4.33	1.00	5.00	–1.11	0.87	0.86	0.02
PR	3.48	0.66	3.50	1.00	5.00	–0.25	0.20	0.83	0.15
Closeness in TSR	4.18	0.72	4.33	1.00	5.00	–1.32	2.03	0.84	0.09
Conflict in TSR	1.59	0.68	1.50	1.00	5.00	1.96	5.11	0.71	0.07

Note. N = 1303; PR – Peer Relationships; TSR - Teacher–Student Relationships; ICC - intraclass correlation coefficients.

Overall, our scales exhibit good reliability. The mean scores of Victimization and Perpetration scale show that students on average perceive that they are being bullied more often than they are perpetrating bullying. To an average student, bullying situations occur two to three times a month. Students on average have a high sense of belonging to classroom, perceive highly positive relationships with homeroom teachers, rarely report conflict in the mentioned relationship and have predominantly supportive peer relationships. To assess the extent of variability attributed to differences between classrooms, we calculated the intraclass correlation coefficients (ICCs). The highest ICC was found for peer relationships, indicating that approximately 15% of the total variance in student scores can be attributed to differences between classrooms. The lowest ICC was found for Belonging scale.

Table 2

Spearman's Rho Correlation Coefficients Between the Studied Variables

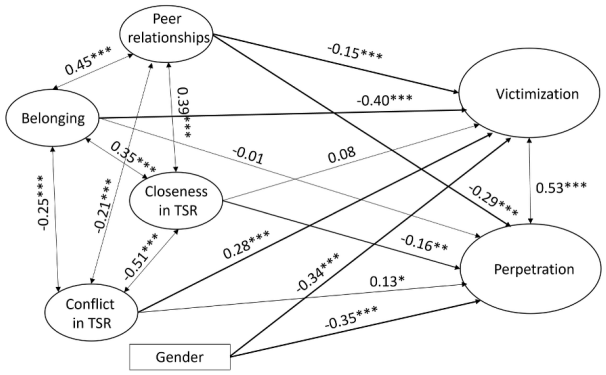
	1.	2.	3.	4.	5.	6.
1. Victimization	1.00					
2. Perpetration	.57**	1.00				
3. Belonging	–.43**	–.22**	1.00			
4. PR	–.40**	–.34**	.46**	1.00		
5. Closeness in TSR	–.26**	–.29**	.34**	.31**	1.00	
6. Conflict in TSR	.35**	.27**	–.26**	–.20**	–.36**	1.00

Note. **p < 0.01; PR – Peer Relationships; TSR - Teacher–Student Relationships

The correlations among the studied variables (Table 2) show a clear pattern linking classroom relationships with students' involvement in bullying. Both victimization and perpetration were negatively associated with classroom belonging, peer relationships, and perceived closeness in teacher–student relationships. This means that students who feel less accepted in the classroom or perceive lower-quality relationships with peers and teachers tend to report more frequent involvement in bullying. In contrast, conflict in teacher–student relationships showed positive associations with both outcomes, suggesting that negative interactions with teachers may relate to more problematic peer interactions. The correlation between victimization and perpetration was moderate, indicating that the two experiences often occur together but represent distinct forms of involvement. The correlations between the studied variables were computed using the Spearman's rho coefficient since the variables were not normally distributed. The correlations between constructs were small to moderate, suggesting the necessity of examining constructs individually and indicating that multicollinearity is not a concern.

Figure 2

The Resulting Structural Equation Model for Relationships Between Studied Variables and Bullying Perpetration and Victimization.



Note. TSR – Teacher–Student Relationships; ***p < 0.001; **p < 0.01; *p < 0.05

Figure 2 shows the relationships among the variables included in the Structural Equation Model (SEM). Standardized path coefficients are shown for all paths. The fit indices ($\chi^2(1154) = 2756.72$, $p < 0.001$, CFI = 0.912, TLI = 0.907, RMSEA = 0.033, SRMR = 0.050) suggest an overall good fit to the data and suggest that the model provides an adequate representation of the underlying data structure. Victimization was most strongly predicted by lower classroom belonging, less positive peer relationships, and higher teacher–student conflict. For perpetration, the strongest predictors were poorer peer relationships and lower perceived closeness with the teacher, while teacher–student conflict made a smaller but still significant contribution. In addition, girls reported lower levels of involvement in both forms of bullying. Taken together, the model highlights the importance of classroom relationships for understanding both the risk and protective factors linked to bullying involvement in late childhood.

Discussion

Bullying remains a pervasive and serious issue affecting schools globally, with well-documented negative consequences for students' psychological and social well-being (Pečjak et al., 2021). This study investigated how individual and contextual factors—specifically peer relationships, teacher–student relationships, classroom belonging, and gender—relate to bullying perpetration and victimization among 4th- and 5th-grade students. While a moderate and significant correlation between victimization and perpetration was observed—consistent with prior research showing their frequent co-occurrence (Chan & Wong, 2015; Karataş et al., 2016; Kloo et al., 2023; Košir et al., 2023)—our results also indicate that these two forms of bullying involvement have both shared and distinct predictors. This finding supports Walters' (2021) meta-analytic conclusion that the relationship between bullying perpetration and victimization is both reciprocal and bidirectional. Some students may alternate between roles due to shifting peer hierarchies, while others may respond to past victimization by becoming perpetrators.

Among the predictors, the sense of classroom belonging showed the strongest negative association with bullying victimization. Students who reported feeling excluded, lonely, or socially disconnected—such as having difficulty forming friendships or feeling out of place—were significantly more likely to report experiences of victimization. This aligns with findings from Košir et al. (2023), who showed that social exclusion in the classroom context is often perceived as a direct form of victimization. These results support the notion that emotional inclusion within the peer group serves as a protective function against bullying.

Conflict in teacher–student relationships also emerged as a significant predictor of victimization. Students who experienced more negative interactions with their teachers—such as being treated unfairly, criticized, or humiliated—were more likely to victimized by peers. This is consistent with the findings of ten Bokkel et al. (2022), and it highlights how teacher behavior can shape peer dynamics by modeling either inclusive or exclusionary norms. Particularly in this age group, where teacher approval holds strong social weight, students may become marginalized when they are frequently in conflict with their teacher.

Interestingly, teacher–student relationships closeness was not significantly associated with victimization. This is difficult to interpret due to the scarcity of research on this specific relationship, especially in younger age groups. One explanation may be a ceiling effect: as younger students generally perceive their relationships with teachers positively (Fauth et al., 2014), the variation in teacher–student relationships closeness may have been too small to detect effects. Additionally, studies with non-significant results may be underrepresented due to publication bias (Ferguson & Heene, 2012).

Our results also showed that less favorable peer relationships were significantly associated with higher levels of victimization. Students who perceived their classmates as unkind, unsupportive, or indifferent—and who reported lower levels of mutual care, help, and respect—were more likely to report being bullied. These findings are consistent with previous studies emphasizing that supportive peer dynamics act as a buffer against victimization (Thornberg et al., 2017; Wang et al., 2021).

