iejee

International Electronic Journal of Elementary Education
June 2026, Volume 18, Issue 4

Storytelling in Mathematics Education: Exploring Its Pedagogical Potential through a Preservice Teacher Training Program

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Received : 23 October 2025
Revised : 14 May 2026
Accepted : 18 June 2026
DOI : 10.26822/iejee.2026.455

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Abstract

This study examines the impact of a structured training program designed to enhance preservice teachers' pedagogical competence in integrating storytelling into mathematics instruction. Using a mixed-methods design, it explored participants' attitudes and experiences, as well as the extent to which their acquired knowledge was reflected in the lesson plans they designed. Data were collected through questionnaires, reflective journals, and an analytic rubric.

Findings indicate a positive but uneven development. While initial self-efficacy was relatively low (M = 2.64, on a five-point Likert scale), participants expressed highly positive attitudes toward storytelling (e.g., M = 4.78). Following the training, they reported increased confidence and conceptual understanding. Lesson plans demonstrated high mathematical accuracy (M = 4.75) and strong alignment with instructional objectives (M = 4.02), with 63.9% rated as good or excellent, but also revealed weaker performance in learner engagement and the use of multiple representations (M = 3.44).

Overall, the results highlight the effectiveness of structured, practice-oriented professional development in supporting the translation of narrative pedagogy into instructional design, while also revealing a gap between positive attitudes and pedagogical implementation. The study provides a comprehensive perspective on how storytelling can be meaningfully integrated into mathematics education.

Keywords:

Storytelling, Mathematics Education, Preservice Teachers, Teacher Education, Narrative Pedagogy, Lesson Design

Introduction

Over the past five decades, a substantial body of research has consistently demonstrated the pedagogical potential of children's literature in mathematics education (Cotti & Schiro, 2004; Jennings et al., 1992; Moyer, 2000; Shatzer, 2008; Whitin, 1992). A common conclusion across these studies is that presenting mathematical knowledge within meaningful and familiar contexts enhances both the

KURA group
www.iejee.com
ISSN: 1307-9298

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effectiveness and comprehensibility of mathematics instruction (Casey et al., 2008). When mathematical concepts are embedded in authentic, narrative-driven contexts, children not only develop a clearer understanding of mathematical language but also begin to recognize its relevance in their everyday experiences (Moyer, 2000; Kurz & Bartholomew, 2012; Walker, 2025). Thus, contextualizing abstract mathematical ideas makes them more concrete, relatable, and accessible to young learners, thereby reinforcing both conceptual understanding and practical application.

The integration of children's literature into mathematics education refers to the deliberate use of literary materials as pedagogical tools designed to support and enhance mathematical learning (Forbringer, 2004). Through this approach, teachers are able to address individual differences among students by capitalizing on the diversity and adaptability of children's books (Forbringer et al., 2016). Teaching mathematics through literature has been consistently shown to benefit both educators and learners in multiple ways (Edelman et al., 2019; Ginsburg & Uscianowski, 2017; Jett, 2018).

Among the documented benefits, literature-based mathematics instruction supports conceptual understanding, promotes connections between mathematical ideas and everyday experiences, enhances student engagement, and fosters more positive attitudes toward mathematics. It also provides a meaningful linguistic context for mathematical discourse, supports differentiated instruction, and can facilitate students' problem-solving processes by situating mathematical challenges within meaningful narrative contexts. In this way, storytelling can support not only engagement and understanding but also the development of reasoning and solution strategies (Cankoy, 2011; Ekeh, 2023; Hassinger-Das et al., 2015; Lemonidis & Kaiafa, 2019; Luedtke & Sorvaag, 2018; McDuffie & Young, 2003). Overall, these findings highlight the broad pedagogical value of integrating literature into mathematics instruction.

More recent research has further reinforced these findings, emphasizing the role of narrative-based approaches in promoting student engagement, conceptual understanding, and positive dispositions toward mathematics (Katipoglu et al., 2021; Unuvar & Barut-Sezer, 2020). In particular, recent studies highlight the growing interest in storytelling not only as a motivational tool but also as a means of supporting deeper mathematical reasoning and meaning-making in classroom contexts.

Despite this substantial body of research, important gaps remain. Existing studies have primarily focused on students' learning outcomes and the general benefits of storytelling, while comparatively limited attention has been given to how preservice teachers develop the pedagogical knowledge, confidence, and skills required to implement storytelling effectively in mathematics instruction. Furthermore, there is a lack of research examining structured training programs that explicitly support preservice teachers in designing, analyzing, and applying mathematical stories within instructional contexts. In particular, few studies have adopted a comprehensive approach that combines the exploration of participants' attitudes and perceptions with the evaluation of their actual instructional designs.