The results reinforce the idea that victimization is not only a function of individual vulnerability, but also a relational and environmental phenomenon, shaped by the quality of interactions in the peer group. When students feel disconnected from their peers or excluded from positive group norms, their risk of being victimized increases. From a theoretical standpoint, this supports socio-ecological models that place classroom climate at the core of classroom bullying dynamics.

Regarding bullying perpetration, students who perceived lower-quality peer relationships—marked by a lack of kindness, mutual respect, and social inclusion—were more likely to report engaging in bullying behaviors. These findings are in line with previous research showing that negative peer relationships contribute not only to victimization but also to aggressive behaviors within the group (Stefanek et al., 2011; Thornberg et al., 2017). In classrooms where exclusion, disrespect, or social instability are perceived as common, such behaviors may become normalized, increasing the likelihood of bullying.

A key difference from victimization is that closeness in teacher–student relationships emerged as a significant negative predictor of perpetration. Students who perceived their teacher as warm, trustworthy, and supportive were less likely to engage in bullying. This supports findings that a secure and affirming teacher relationship may act as a protective factor by promoting prosocial norms, self-regulation, and empathy (Kloo et al., 2023; Lee et al., 2021).

Furthermore, conflictual teacher–student relationships were also positively associated with perpetration. Students who perceived more antagonism, unfair treatment, or disrespect from their teacher were more likely to report bullying others. This aligns with ten Bokkel et al.'s (2022) meta-analysis, which found stronger associations between teacher–student conflict and bullying than between teacher–student closeness and bullying. However, in our model, conflict in teacher–student relationships was the weakest significant predictor of perpetration, suggesting variability in the strength of this association across contexts. These findings emphasize that both the presence of teacher support and the absence of teacher hostility are important in reducing bullying behavior.

Contrary to our expectations, sense of classroom belonging was not significantly associated with bullying perpetration. While belonging emerged as a key protective factor for victimization, it did not appear to influence whether students reported engaging in bullying behavior. One possible explanation is that some students who perpetrate bullying may still feel socially included or even supported by peers, particularly if their behavior serves to reinforce dominance or social status within the group. As suggested by Álvarez-García et al. (2015), classmates may tolerate or align with bullies to avoid becoming targets themselves, which can allow perpetrators to maintain a sense of belonging despite violating group norms.

We also found that female students were less likely to be involved in bullying, both as victims and perpetrators. While this is consistent with studies showing lower rates of overt bullying among girls, findings in the literature remain mixed and may depend on the type of bullying assessed (e.g., physical vs. relational), the measurement method, and developmental stage (Smith et al., 2019). One possible explanation relates to the distribution of bullying items included in the measurement instruments. Although the scales captured a broad range of behaviors, they contained proportionally more items reflecting physical and verbal bullying than relational or covert forms. Previous research has shown that girls are typically less involved in physical aggression but may engage more frequently in relational forms such as social exclusion or spreading rumors (Dane et al., 2016; Gloppen et al., 2018). Consequently, when measurement instruments emphasize overt behaviors, gender differences may appear more pronounced, potentially underestimating girls' involvement in relational bullying. This interpretation aligns with meta-analytic findings suggesting that observed gender patterns partly depend on the types of bullying behaviors assessed and the sensitivity of the measurement tools to more subtle or indirect forms of aggression (Kljakovic & Hunt, 2016). Nonetheless, gender remains an important variable in understanding the dynamics of school bullying. This finding also has implications for intervention design. A meta-analysis by Kennedy (2020) showed that bullying prevention programs tend to be more effective for boys, particularly in reducing victimization. In contrast, the limited impact of such interventions on girls suggests that current approaches may overlook gender-specific mechanisms of peer aggression and victimization. Our findings support the call for more differentiated, gender-responsive strategies in bullying prevention that consider how bullying manifests and is experienced differently across genders.

Limitations and Future Directions

Despite the strengths of this study—such as a large and diverse sample of primary school students—several limitations should be acknowledged. First, approximately half of the participating schools were implementing anti-bullying activities or prevention programs at the time of data collection. However, we did not gather information about which specific classrooms were involved in these programs. This limits our ability to account for potential intervention effects, which could have influenced rates of bullying involvement.

Furthermore, school participation was voluntary, and it is possible that schools with stronger interest in social-emotional learning or classroom relationships were more inclined to participate, potentially introducing a self-selection bias.

Another limitation is that we did not collect information on partial survey completions or student dropouts during data collection. As already noted in the Method section, the online survey required students to respond to all items, which ensured that completed questionnaires contained no missing data. However, because we did not record how many students started but did not finish the survey, we cannot determine overall participation rates or assess whether non-completion may have introduced any bias into the final sample.

Second, while our model included several theoretically grounded individual and classroom-level predictors, it did not address influences from other ecological

layers, such as family dynamics, school-wide norms, or neighborhood/community contexts (Espelage & Swearer, 2009). Future research should explore multi-level models that account for these broader systems and examine possible cross-context interactions (e.g., does parenting style moderate the effect of teacher–student conflict).

Third, although we treated the predictors as independent influences on bullying behavior, it is plausible that bullying involvement may itself shape social relationships, including teacher–student relationships and peer relationships. Prior studies suggest that students involved in bullying may elicit more negative responses from teachers (Demol et al., 2020). This bidirectional dynamic was not captured in our model and should be addressed in longitudinal or cross-lagged designs.

Finally, all variables were assessed through student self-report, which introduces the possibility of shared method variance. Although students' subjective experiences are highly relevant when studying peer and teacher relationships, relying on a single source may inflate correlations among constructs (ten Bokkel et al., 2022). Future research should consider incorporating multi-informant approaches (e.g., teacher or peer nominations) or observational methods.

Educational Implications

Despite its limitations, this study offers several valuable insights for school psychologists and educators aiming to reduce bullying in classrooms. First, the findings underscore the importance of fostering supportive peer relationships and close, respectful teacher–student relationships, both of which were associated with lower levels of bullying involvement. These relational dimensions are modifiable within school settings and should be targeted through universal prevention programs as well as teacher training. Given the central role of teachers in shaping classroom norms and climate, equipping them with strategies to build trust, show warmth, and promote fairness is essential (Marsh et al., 2023).

Specifically, since lower teacher–student closeness was associated with more frequent perpetration, even small, everyday teacher behaviors can make a meaningful difference. For example, research by Cook et al. (2018) shows that simple gestures—such as warmly greeting students at the classroom door—can foster inclusion and strengthen relational bonds. Teachers might also enhance connections by showing personal interest in students' lives, listening actively, and providing consistent emotional support. Importantly, these relational investments may not only improve behavior but also increase students' sense of belonging, which our findings identify as a key protective factor against victimization.

Furthermore, it is crucial that teachers avoid behaviors that could contribute to student alienation, such as inconsistent discipline or public criticism, which may indirectly encourage bullying or social exclusion. As our findings show, the absence of conflictual interactions is just as important as the presence of closeness in teacher–student relationships.

However, creating a safe and inclusive classroom climate is not the responsibility of teachers alone. School leadership plays a pivotal role in supporting these efforts. As highlighted by O'Keeffe (2013), school administrators can enhance students' sense of belonging by promoting a school culture where emotional safety is prioritized alongside academic goals. Our findings reinforce the need for school-wide approaches that involve collaboration between teachers, psychologists, counselors, and leadership to foster safe classroom environments.