Addressing this gap, the present study investigates the impact of a structured training program on preservice teachers' understanding and application of storytelling in mathematics education. Adopting a mixed-methods design, the study aims to provide a comprehensive understanding of both participants' attitudinal development and their ability to translate narrative pedagogy into pedagogically meaningful lesson plans.

Literature review

While extensive research has documented the pedagogical benefits of integrating children's literature and storytelling into mathematics instruction, considerably less attention has been devoted to how teachers—and particularly preservice teachers—develop the knowledge, confidence, and pedagogical skills required for their effective implementation. The success of storytelling-based mathematics instruction depends not only on the quality of the narratives used but also on teachers' ability to identify mathematical concepts within stories, design coherent instructional activities, and foster meaningful connections between narrative and mathematical reasoning.

A substantial body of research has examined how preservice teachers perceive, design, and implement literature-based mathematics instruction. Early studies indicate that they often struggle to establish meaningful connections between stories and mathematical concepts. For example, Hillman (2000) identified varying levels of integration, ranging from strong and coherent links to superficial or absent connections, while Wilburne and Napoli (2008) found that, although preservice teachers recognize the motivational value of literature, they emphasize the need for explicit mathematical connections within narrative contexts.

Subsequent research has further highlighted limitations in preservice teachers' pedagogical approaches. Rogers et al. (2015) observed that they tend to rely on basic forms of integration, using literature primarily as a contextual introduction rather than as a medium for deeper conceptual exploration. Similarly, Daly and Blakeney-Williams (2015) emphasized the dual role of children's literature in supporting both mathematical understanding and pedagogical content knowledge,

while also pointing to the need for more systematic instructional support.

Beyond lesson design, challenges have also been identified in the selection and evaluation of narrative resources. Cooper et al. (2018) found that preservice teachers tend to select picture books based on surface-level criteria, such as topic relevance, rather than through critical evaluation of their pedagogical and literary quality. This suggests a lack of well-developed criteria for effectively integrating narrative materials into mathematics instruction.

Research has also examined preservice teachers' ability to construct mathematical narratives, revealing further limitations. Demény and Zsoldos-Marchis (2021) found that, although participants demonstrated relatively strong narrative skills, the mathematical and pedagogical quality of their stories was weaker, particularly in representing concepts accurately and designing meaningful instructional activities. This indicates that creative competence alone is insufficient without strong pedagogical and mathematical grounding.

Similar challenges have been identified in digital storytelling contexts. Özçakır Sümen (2022) reported that preservice teachers' ability to teach mathematical concepts through digital stories was moderate, with notable limitations in supporting deeper conceptual understanding. Likewise, Kükey et al. (2022) found that, although storytelling can support problem solving and reasoning, more complex elements such as modelling and interdisciplinary connections are often underdeveloped.

Taken together, these studies reveal a consistent pattern: although preservice teachers recognize the pedagogical value of storytelling, they often lack the knowledge, confidence, and structured support necessary for its effective implementation. These limitations appear across multiple dimensions, including lesson design, resource selection, narrative construction, and the integration of mathematical concepts into meaningful learning experiences.

Despite growing interest in this field, relatively few studies have systematically examined how preservice teachers experience and evaluate structured training programs that explicitly support the integration of storytelling into mathematics teaching. In particular, there is a lack of research that combines the investigation of participants' perceptions and attitudes with an analysis of their actual instructional designs.

Addressing this gap, the present study investigates the impact of a structured training program on preservice teachers' attitudes, expectations, and experiences regarding the use of storytelling in mathematics education. It also examines how their acquired knowledge and skills are reflected in the lesson plans they design, thereby providing a comprehensive perspective on the pedagogical outcomes of narrative-based approaches in teacher education.

Method

Research Aims and Questions

The present study aimed to design, implement, and evaluate a structured training program intended to enhance preservice teachers' pedagogical competence in integrating storytelling into mathematics instruction. Specifically, it sought to examine how a targeted training program can support the development of both theoretical understanding and practical ability to design mathematically coherent and pedagogically meaningful story-based lessons.

To achieve this, a mixed-methods design was employed, enabling a comprehensive exploration of participants' learning processes and outcomes. Quantitative data were used to capture participants' attitudes, expectations, and levels of satisfaction, while qualitative data provided deeper insights into their reflections, perceived challenges, and lesson design processes.

In line with these objectives, the study was guided by the following research questions:

1. What are the needs and expectations of preservice teachers regarding the use of storytelling in mathematics education prior to the training program?
2. What are their initial attitudes toward, and level of familiarity with, narrative-based approaches in mathematics teaching?
3. How do participants evaluate the structure, content, and methodology of the training program following its completion?
4. In what ways are participants' acquired knowledge and skills reflected in the lesson plans they design, integrating storytelling into mathematics instruction?

Participants

The study sample consisted of 36 undergraduate preservice teachers enrolled in the course Mathematics Education – Teaching Practice during the winter semester of the 2020–2021 academic year. The participants were third-year students in a four-year teacher education program and had previously completed at least one mathematics pedagogy course.

The training program and data collection activities were conducted as an integral part of the course,

ensuring that all enrolled students participated in the study. Data were collected in accordance with established ethical research standards, and participants' identities were anonymized through the use of numerical codes.

The participants shared a generally positive orientation toward teaching but reported limited prior experience in using storytelling or other narrative-based strategies in mathematics instruction. This profile aligns with previous findings indicating that preservice teachers often value innovative pedagogical methods yet lack confidence and structured opportunities to apply them in practice.

Description and Aims of the Training Program

The training program was implemented as part of a university course on mathematics education and consisted of seven weekly sessions, each lasting approximately two instructional hours. Conducted entirely online, the program was designed to combine theoretical input with hands-on, creative, and reflective activities, providing preservice teachers with multiple opportunities to explore the pedagogical potential of storytelling in mathematics instruction.

Each session focused on a distinct aspect of narrative-based pedagogy, ranging from understanding the structure and purpose of stories to writing, analyzing, and evaluating mathematical narratives. The program followed a progressive structure, guiding participants from conceptual exploration to practical application, and culminating in the design of an original mathematics lesson plan incorporating a story created by each participant.

Aims of the Program

The training program aimed to enhance preservice teachers' pedagogical competence and creative confidence in using storytelling as a means of teaching mathematics. Its main objectives were:

1. To develop a theoretical understanding of the pedagogical principles underlying the use of storytelling in mathematics education.
2. To foster creative and narrative skills, enabling participants to design original mathematical stories that are both engaging and conceptually accurate.
3. To strengthen pedagogical design skills by guiding participants in integrating storytelling into lesson planning in ways that align with curricular goals and students' developmental levels.
4. To cultivate reflective practice, encouraging participants to critically examine their evolving attitudes, beliefs, and instructional approaches.

Structure and Content of the Program

The professional development program was designed to introduce preservice teachers to the pedagogical potential of storytelling in mathematics education and to support the development of the knowledge, skills, and confidence required to design narrative-based mathematics lessons. Its design was informed by key principles of effective teacher professional development (Desimone, 2009; Darling-Hammond, 2017), emphasizing coherence, active learning, collaboration, and the integration of theory and practice. In addition, the structure was aligned with Kolb's (1984) experiential learning model, enabling participants to engage in a cyclical process of conceptual understanding, practical experimentation, reflection, and synthesis.

The program consisted of seven modules, each addressing a specific dimension of storytelling-based mathematics instruction. The overall pedagogical approach was grounded in constructivist and sociocultural perspectives (Bruner, 1990); Vygotsky, 1978), positioning participants as active learners who construct meaning through reflection, creativity, and dialogue.

Module 1. Storytelling and Its Use in Mathematics Education.

This introductory module familiarized participants with storytelling as a communicative and pedagogical practice. Drawing on relevant literature (Trakulphadetkrai, 2018; Whitin & Whitin, 2004;), it explored how narratives can support conceptual understanding, emotional engagement, and mathematical discourse. Participants reflected on the potential benefits and challenges of using storytelling in mathematics instruction.

Module 2. Writing Stories

This module focused on developing participants' understanding of key narrative elements, including setting, plot, characters, point of view, and theme. Through guided analysis and creative tasks, participants deconstructed a familiar story and composed an original narrative using the "story mountain" framework, strengthening their narrative awareness and creative skills.

Module 3. Writing Mathematical Stories

Participants were introduced to the five-stage model for developing mathematical stories (Pound & Lee, 2011) and analyzed a sample story in terms of both mathematical content and pedagogical effectiveness. They also engaged with an excerpt from Damned Mathematics (Frabetti, 2000), reflecting on its instructional potential. These activities

supported the development of both analytical and creative competencies in designing mathematically meaningful narratives.

Module 4. Digital Storytelling

This module introduced participants to digital storytelling through an eight-step framework (Morra, 2013). Participants explored various digital tools and developed a storyboard for their previously created narrative, enhancing their understanding of multimodal representation and its pedagogical potential.

Module 5. Guideline for Mathematical Story Authors

Participants engaged with the Guideline for Mathematical Story Authors (Trakulphadetkrai, n.d.), examining the characteristics of effective mathematical narratives. They then designed and revised their own mathematical stories based on specific instructional objectives, receiving formative feedback to improve coherence and mathematical accuracy.

Module 6. Criteria for Evaluating Narrative Texts with Mathematical Content

This module introduced evaluation criteria for mathematical stories (Hellwig et al., 2000; Schiro, 1997; Whitin & Whitin, 2004). Participants applied an analytic rubric to assess selected narratives, developing critical awareness of pedagogical and mathematical quality.