In summary, this study shows that bullying prevention efforts should not only address individual behavior, but also focus on the relational ecosystems in which bullying emerges. Particularly in middle childhood, both positive peer relationships and healthy teacher–student dynamics play critical roles in protecting students from bullying and reducing its occurrence. Addressing both protective and risk factors may lead to more comprehensive and developmentally appropriate prevention strategies.

Footnotes

[1]Slovenian primary school education follows a three-tier system, each lasting three years. During the initial three-year period, in the 4th and in the 5th grades, a single teacher typically instructs most subjects within a designated classroom. In contrast, from the 6th to the 9th grade, students encounter various teachers, each specializing in a specific subject. During the final four years of primary education, students transition between classrooms for each distinct subject.

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Appendix A

Table 3.

Standardized Factor Loadings and Reliabilities

Latent variable	Observed Variable	Standardized Factor Loading	α
Peer Relationships (PR)	PR1	0.767	0.83
	PR2	0.461	
	PR3	0.804	
	PR4	0.710	
	PR5	0.727	
	PR6	0.747	
	PR7	0.169	
	PR8	0.683	
Sense of Belonging (SoB)	SoB1	0.753	0.86
	SoB2	0.737	
	SoB3	0.653	
	SoB4	0.743	
	SoB5	0.622	
	SoB6	0.797	
Closeness in Teacher-Student Relationships (TSR)	TSR1	0.349	0.84
	TSR2	0.638	
	TSR3	0.718	
	TSR4	0.755	
	TSR5	0.473	
	TSR6	0.632	
	TSR7	0.791	
	TSR8	0.744	
	TSR9	0.583	
Conflict in Teacher-Student Relationships (CTSR)	CTSR1	0.276	0.71
	CTSR2	0.735	
	CTSR3	0.658	
	CTSR4	0.728	
	CTSR5	0.650	
Victimization (VIC)	VIC1	0.659	0.89
	VIC2	0.684	
	VIC3	0.623	
	VIC4	0.572	
	VIC5	0.654	
	VIC6	0.530	
	VIC7	0.751	
	VIC8	0.655	
	VIC9	0.719	
	VIC10	0.653	
	VIC11	0.689	
Perpetration (PER)	PER1	0.714	0.86
	PER2	0.538	
	PER3	0.628	
	PER4	0.730	
	PER5	0.554	
	PER6	0.660	
	PER7	0.632	
	PER8	0.406	
	PER9	0.710	
	PER10	0.559	

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Leveraging Storytelling to Foster Early Childhood Cultural Recognition and Identity: A Case Study of Minangkabau Heritage

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Abstract

This study investigated the effectiveness of storytelling as a method for enhancing early childhood recognition of Minangkabau cultural heritage and fostering cultural identity. Employing a mixed-methods action research design, this research bridges a gap in the literature by integrating quantitative measures of cultural recognition with qualitative insights into identity formation. The study involved ten kindergarten children aged 5–6 years in Bukittinggi City, West Sumatra, Indonesia. Data were collected over two cycles, combining pre- and post-intervention cultural recognition assessments with qualitative observations, semi-structured interviews, and documentation. Quantitative findings revealed substantial improvements in children's cultural recognition scores (from 56.25% to 82.16%), while qualitative evidence highlighted increased engagement, expressions of pride, and stronger connections to identity. Children frequently referenced cultural landmarks, recreated stories through drawings and role-play, and shared narratives with family members, demonstrating the transmission of heritage beyond the classroom. Key factors enhancing effectiveness included interactive storytelling, visual aids, peer collaboration, and parental reinforcement. By integrating numeric gains with rich narrative accounts, the study demonstrates how storytelling simultaneously strengthens cognitive recognition and affective cultural identity in early learners. The findings align with literature on storytelling's developmental benefits while extending understanding of its role in cultural preservation through a dual-focus framework. This research offers practical insights for educators and contributes to broader discussions on culturally responsive pedagogy and heritage sustainability in early childhood education.

Keywords:

Cultural Understanding; Storytelling Pedagogy; Minangkabau Culture; Cultural Identity Development; Parental Involvement

Introduction

In today's globalized world, preserving cultural heritage has become a pressing challenge as communities navigate the tension between modernization and the maintenance of unique identities. Education, particularly in early

childhood, serves as a vital arena for transmitting cultural knowledge, values, and practices. Scholars highlight that early childhood education (ECE) represents the "golden age" of learning, during which children's cognitive, linguistic, social, and emotional foundations are formed (Alhosani, 2022; Allison-Burbank et al., 2023; Damjanovic & Harrison, 2023). Within this developmental window, culturally responsive pedagogies can instill a sense of belonging and identity while supporting overall growth (Fleer, 2021; Iruka et al., 2023; Yücesan et al., 2023).

For the Minangkabau community of West Sumatra, Indonesia, storytelling—an intergenerational oral tradition—offers a culturally embedded pedagogical tool for transmitting heritage. Previous research confirms storytelling's benefits for language development, imagination, and critical thinking (Moeslichatoen, 2004; Shin & Collins, 2024), and emerging studies indicate its potential for fostering cultural literacy (Gayatri et al., 2023; Yetti et al., 2017). However, most of these studies remain either purely qualitative, exploring narrative experiences, or quantitative, focusing on test scores, without integrating both perspectives. As a result, the complex ways in which storytelling fosters cultural recognition, pride, and identity in early learners remain underexplored.

This study is conceptually grounded in Sociocultural theory (Vygotsky, 1978) and Narrative Identity theory (McAdams, 2001). Sociocultural theory posits that learning and identity are constructed through social interaction and culturally mediated tools, with storytelling as a prime example. Narrative Identity theory suggests that individuals form their sense of self through the stories they internalize and tell. Integrating these frameworks provides a lens to understand how storytelling functions not merely as an information-transfer method but as a participatory, meaning-making activity that scaffolds cognitive understanding (cultural recognition) while co-constructing personal and cultural identity.

The Minangkabau context provides a particularly compelling case. Despite the richness of its oral traditions, art, and social systems, younger generations face diminishing exposure to these cultural resources (Darwis & Muslim, 2024). While some studies advocate embedding local wisdom in school curricula (Arsih et al., 2021; Mulyani et al., 2024), few have addressed how storytelling impacts children's learning and identity formation explicitly during the earliest stages of education. This creates a critical need for empirical work that captures both measurable learning outcomes and the nuanced experiences of children, families, and educators. Consequently, a significant gap exists in understanding the integrated mechanisms through which storytelling influences early learners. While qualitative studies illuminate narrative experiences and quantitative studies measure knowledge gains, there is a paucity of research that systematically connects measurable improvements in cultural recognition with the nuanced, affective processes of identity and pride formation within a single, culturally specific intervention. This study responds to this gap by employing a mixed-methods action research design to provide a holistic account of storytelling's dual impact on the cognitive and socio-emotional dimensions of cultural learning.

Accordingly, this research pursues three aims: (1) to examine the effectiveness of storytelling in improving children's understanding of Minangkabau cultural history; (2) to explore how storytelling fosters cultural pride and identity in early learners; and (3) to identify key pedagogical factors that enhance storytelling's impact in ECE. The study addresses the following questions:

1. How does storytelling influence young children's recognition and understanding of Minangkabau cultural heritage?
2. In what ways does storytelling contribute to fostering cultural pride and identity in early learners?
3. What key factors enhance the effectiveness of storytelling as a pedagogical tool in early childhood education?

By situating storytelling within a mixed-methods framework, this study aims not only to enrich theoretical discussions on culturally responsive pedagogy but also to provide practical guidance for educators and policymakers seeking to preserve cultural heritage through innovative early education practices.

Methods

Research Design

This study employed a mixed-methods action research approach to holistically investigate the process and outcomes of storytelling in introducing Minangkabau cultural history to children aged 5–6 years. Action research was chosen as it allows educators to systematically investigate and improve pedagogical practices within their own classroom context (Wijaya, 2001), following the cyclical Kemmis and McTaggart model of planning, action/observation, and reflection (Kusumah & Dwitagama, 2001).

A convergent mixed-methods design (Creswell & Plano Clark, 2018) was embedded within this action research framework. This approach was selected to capture both the measurable learning outcomes (through quantitative pre/post recognition scores) and the rich, experiential dimensions of cultural learning (through qualitative observations, interviews, and documentation). As visualized in Figure 1, the iterative

cycles of action research provided the structure for concurrently collecting, analyzing, and integrating both data strands.

Data Integration Strategy: The quantitative (QUAN) and qualitative (QUAL) data were analyzed separately and then integrated during the interpretation phase to provide a comprehensive understanding of the intervention's impact. Integration was operationalized in three primary ways:

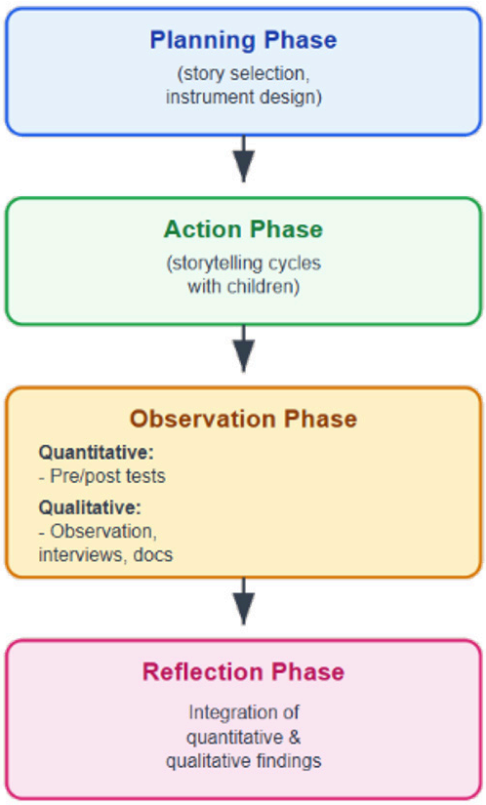
1. Triangulation: Using QUAL observations to explain how QUAN score improvements manifested in children's classroom behavior and interactions.

2. Complementarity: Using QUAL data (e.g., interview excerpts, children's drawings) to elaborate on, illustrate, and give voice to the statistical trends observed in the QUAN results.

3. Development: Insights from Cycle I QUAL data (e.g., noting low engagement with certain stories) directly informed pedagogical refinements to the intervention in Cycle II, the effects of which were subsequently measured by QUAN means.

This integrated strategy ensured that the findings were not merely parallel accounts but were synthesized to offer a deeper, more nuanced explanation of how storytelling influences both cognitive recognition and socio-emotional identity formation.

Figure 1.
Mixed-methods action research design



Participants

The study was conducted in a kindergarten located in Bukittinggi City, West Sumatra, Indonesia. The participants were children enrolled in Group B, consisting of 10 students aged 5-6 years. This age group was selected because they are at a critical developmental stage in which they begin to recognize and learn about their cultural heritage (Hildayani, 2018). The sampling technique employed was purposive sampling, as the researchers specifically targeted a kindergarten group that would benefit from an intervention focused on Minangkabau cultural history. Parental consent was obtained for all participating children prior to the study (Hartati, 2007). The demographic characteristics of the participants are presented in Table 1, which includes details such as age, gender, ethnicity, socioeconomic status, and prior exposure to Minangkabau culture, providing a contextual understanding of the sample.

Table 1.
The demographic characteristics of the participants

Participant	Age	Gender	Ethnicity	Socioeconomic Status	Prior Exposure to Minangkabau Culture
AC	5	Female	Minangkabau	Middle class	Moderate exposure through family
AL	5	Female	Minangkabau	Upper-middle class	High exposure through community events
AN	6	Male	Minangkabau	Lower-middle class	Low exposure
BB	5	Female	Javanese	Lower class	Minimal exposure
KN	6	Male	Minangkabau	Upper class	High exposure through formal education
RC	6	Female	Minangkabau	Middle class	Moderate exposure to media
FG	5	Male	Minangkabau	Lower-middle class	Low exposure
HH	6	Female	Minangkabau	Upper-middle class	High exposure through family traditions
TN	5	Male	Minangkabau	Middle class	Moderate exposure through the community
ZC	6	Female	Minangkabau	Upper class	High exposure through cultural immersion

The use of a small, purposive sample (n=10) is consistent with the action research paradigm, which prioritizes in-depth, contextual understanding and iterative pedagogical refinement over statistical generalizability (Kemmis & McTaggart, 2000). The sample's demographic diversity (Table 1) ensured the intervention was tested across varying levels of prior cultural exposure and socioeconomic status, enhancing the transferability of insights to similar contexts rather than aiming for broad generalization. Furthermore, the rich, thick qualitative data gathered from each participant compensates for the sample's numerical size, aligning with the study's goal of depth over breadth.

Multiple strategies were further employed to ensure reliability and validity. Triangulation was achieved

by collecting data from diverse sources, including participant observation, semi-structured interviews, and documentation of storytelling sessions. Thematic analysis followed Braun and Clarke's (2006) guidelines, with codes reviewed and validated by independent researchers to minimize bias. Observational field notes were cross-checked with audio recordings to ensure accuracy, while members checked with teachers and parents to confirm the credibility of the interpretations. These measures collectively enhance the robustness of the findings, making them applicable for broader theoretical and practical discussions in culturally responsive education. To align with the mixed-methods design, participants' responses were examined not only through qualitative engagement but also through quantitative cultural recognition scores.

Data Collection

Data were gathered through participant observation, semi-structured interviews, documentation, and a structured cultural recognition assessment. Participant observation enabled the researchers to directly observe the implementation of storytelling activities and the children's responses. Field notes were meticulously recorded to capture behaviors, interactions, and emerging themes (Mardalis, 2004). Semi-structured interviews with teachers and parents provided additional insights into the children's engagement and understanding of the cultural narratives. This method allowed for flexibility in exploring topics while maintaining a focus on the research objectives (Creswell, 2014). Documentation included audio recordings of storytelling sessions and samples of the children's work, such as drawings and role-play notes. These artefacts enriched the dataset and enabled triangulation.