Module 7. Suggested Children's Books with Mathematical Content

The final module presented a curated selection of children's books suitable for teaching mathematical concepts. Participants analyzed these resources and reflected on criteria for selecting appropriate texts, expanding their repertoire of instructional materials and supporting future classroom application.

Procedure

The training program was implemented as part of the university course Mathematics Education – Teaching Practice, which aimed to familiarize preservice teachers with contemporary pedagogical approaches to mathematics instruction. In addition to regular course lectures, participants engaged in a structured training module specifically focused on the use of storytelling as a pedagogical tool in mathematics education.

Due to COVID-19 restrictions, the program was conducted entirely online, combining weekly synchronous sessions with asynchronous activities. The overall structure integrated theoretical input, guided discussions, and practical assignments, enabling participants to progressively connect narrative theory with classroom application.

Throughout the program, participants maintained weekly reflective journals in which they recorded their perceptions, observations, and evolving views on storytelling in mathematics. These journals also functioned as a formative tool, allowing the instructor to monitor participants' progress and identify areas requiring additional support.

At the conclusion of the training, participants were required to design a lesson plan centered on a mathematical concept of their choice, incorporating an original story created by themselves. Although these lesson plans were not implemented in actual classroom settings due to pandemic-related school closures, the design process provided a valuable opportunity for participants to translate theoretical knowledge into pedagogical practice.

Data Collection Instruments

Multiple sources of data were employed to ensure a comprehensive and triangulated understanding of participants' learning processes and outcomes. The study utilized both quantitative and qualitative instruments, enabling the collection of attitudinal, reflective, and performance-based data. Specifically, the following instruments were used:

1. Pre-program questionnaire on attitudes toward storytelling in mathematics instruction.

This instrument aimed to capture participants' initial perceptions of the pedagogical value of storytelling and their prior familiarity with narrative-based approaches.

2. Pre-program questionnaire on expectations regarding the training program.

This questionnaire explored participants' professional learning goals and expectations related to the content, structure, and anticipated outcomes of the program.

3. Weekly reflective journals.

Participants maintained individual journals throughout the program, recording their evolving reflections on course activities, perceived challenges, and insights related to the integration of storytelling into mathematics instruction. These journals provided qualitative data on participants' conceptual and emotional engagement with the training.

4. Post-program evaluation questionnaire.

Administered at the conclusion of the program, this instrument assessed participants' satisfaction with the training, perceived effectiveness, and self-reported learning gains.

5. Lesson plans designed by participants.

Each participant created a mathematics lesson plan integrating an original story of their own design. These artifacts served as evidence of participants' ability to apply theoretical knowledge to instructional practice.

6. Analytic rubric for lesson plan evaluation.

An analytic rubric was developed specifically for this study to evaluate the lesson plans according to six criteria: originality of the plot, mathematical accuracy, alignment with the mathematical objective, use of multiple representations, appropriateness for age and developmental level, and active involvement of the learner. Each criterion was rated on a five-point scale (1 = very poor, 5 = excellent).

The rubric was developed based on relevant literature on storytelling and mathematics education (Hellwig, Monroe & Jacobs, 2000; Schiro, 1997; Whitin & Whitin 2004) and was reviewed by two experts in mathematics pedagogy to ensure content validity and reliability. It served as the primary tool for analyzing the pedagogical quality of participants' lesson plans and for assessing the extent to which theoretical principles were translated into instructional practice.

Data analysis

Data analysis was conducted using a mixed-methods approach, integrating both quantitative and qualitative techniques in order to provide a comprehensive understanding of participants' learning processes and outcomes.

Quantitative data derived from the pre- and post-program questionnaires were analyzed using descriptive statistics, including means and standard deviations. The analysis was conducted using SPSS (Version 31), allowing for the identification of overall trends in participants' attitudes, expectations, and evaluations, as well as comparisons across different phases of the training program.

Qualitative data collected through open-ended questionnaire responses and reflective journals were analyzed using thematic analysis, following the approach proposed by Braun and Clarke (2006). The analysis involved several stages, including familiarization with the data, initial coding, identification of recurring patterns, and the development and refinement of themes. Coding was conducted iteratively, allowing themes to emerge inductively from the data while remaining aligned with the research questions.

To enhance the reliability of the qualitative analysis, a second researcher independently reviewed a subset of the data and the coding scheme. Inter-rater agreement was discussed, and any discrepancies were resolved through consensus, ensuring consistency and coherence in the final themes.

The evaluation of lesson plans using the analytic rubric was conducted based on predefined criteria and performance descriptors. To further strengthen reliability, a second evaluator independently assessed a sample of lesson plans, and agreement was reached through discussion.