To obtain quantitative data on learning outcomes, a Cultural Recognition Assessment was developed and administered pre- and post-intervention. This structured, picture-based task contained 20 items depicting key Minangkabau cultural elements (e.g., Rumah Gadang, traditional clothing, ceremonial objects) presented in random order. For each image, children were asked to name or describe its cultural significance. Responses were scored using a standardized rubric (0 = no recognition, 1 = partial recognition, 2 = full recognition), yielding a maximum score of 40, which was then converted to a percentage. The instrument's content validity was established through review by three experts in Minangkabau culture and early childhood education. Inter-rater reliability was assessed by having a second researcher independently score 20% of the responses; Cohen's Kappa (Cohen, 1988) was 0.87, indicating strong agreement. All data collection procedures were conducted with the informed consent of participants and in compliance with ethical research practices.

Intervention Design and Implementation

The storytelling intervention was designed according to principles of culturally responsive pedagogy, which emphasize the inclusion of local cultural elements in educational practices (Gayatri et al., 2023; Mulyani et al., 2024). The researchers collaborated with the kindergarten teachers to select Minangkabau folktales that were age-appropriate and culturally significant. Each session involved the teacher narrating a story using visual aids, props, and interactive activities to engage the children and enhance comprehension.

The intervention was implemented over two cycles, following the Kemmis and McTaggart (2000) model of action research, which includes planning, action, observation, and reflection. In the first cycle, the researchers introduced the storytelling sessions and observed the children's initial responses. Based on these observations, adjustments were made to the delivery methods, such as incorporating more repetition and visual aids to reinforce key cultural concepts. The second cycle focused on refining these strategies and measuring the intervention's impact on the children's recognition of Minangkabau cultural heritage.

Data Analysis

The collected data were analyzed using a convergent mixed-methods approach (Creswell & Plano Clark, 2018). Observational and interview data were coded and categorized to identify recurring themes and patterns. Qualitative data were analyzed using thematic analysis following the framework of Braun and Clarke (2006), with an emphasis on examining the children's levels of engagement, comprehension, and displays of cultural pride. Quantitative data, such as pre- and post-intervention scores on cultural recognition tasks, were analyzed descriptively to assess changes in the children's knowledge and understanding. The integration of qualitative and quantitative analyses provided a comprehensive understanding of the intervention's outcomes. This mixed-methods approach ensured that the findings were robust and reflected the complexities of educational interventions in early childhood settings (Creswell & Plano Clark, 2018).

Ethical Considerations

The study adhered to strict ethical guidelines to protect and ensure the well-being of the participating children. Informed consent was obtained from the parents or legal guardians of all children involved in the research. Additionally, the researchers maintained the confidentiality of the participants and obtained permission from the school authorities to conduct the study on the premises. The research plan and data collection procedures were reviewed and approved

by the Institutional Review Board of the researchers' affiliated university to ensure compliance with ethical standards in educational research.

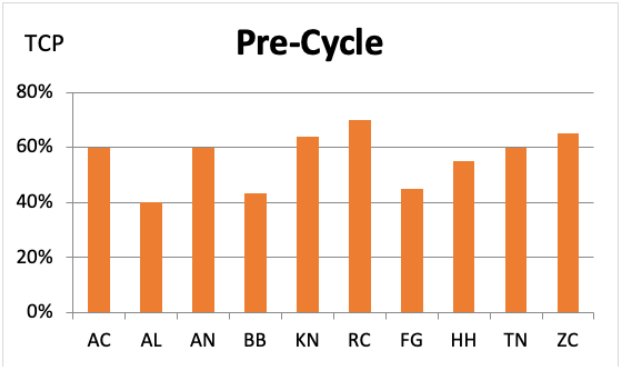
Results

The study aimed to investigate the effectiveness of storytelling methods in enhancing children's recognition and understanding of Minangkabau cultural history. The research was conducted in three phases: a pre-cycle assessment, followed by two intervention cycles. Quantitative findings (cultural recognition scores) are presented alongside qualitative insights (observations, interviews, children's reflections), providing a comprehensive picture of the intervention's impact.

Pre-Cycle Assessment

The initial assessment of the children's ability to recognize the history of Minangkabau culture through storytelling revealed that many participants already had some familiarity with the subject matter. Figure 2 presents the pre-cycle results.

Figure 2.
Pre-cycle Results of the Ability to Recognize Minangkabau Cultural History



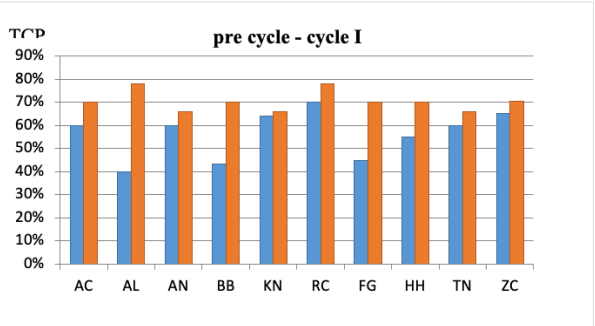
As shown in Figure 2, the majority of the children were either at the "not yet evident" or "beginning to appear" stages in their ability to retell the Minangkabau cultural stories presented by the teacher. Only a few children reached the "frequently appearing" or "consistent" stages. The average pre-intervention score across all participants was M = 56.25% (SD = 10.12), indicating moderate baseline familiarity with substantial room for improvement. The pre-cycle data analysis shows that targeted interventions were necessary to enhance early childhood recognition of Minangkabau cultural history, as only six children scored above the average, with the highest individual score being 70% (achieved by participant RC).

Qualitative observations supported these findings. Several children hesitated when asked to retell story elements, often pausing or asking peers for help. For example, AN remarked, "It's hard to remember the names," highlighting limited prior exposure. Teachers also noted that children often confused Minangkabau landmarks with generic features of their environment.

Cycle I Intervention

Following the pre-cycle assessment, the researchers implemented a stimulation intervention using the Minangkabau storytelling method. The results of this first cycle are presented in Figure 3.

Figure 3.
Graph of the results of the ability to recognize the Minangkabau cultural history



The results after Cycle I, visualized in Figure 3, showed an improvement in the children's recognition ability. The class average score increased to *M* = 70.40% (*SD* = 4.40). However, only 2 out of 10 children (AL and RC) achieved the target score of 75%. A paired-samples t-test comparing pre-intervention scores (*M* = 56.25, SD=10.12) to post-Cycle I scores showed a significant increase, $t(9) = 3.78$, $p < .001$, $d = 1.20$, confirming a large and statistically significant improvement after the first intervention cycle. However, the class had not yet met the overall target.

Qualitative data revealed partial but growing engagement. Children began asking more questions during storytelling, such as ZC's query, "Why do we call it Rumah Gadang?" This indicated emerging curiosity. Teachers observed improved attention when visual aids were introduced, though some participants, such as BB, remained less engaged, often looking around the room rather than focusing on the story. Parents also reported that children mentioned cultural terms at home, but only superficially.