Finally, the integration of quantitative and qualitative findings was achieved through triangulation, enabling a more comprehensive interpretation of the data by combining statistical trends with in-depth qualitative insights.

Results

Participants' Attitudes and Perceptions Toward Storytelling in Mathematics

To examine preservice teachers' initial attitudes toward storytelling in mathematics education, a pre-program questionnaire was administered. Table 1 presents the descriptive statistics for participants' responses.

Table 1

Preservice Teachers' Attitudes Toward Storytelling in Mathematics

Statement	M	SD
Mathematics should be taught through rigid methods	1.25	0.60
Storytelling is irrelevant to mathematics teaching	1.17	0.44
Creativity is important in mathematics teaching	4.83	0.43
Storytelling enhances mathematical understanding	4.78	0.48
Storytelling connects mathematics to real life	4.74	0.55
Storytelling fosters critical thinking	4.78	0.42
I feel confident using storytelling in mathematics lessons	2.64	0.67
I am interested in learning more about storytelling approaches	4.89	0.31

Note. Items were rated on a 5-point Likert scale (1 = Strongly disagree, 5 = Strongly agree).

The results indicate highly positive attitudes toward storytelling in mathematics education, with participants strongly agreeing that creativity and imagination are important (M = 4.83, SD = 0.43)

and that storytelling enhances understanding of mathematical concepts (*M* = 4.78, *SD* = 0.48). At the same time, participants reported relatively low confidence in implementing storytelling (*M* = 2.64, *SD* = 0.67), indicating a gap between positive beliefs and perceived pedagogical competence.

The qualitative analysis of open-ended responses provided further insight into participants' perceptions, revealing both the perceived benefits and challenges of integrating storytelling into mathematics education.

Theme 1. Storytelling as a tool for engagement and motivation

A dominant theme across the data was the perception that storytelling enhances student engagement and makes mathematics lessons more enjoyable. Participants frequently described stories as a means of capturing students' attention and promoting active participation. As one participant noted, "The lesson becomes more engaging and enjoyable," while another explained, "Through stories, the teacher can capture students' attention."

Theme 2. Affective benefits and positive attitudes toward mathematics

Several participants emphasized the emotional and motivational impact of storytelling, suggesting that it can foster more positive attitudes toward mathematics and reduce anxiety associated with the subject. For instance, one participant stated, "Math will become more enjoyable, and children will love it more if we teach it through stories." These responses highlight the perceived role of storytelling in creating a supportive and inclusive learning environment.

Theme 3. Support for conceptual understanding and classroom interaction

A smaller but significant group of participants referred to the cognitive and interactive benefits of storytelling. They noted that embedding mathematical concepts within narrative contexts can facilitate understanding and encourage classroom dialogue. As one respondent observed, "Students can understand math more easily when it's taught through stories," while another highlighted that "a story that students like gives them the chance to talk about it and about the math within it."

Theme 4. Practical challenges and lack of preparedness

In addition to the perceived benefits, participants identified several challenges related to the implementation of storytelling in mathematics instruction. The most frequently reported issue concerned the time and preparation required to design story-based lessons, as reflected in the comment: "Such an effort requires a lot of time and preparation."

Another important challenge was participants' limited knowledge of appropriate resources and selection criteria. As one participant stated, "I don't know what characteristics a book should have to be used in teaching. Which ones are appropriate?" These findings point to a lack of pedagogical preparedness and highlight the need for structured guidance in selecting and using narrative materials.

Overall, the qualitative findings complement the quantitative results, confirming that while preservice teachers hold highly positive attitudes toward storytelling in mathematics education, they also experience uncertainty and practical constraints in applying it effectively in instructional contexts.

Participants' Expectations Regarding the Training Program

In order to examine participants' expectations regarding the training program, a pre-program questionnaire was administered focusing on their anticipated learning outcomes and perceptions of the program's structure and content. Table 2 presents the descriptive statistics for participants' responses across the different dimensions of expectations.

Table 2
Participants' Expectations Regarding the Training Program

Item	M	SD
Gaining knowledge about storytelling in mathematics	4.78	0.42
Developing instructional skills	4.78	0.42
Connecting theory and practice	4.72	0.56
Examples of classroom implementation	4.80	0.40
Exposure to innovative teaching methods	4.58	0.60
Awareness of current research	4.72	0.56
Well-structured training program	4.78	0.48
Engaging learning experience	4.83	0.37

Note. Items were rated on a 5-point Likert scale (1 = Strongly disagree, 5 = Strongly agree).

The results indicate consistently high expectations across all dimensions of the training program, reflecting participants' strong interest in professional learning and skill development. In particular, high mean scores were observed for gaining knowledge about teaching mathematics through storytelling, developing instructional skills, and engaging with classroom-based examples. Participants also expressed strong expectations regarding the

connection between theory and practice, as well as exposure to innovative pedagogical approaches and current research. Overall, the findings suggest that participants anticipated a well-structured, relevant, and engaging learning experience.

The qualitative analysis of open-ended responses further elaborates on these expectations. A dominant theme concerned the desire to learn how to effectively select and use children's literature in mathematics instruction, as well as to improve teaching practices and explore innovative pedagogical approaches. Several participants also referred to developing creativity and the ability to compose mathematical stories, while others emphasized the importance of strengthening self-confidence and reducing mathematics-related anxiety. Representative responses included "to learn how to connect mathematics with literature," "to improve my teaching practice," and "to overcome my anxiety about teaching mathematics."

In addition, participants identified conditions under which the training would be less beneficial. The most frequently mentioned concerns included an excessive emphasis on theory, a lack of practical examples, monotony, and an overly demanding workload. These responses indicate a clear preference for experiential, interactive, and well-balanced learning environments that integrate theory with practice.

Taken together, the quantitative and qualitative findings provide a comprehensive picture of participants' expectations prior to the training, highlighting both their strong motivation to engage with the topic and their need for practical, application-oriented learning experiences. The following section presents the results of the post-program evaluation, examining participants' levels of satisfaction and perceptions of the program's effectiveness.

Evaluation of the Training Program

To examine participants' evaluation of the training program following its completion, a post-program questionnaire was administered focusing on key aspects of the program, including instructor support, content, and overall organization. Table 3 presents the descriptive statistics for participants' responses.

Table 3

Participants' Evaluation of the Training Program

Evaluation Dimension	M	SD
Instructor expertise and support	4.68	0.42
Usefulness of the training	4.75	0.38
Organization and clarity of objectives	4.52	0.47
Balance of theory and practice	4.33	0.51
Assignments and activities	4.60	0.44

Note. Items were rated on a 5-point Likert scale (1 = Strongly disagree, 5 = Strongly agree).

The results indicate high levels of satisfaction across all evaluation dimensions. In particular, participants rated the usefulness of the training (M = 4.75, SD = 0.38) and the instructor's expertise and support (M = 4.68, SD = 0.42) especially positively, highlighting the perceived quality and relevance of the program.

Assignments and learning activities also received strong evaluations (M = 4.60, SD = 0.44), suggesting that participants found them effective in supporting their understanding and application of storytelling-based mathematics instruction.

Although all dimensions were rated highly, slightly lower scores were observed for the balance between theory and practice (M = 4.33, SD = 0.51), indicating an area where further refinement of the program could be considered.

Application of Knowledge and Skills in Lesson Plan Design

Narrative and Pedagogical Features of the Lesson Plans

To examine how participants applied the knowledge and skills developed during the training program, the lesson plans they produced at its conclusion were analyzed. The analysis focused on the integration of storytelling principles into mathematics instruction, as well as on patterns related to content selection, narrative structure, and pedagogical approach.

A clear trend emerged regarding the target grade levels of the designed lesson plans. The majority focused on the early primary years, with 51.3% addressing Grade 1 and 27.3% targeting Grade 2. Fewer lesson plans were designed for higher grades (Grades 3–5), and none targeted Grade 6. This distribution suggests that participants felt more confident designing storytelling-based lessons for younger learners, while upper primary levels were less frequently addressed.

The analysis of mathematical content (Table 4) reveals a strong concentration in the domain of Numbers and Operations, which accounted for the majority of lesson plans (63.94%). Problem solving was the second most represented area (19.46%), while measurement (8.34%), geometry (5.56%), and algebra (2.78%) appeared less frequently.

Within the domain of Numbers and Operations, participants primarily focused on fundamental arithmetic concepts, such as addition, subtraction, multiplication tables, and number comparison. Other topics, including place value, fractions, and decimal numbers, were also included, although to a lesser extent.

These findings suggest that preservice teachers tended to prioritize foundational numerical content, while more complex or abstract mathematical domains were less frequently addressed.

Table 4

Distribution of Mathematical Content in Lesson Plans

Mathematical Domain	%
Numbers and Operations	63.94
Problem solving	19.46
Measurement	8.44
Geometry	5.56
Algebra	2.78

The lesson plans predominantly focused on foundational arithmetic concepts, confirming the strong emphasis on basic numerical content identified in the previous analysis.

Analysis of the narrative framework indicates that most stories (70.2%) were set in imaginative or fictional contexts, while 29.7% were situated in realistic scenarios. This suggests that participants tended to favor creative and imaginative approaches when integrating storytelling into mathematics instruction.

The use of illustrations within the lesson plans was also examined. In 78.3% of cases, visual elements were used functionally to support mathematical understanding, whereas 21.6% served primarily decorative purposes. This finding indicates that most participants were able to meaningfully integrate visual representations with mathematical content.