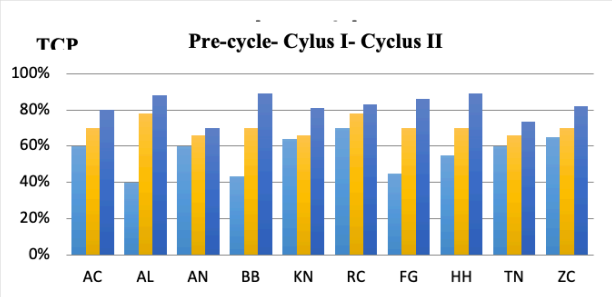
The Cycle I results indicate that there were still areas that needed attention in order to maximize the children's learning outcomes. Therefore, the researchers decided to implement a second cycle to further enhance the children's recognition and understanding of Minangkabau cultural history.

Cycle II Intervention

In the second cycle of the intervention, the researchers addressed the shortcomings identified in Cycle I

and continued to stimulate the children through the Minangkabau storytelling method. The results of Cycle II are presented in Figure 4.

Figure 4.
Graph of the results of improving the ability to recognize Minangkabau cultural history



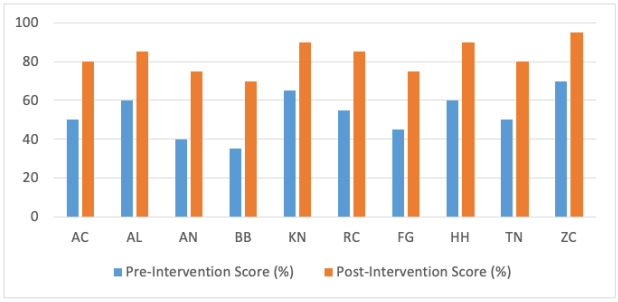
As shown in Figure 4, the Cycle II intervention yielded additional significant gains. The final post-intervention class average was M = 82.16% (*SD* = 6.43), exceeding the target of 70.44%. The improvement from the post-Cycle I score (*M* = 70.40, *SD* = 4.40) to the post-Cycle II score was also statistically significant, t(9) = 6.81, $p < .001$, $d = 2.15$, indicating that the refinements in the second cycle led to substantial additional learning.

Qualitative findings confirmed these gains. Participant AC stated, "The stories helped me imagine the big ceremonies my grandparents talked about," illustrating the connection between narrative and cultural pride. Teachers reported more enthusiastic participation, with children volunteering to retell parts of the story. Parents echoed this change: one noted, "My daughter explained the meaning of the traditional clothes with excitement." These reflections show that by Cycle II, storytelling extended beyond recognition to pride and identity-building. The researchers did not deem it necessary to conduct additional cycles, as the results had met the established criteria for successful implementation.

RQ1: How does storytelling influence young children's recognition and understanding of Minangkabau cultural heritage?

To address RQ1, the effectiveness of the storytelling intervention was evaluated by comparing children's cultural recognition scores before and after the two-cycle program. Figure 5 visually contrasts the pre- and post-intervention scores for each child, illustrating that all ten participants showed individual improvement, with the group average shifting substantially toward higher scores.

Figure 5.
Comparison of pre- and post-intervention cultural recognition scores



The quantitative change was assessed statistically, with the results summarized in Table 2.

Table 2
Paired Samples T-Test Results for Cultural Recognition Scores

Pair	M	SD	t (9)	p	Cohen's d
Pre-Intervention	56.25	10.12			
Post-Intervention	82.16	6.43			
Difference (Post - Pre)	25.91	14.64	5.60	<.001	1.77

Note. N = 10. All scores are percentages. Cohen's d is calculated as the mean difference divided by the standard deviation of the differences.

As shown in Table 2, the paired samples t-test revealed a statistically significant improvement in cultural recognition scores from pre- to post-intervention, with a very large effect size (Cohen's d = 3.89). This quantitative finding aligns with the qualitative evidence, where increased engagement—through repeating cultural terms, pointing at illustrations, and relating stories to family traditions—was observed to underpin these knowledge gains. For example, KN commented, "Now I know why we call our houses so unique," while ZC expressed appreciation for cultural landmarks: "I loved learning about the Rumah Gadang; it looks so special." These examples illustrate how storytelling transformed abstract cultural content into meaningful knowledge.

Qualitative observations support these quantitative findings. Children demonstrated increased engagement and enthusiasm during storytelling sessions, often asking questions about Minangkabau landmarks, traditions, and folktales. Participant ZC remarked, "I loved learning about the Rumah Gadang; it looks so special," highlighting a developing appreciation for cultural symbols. Similarly, KN's response, "Now I know why we call our houses so unique," indicates a deeper understanding.

Participant AC elaborated, "The stories helped me imagine the big ceremonies my grandparents talked about. I can see it now in my head," showing how storytelling bridged the gap between abstract cultural concepts and tangible understanding. The role of

imagination here aligns with theoretical perspectives on storytelling as a cognitive and cultural tool (Fleer, 2021). Conversely, AN initially stated, "It was hard to remember all the names," reflecting the challenges posed by limited prior exposure to cultural references. However, the use of visual aids and repetition helped overcome this difficulty, suggesting that scaffolding techniques are critical in storytelling interventions.

From observational data, children frequently pointed at illustrations during the sessions, actively engaging by repeating the names of Minangkabau landmarks. One teacher noted, "The children's focus improved significantly when we used visuals; they started making connections to their own families and surroundings." These interactions demonstrate how storytelling fosters participatory learning, a critical factor for comprehension at this developmental stage.

RQ2: In what ways does storytelling contribute to fostering cultural pride and identity in early learners?

The qualitative data revealed that storytelling significantly fostered cultural pride and identity among participants. Many children expressed enthusiasm for sharing their newfound knowledge with family members. For instance, participant HH stated, "I told my parents about the legends, and they said they used to hear the same stories!" This indicates that storytelling bridged generational gaps, reinforcing familial and cultural connections.

Children's drawings and verbal expressions further illustrated their cultural pride. AC drew a Rumah Gadang and added, "This is where my grandparents are from. I am so proud of it." Similarly, RC said, "Hearing the stories made me feel like I belong to something very big and special." These sentiments reflect the role of storytelling in fostering a sense of identity and belonging, which is crucial in early childhood development.

Participant TN remarked, "The stories make me want to visit the places they talk about, like the lake and the mountains." This response suggests that storytelling not only instilled pride but also inspired curiosity and a desire for experiential learning. FG expressed a similar sentiment, stating, "Now I know why our clothes are colorful; they tell a story too." This critical reflection shows that storytelling extended beyond passive listening to active meaning-making, where children connected cultural symbols to their personal identities.

During classroom discussions, HH exclaimed, "I want to wear the traditional clothes we heard about and show my friends." This highlights the tangible ways storytelling fosters pride, prompting children to envision themselves as active participants in their cultural traditions. Observational data revealed that after storytelling sessions, several children gathered to recreate elements of the stories through role-play, demonstrating the internalization of cultural concepts.