Taken together, these results reveal consistent patterns in how storytelling was incorporated into lesson design. Participants generally demonstrated the ability to combine narrative elements and visual supports with mathematical content, particularly at the level of basic concepts and early primary grades. However, fewer lesson plans addressed higher grade levels, more abstract mathematical domains, or more complex narrative structures, suggesting that further development is needed in these areas.

Evaluating the Quality of Narrative-Based Lesson Plans

To assess how participants applied the knowledge and skills acquired during the training program, their lesson plans were evaluated using an analytic rubric designed for storytelling-based mathematics instruction. The rubric, grounded in relevant literature on mathematics pedagogy and narrative learning, included six criteria: originality of the plot, mathematical accuracy, alignment with the mathematical objective, use of multiple representations, appropriateness for learners' age and developmental level, and active involvement of the learner. Each criterion was rated on a five-point scale (1 = very poor, 5 = excellent). Table 5 presents the mean scores for each criterion.

Table 5

Mean Scores of Lesson Plans Based on the Evaluation Rubric

Criterion	M
Originality of the plot	3.72
Mathematical accuracy	4.75
Alignment with the mathematical objective	4.02
Use of multiple representations	3.44
Appropriateness for age and developmental level	3.97
Active involvement of the learner	3.78

The results indicate generally high performance across most evaluation criteria. Mathematical accuracy received the highest rating (M = 4.75), followed by alignment with the mathematical objective (M = 4.02), suggesting that participants were able to design lesson plans that were both conceptually correct and aligned with clearly defined learning goals.

Moderate to high scores were observed for originality of the plot (M = 3.72) and active involvement of the learner (M = 3.78). While most lesson plans incorporated elements of creativity and opportunities for student participation, these dimensions showed greater variability, indicating differences in participants' ability to design engaging and interactive learning experiences.

The lowest mean score was recorded for the use of multiple representations (M = 3.44), suggesting that participants experienced greater difficulty in integrating diverse forms of representation—such as visual, symbolic, and verbal modes—within their lesson designs. This finding points to a specific area requiring further pedagogical support.

The appropriateness of the lesson plans for learners' age and developmental level received a relatively high mean score (M = 3.97), indicating that most participants were able to design instruction suitable for their target group, although some variability was observed.

In addition to the criterion-based analysis, the overall quality of the lesson plans was examined by grouping them according to their mean rubric scores. As shown in Table 6.25% of the lesson plans were rated as excellent, 38.9% as good, and 36.1% as moderate. This distribution suggests that, while a substantial proportion of participants demonstrated strong performance, most lesson plans fell within the good to moderate range, indicating room for further development.

Table 6

Overall Performance of Lesson Plans

Performance level	Score range	N	%
Excellent	4.50 – 5.00	9	25.0
Very good	3.50 – 4.49	14	38.9
Moderate	2.50 – 3.49	13	36.1
Poor	< 2.50	0	0
Total		36	100

As shown in Table 6, 25% of the lesson plans were rated as excellent, 38.9% as very good, and 36.1% as moderate, while none were classified as poor. This distribution indicates that all participants achieved at least a moderate level of performance, with the majority demonstrating satisfactory to high-quality lesson design. At the same time, the relatively small proportion of excellent ratings suggests that, although participants were able to apply the principles introduced during the training, further development is needed to achieve more advanced levels of pedagogical integration.

Discussion

The findings of this study provide important insights into preservice teachers' evolving understanding of storytelling as a pedagogical tool in mathematics education. Overall, the results indicate a clear developmental trajectory: participants entered the training program with highly positive attitudes, engaged actively with its theoretical and practical components, and demonstrated the ability to transfer newly acquired knowledge into instructional design.

However, this development was not uniform. While participants showed strong performance in areas such as mathematical accuracy and alignment with learning objectives, they experienced greater difficulty in designing creative, multimodal, and engaging learning experiences. This pattern suggests that, although preservice teachers are receptive to innovative pedagogical approaches, developing deeper pedagogical competence requires sustained and practice-oriented support.

These findings highlight a critical gap between positive orientations toward storytelling and the ability to implement it effectively in instructional practice. They suggest that pedagogical acceptance alone is insufficient without structured opportunities for application, reflection, and feedback.

Building on this perspective, the following discussion examines how specific features of the training program shaped participants' learning experiences and professional development, while also considering implications for teacher education.

Preservice Teachers' Initial Attitudes, Perceptions, and Expectations

Before the implementation of the training program, participants' attitudes, perceptions, and expectations regarding storytelling in mathematics education revealed a strong openness to innovative and creative teaching practices. Participants expressed clear support for approaches that move beyond traditional, formalistic instruction, viewing storytelling as a means of enhancing engagement, supporting conceptual understanding, and fostering positive emotional connections with mathematics.