Despite the positive outcomes, not all participants expressed the same level of pride. Participant BB, who identified as Javanese, commented, "I liked the stories, but they're not about my family." This response underscores the need for inclusivity in cultural education. However, the divergent experience of Participant BB, who identified as Javanese, underscores a critical theoretical and practical tension. While Cultural-Historical Activity theory (a branch of Sociocultural theory) emphasizes the importance of culturally mediated tools, it also acknowledges that tools must be meaningful within the learner's own activity system (Engeström, 2001). BB's comment, 'I liked the stories, but they're not about my family,' highlights that while storytelling as a tool was engaging, the specific cultural content was not fully resonant with her personal 'funds of knowledge' (Moll et al., 1992). This finding does not diminish the value of localized storytelling. Instead, it advocates its integration into a broader multicultural pedagogy framework, where dominant local narratives are complemented by stories from other cultures present in the classroom, fostering both specific cultural pride and inclusive, intercultural understanding.

RQ3: What are the key factors that enhance the effectiveness of storytelling as a pedagogical tool in early childhood education?

The study identified several factors that enhanced storytelling effectiveness, including engaging visuals, repetition, and interactive elements. Teachers' facilitative roles were critical, as observed during sessions in which children were actively encouraged to ask questions and share their thoughts. Participant AL explained, "When the teacher showed pictures and asked us what we thought, it made the story fun and easy to understand." This demonstrates the importance of interactive storytelling in maintaining children's attention and fostering comprehension.

Another key factor was the use of culturally resonant narratives. HH expressed, "The stories feel like they're about my family," demonstrating the impact of relatable content. The teacher's incorporation of tangible cultural symbols, such as a model of Rumah Gadang, further deepened children's engagement. FG noted, "Seeing the house made the story real for me." This underscores the role of sensory and visual aids in making abstract cultural concepts tangible for young learners.

Parents' involvement also emerged as a significant factor. RC mentioned, "My mom helped me remember the names of the stories, and we talked about them after school." This highlights the importance of parental reinforcement in extending the impact of storytelling

beyond the classroom. Conversely, AN commented, "I didn't talk about it much at home because my parents don't know the stories." This reveals that limited familial support can constrain the reach of storytelling interventions, emphasizing the need for community engagement in cultural education.

Observation data further highlighted how interactive elements boosted effectiveness. During one session, children clapped along to a rhythmic retelling of a Minangkabau folktale, showing heightened participation and joy. Teachers reported, "The children's energy levels and excitement peaked when we included music and movement." This supports the idea that multimodal engagement can enhance comprehension and retention.

Additionally, peer interaction played a critical role in the effectiveness of storytelling. TN shared, "When my friend answered the teacher's question, I remembered the story better." This suggests that collaborative discussions among children helped reinforce cultural concepts and enhanced memory retention. Teachers observed that children frequently explained story details to one another, which created a supportive learning environment.

The incorporation of physical activities also emerged as a significant factor. AC stated, "When we acted like the people in the story, I felt like I was really there." Role-playing activities allowed children to embody cultural narratives, deepening their connection to the material. Teachers emphasized that these activities were particularly effective in maintaining engagement and ensuring long-term recall of cultural elements. These findings underscore that multimodal engagement, parental involvement, and peer learning were essential in reinforcing storytelling's impact. They also reveal that scaffolding (repetition, visuals, interactive dialogue) was significant for children with minimal prior exposure.

The study also highlighted the challenges of limited prior exposure. Participant FG, who had minimal familiarity with Minangkabau culture, remarked, "At first, I didn't understand the names, but the teacher's pictures helped a lot." This indicates that scaffolding—through repetition, visual aids, and interactive discussions—is essential for children with limited cultural knowledge to benefit from storytelling fully. The study demonstrates that storytelling is a powerful tool for enhancing cultural recognition, pride, and identity among young learners. The combination of engaging delivery methods and culturally relevant content was instrumental in achieving these outcomes.

While most children responded positively, variations in prior exposure and cultural backgrounds influenced their engagement levels. These findings suggest that storytelling should be adapted to individual needs and supported by broader educational and familial contexts. The study contributes to the growing body of research on culturally responsive education, affirming the role of storytelling in bridging cognitive and cultural learning. By critically interpreting both supporting and divergent data, this research underscores storytelling's potential to preserve heritage and foster inclusive learning environments.

Discussion

The findings of this study illustrate the decisive role of storytelling in enhancing young children's recognition and understanding of Minangkabau cultural heritage, fostering cultural pride and identity, and identifying key factors that contribute to its effectiveness as a pedagogical tool (Alwi et al., 2024; Pratama & Husni, 2024; Wardani et al., 2024). By combining quantitative improvements in cultural recognition scores with qualitative insights from observations, interviews, and children's voices, this study provides a more comprehensive understanding of how storytelling functions as a culturally responsive pedagogy. These results align with, extend, and, in some instances, diverge from existing literature and theoretical frameworks, offering unique contributions to the field of culturally responsive education.

The significant improvement in children's recognition of Minangkabau cultural elements aligns with previous studies emphasizing the cognitive benefits of storytelling. For example, Moeslichatoen (2004) and Dhieni (2005) highlight storytelling's role in fostering memory, attention, and comprehension. The quantitative increase from 56.25% to 82.16% confirmed storytelling's effectiveness, while qualitative findings, such as children's excitement in naming landmarks and symbols, illustrated how learning was internalized through imagination and dialogue. The increased scores observed in this study, coupled with children's active engagement during storytelling sessions, validate these claims. Theoretical frameworks such as Slavin's (2011) learning theory and Winkel's (2004) psychology of teaching support these outcomes by demonstrating how storytelling engages learners through interactive, meaningful contexts. The integration of numeric and narrative data thus strengthens the evidence that storytelling bridges abstract cultural knowledge with concrete understanding, as also noted by Fleer (2021). Additionally, children's ability to connect cultural stories to their personal experiences, as seen in the remarks of participants like AC and KN, resonates with Fleer's (2021) assertion that storytelling bridges abstract concepts with tangible understanding through imagination and narrative structures.

The findings also emphasize storytelling's role in fostering cultural pride and identity. This aligns with Yetti et al. (2017) and Gayatri et al. (2023), who identified

storytelling as a medium for preserving cultural heritage and instilling a sense of belonging in children. Qualitative data provided particularly rich evidence here: children expressed pride through drawings, role-play, and family conversations, while parents reported that stories "revived" cultural dialogue at home. These identity-building outcomes complemented the quantitative recognition scores, which alone could not have captured such affective dimensions. Participants' expressions of pride and curiosity, such as HH's desire to share stories with family and FG's newfound appreciation for cultural symbols, reinforce storytelling's ability to deepen cultural connections. These observations extend Liu's (2021) and Si'ilata et al.'s (2023) findings on dual-language and cultural literacy by showcasing storytelling's role in preserving language and revitalizing cultural identity. However, this study also highlights the challenges of inclusivity, as seen in BB's difficulty relating to Minangkabau stories due to her Javanese background (Bell & Jackson, 2021; Pratama & Husni, 2024; Saleh-Alwazzan & Esmail-Ahmad, 2022). The mixed-methods approach helped illuminate this tension: while test scores improved for all participants, interviews revealed varying levels of cultural pride across children's backgrounds. This divergence underscores the need for multicultural storytelling practices. This divergence underscores the need for multicultural storytelling practices to ensure broader relevance, a gap noted by Iruka et al. (2023).

The identified factors that enhance storytelling's effectiveness, engaging visuals, repetition, interactive elements, peer interaction, and role-playing activities, offer new insights that both align with and expand upon existing literature. The role of visuals and sensory aids, as noted in participants' comments (e.g., FG) and in observations of heightened engagement during rhythmic retellings, supports Mulyani et al. (2024) and Khoo et al. (2024), who emphasize the importance of culturally resonant and multimodal teaching methods. Here, mixed-methods evidence was particularly useful: quantitative results showed marked improvements after Cycle II, coinciding with the introduction of more visuals and repetition. At the same time, qualitative observations and interviews explained why these strategies mattered. Children described the stories as "real" and "fun," and parents noticed better recall at home.

The study's findings on parental involvement align with those of Gao et al. (2022), who identified culturally sensitive teacher agency as crucial for implementing effective pedagogical strategies. However, the significant influence of peer interactions and role-playing activities, as highlighted by TN's and AC's remarks, provides a unique contribution to the field by showcasing the social dimensions of storytelling as a collaborative and experiential learning process (Anderson-Lain, 2017; Kim & Brand, 2023; Putri et al., 2024). These qualitative insights add depth to the quantitative outcomes, showing that test scores alone cannot explain variability in children's cultural learning.

Integrated Contribution: A Dual-Focus Framework

The integrated analysis of quantitative and qualitative data reveals the primary contribution of this study: a dual-focus framework demonstrating that a well-designed storytelling intervention serves as a single pedagogical vehicle driving simultaneous progress on two key axes of culturally responsive education. It concurrently enhances cognitive recognition (as evidenced by significant score improvements) and fosters affective identity development (as evidenced by expressions of pride, belonging, and meaning-making). While much of the existing literature emphasizes storytelling's cognitive benefits (Dhieni, 2005; Madondo & Tsikira, 2022) or its role in cultural preservation (Gayatri et al., 2023; Sihotang & Sitanggang, 2022; Yetti et al., 2017; Yücesan et al., 2023), this study bridges these dimensions, demonstrating how storytelling can simultaneously enhance knowledge, foster identity, and inspire curiosity in early learners. By grounding this in sociocultural and narrative identity theories and rigorously integrating mixed-methods data, the study moves beyond confirming storytelling's utility to modeling how it works in an integrated fashion within a specific cultural context. This framework is replicable and adaptable for other indigenous and minority communities globally.

Theoretical Implications

The theoretical implications of this study reaffirm the importance of integrating cultural narratives in early childhood education, as advocated by Mulyasa (2012) and Moeslichatoen (2004). Storytelling, as a dynamic and inclusive teaching strategy, aligns with the principles of culturally responsive pedagogy by validating learners' cultural identities and fostering pride in their heritage (AlQawod & Al-Dababneh, 2025; Blinne, 2012; Iruka et al., 2023). However, this study also emphasizes the need to address inclusivity challenges, particularly in diverse classroom settings. Incorporating multicultural narratives alongside localized stories could mitigate the limitations observed in this study, ensuring that all learners feel represented and valued.

Implications for Policy and Practice

The findings of this study hold significant implications for policymaking in culturally diverse educational settings. By demonstrating the effectiveness of storytelling in fostering cultural pride, identity, and cognitive engagement, this research underscores the need for integrating culturally responsive pedagogies into early childhood education curricula (Darwis &

Muslim, 2024; Eiker, 2024; Hiltrimartin et al., 2024; Zainil et al., 2024). For policymakers, the mixed-methods evidence offers both statistical justification (improved recognition scores) and narrative validation (children's voices and parental feedback). This dual evidence base is especially persuasive for advocating curriculum reform and teacher training programs that emphasize storytelling and local narratives. Policymakers should consider mandating the inclusion of localized cultural narratives in national and regional education standards, emphasizing their role in preserving intangible cultural heritage while fostering inclusivity (Darandari & Alagla, 2022; Sihotang & Sitanggang, 2022; Yücesan et al., 2023). Additionally, professional development programs should be designed to equip educators with the skills and resources needed to implement storytelling effectively, including training in multimodal teaching strategies and the use of culturally resonant materials. These measures can promote equitable access to culturally responsive education, particularly in communities at risk of losing their cultural traditions.

Limitations and Future Research

However, the study's findings must be interpreted in light of certain limitations. The small sample size and focus on a single cultural group limit the generalizability of the results. Future research should employ larger, more diverse samples to explore the scalability of storytelling interventions across various cultural contexts. Additionally, longitudinal studies could investigate the sustained impacts of storytelling on cultural identity formation and cognitive development. Addressing inclusivity challenges, such as those highlighted by participants from non-Minangkabau backgrounds, will require incorporating multicultural narratives to ensure relevance and engagement for all learners (Abul-Anwaar, 2023; Miftahurrahmi et al., 2024; Simmons & Chen, 2014;). By expanding the scope of storytelling research, future studies can contribute to a more comprehensive understanding of its role in fostering diversity and inclusion in education.

This research underscores the multifaceted benefits of storytelling in early childhood education, particularly in preserving and revitalizing cultural heritage (Humairoh, 2023; Sunarti et al., 2024; Yücesan et al., 2023). By critically analyzing both supportive and divergent findings, the study contributes to a nuanced understanding of how storytelling can serve as a bridge between cognitive development and cultural preservation. Its unique insights into the social and experiential dimensions of storytelling offer valuable directions for future research and practice, advocating a more inclusive, culturally grounded approach to early education.

Conclusion

This study demonstrates the significant potential of storytelling as a pedagogical tool for enhancing cultural recognition and fostering identity among young learners in the Minangkabau context. The integration of traditional narratives with interactive teaching methods effectively bridges cognitive development and cultural preservation goals. By highlighting the importance of culturally responsive pedagogy, this research provides a foundation for practical applications in teacher training and curriculum development. Specifically, the findings advocate incorporating storytelling techniques into professional development programs to equip educators with strategies for delivering culturally resonant and engaging lessons. Additionally, this study underscores the need for curriculum planners to embed local and indigenous narratives into early education frameworks, ensuring that children develop a strong connection to their cultural roots while fostering inclusivity for diverse student populations. Beyond the local context, the global relevance of this research lies in its applicability to other minority or indigenous cultures. The storytelling framework presented here offers a replicable model for preserving cultural heritage and strengthening identity among young learners worldwide. By tailoring storytelling interventions to reflect the unique traditions and values of different communities, educators and policymakers can address the challenges of cultural erosion and promote diversity in educational settings. This study has limitations, including its small sample size and focus on a single cultural group, which affect its generalizability. Future research should: 1) Conduct longitudinal studies to track the persistence of cultural identity markers fostered in early childhood; 2) Scale up the intervention with larger, more diverse samples, employing cluster-randomized designs to strengthen causal claims; and 3) Develop and test integrated storytelling models that strategically combine dominant local heritage narratives with stories from other cultures represented in the classroom, directly addressing the inclusivity challenge identified in this study.

AI Disclosure Statement

The authors confirm that no AI-based tools were used in the drafting, writing, or analysis of this manuscript. All content, data interpretation, and conclusions are the sole work of the authors.

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