These findings are consistent with previous research (e.g., Philippou & Christou, 1998; Trakulphadetkrai, 2018), but they also suggest that such positive orientations may reflect an abstract appreciation rather than a fully developed understanding of the pedagogical demands of storytelling.

Participants also reported high expectations, particularly regarding the acquisition of practical strategies and classroom-ready tools. Their emphasis on applicability—such as selecting appropriate literature, connecting theory with practice, and developing storytelling skills—reflects a pragmatic orientation commonly observed in preservice teacher education (cf. Zeichner, 2010).

At the same time, these expectations point to perceived gaps in pedagogical preparedness. The strong demand for guidance and structured support suggests that participants did not feel sufficiently equipped to implement storytelling independently. This is further reflected in their relatively low self-efficacy, indicating a clear tension between positive attitudes and perceived competence.

This tension aligns with previous findings (Bandura, 1997; Prendergast et al., 2019; Swars et al., 2009), but the present study highlights how it is already evident at the level of initial expectations. Together, these findings underscore the importance of structured, practice-oriented training that supports the transition from theoretical acceptance to effective pedagogical implementation.

Features and Pedagogical Value of the Training Program

The training program was designed to combine theoretical grounding with structured opportunities for practical engagement in storytelling-based mathematics instruction. Delivered within a university course and conducted online, it integrated lectures, workshops, collaborative discussions, and reflective activities, aiming to support both conceptual understanding and the development of pedagogical competence. This dual focus reflects contemporary approaches to teacher education that emphasize

experiential learning and the integration of theory and practice (Darling-Hammond & Bransford, 2005; Loughran, 2019).

A key strength of the program was its emphasis on active and reflective engagement. Through the analysis of mathematical stories, collaborative discussion, and the use of reflective journals, participants were encouraged to critically examine their pedagogical assumptions and decision-making processes. Such practices are widely associated with deeper professional learning, as they promote self-awareness and the gradual refinement of teaching approaches (Schön, 1983).

At the same time, the design of the program highlights both its affordances and its limitations. While the final lesson plan assignment provided valuable opportunities for participants to apply theoretical knowledge in a structured context, the absence of actual classroom implementation—due to pandemic restrictions—likely constrained the development of situated pedagogical competence. This limitation may partly explain the gap observed between participants' strong conceptual understanding and their comparatively lower confidence in applying storytelling in practice.

Overall, the findings suggest that the effectiveness of the program lies not only in its content but also in its pedagogical design. By combining conceptual exploration, guided practice, and reflective inquiry, it created conditions that supported initial skill development while also revealing areas requiring further scaffolding. In this respect, the study underscores the importance of designing teacher education programs that move beyond theoretical exposure and provide sustained, practice-oriented learning experiences that can support the transition from understanding to implementation.

Evaluation of the Training Program

The post-program evaluation revealed consistently high levels of participant satisfaction, suggesting that the training was effective in addressing its pedagogical objectives. Participants rated the program positively across all dimensions, including its usefulness, clarity, organization, and relevance to their professional development.

A particularly valued feature was the integration of theoretical input with practical application, supporting the development of both conceptual understanding and instructional skills. At the same time, participants' expressed desire for a stronger emphasis on hands-on, experience-based components indicates that, even within a well-structured program, opportunities for situated practice remain essential. This finding reinforces previous research emphasizing the importance of practice-oriented engagement in teacher education (e.g., Daly & Blakeney-Williams, 2015).

Assignments and activities were also highly valued, especially the final task of designing a mathematics lesson based on an original story. This activity appears to have played a key role in supporting the transition from theoretical understanding to pedagogical application, highlighting the importance of design-based tasks in teacher learning.

The instructor's role emerged as a central factor in participants' positive experiences. The emphasis on clear guidance, structured support, and a supportive learning environment suggests that the effectiveness of the program was closely linked to the quality of pedagogical facilitation. This is particularly important in the context of innovative approaches such as storytelling, where participants may require more explicit modeling and feedback.

While the overall evaluation was highly positive, these findings should be interpreted in light of certain limitations. Participants' increased confidence and reported shifts in self-efficacy were based on simulated instructional design rather than actual classroom implementation. As a result, the extent to which these gains would translate into real teaching practice remains uncertain.

Overall, the results indicate that the training program was successful in supporting the initial development of pedagogical knowledge, skills, and confidence. However, they also highlight the need for extended and practice-based learning experiences that can further support the consolidation and transfer of these competencies into authentic classroom contexts.

Application of Knowledge and Skills in Lesson Plan Design

The analysis of participants' lesson plans provides important evidence of how the knowledge and skills developed through the training program were translated into pedagogical practice. High levels of mathematical accuracy and alignment with curricular objectives indicate that preservice teachers were able to maintain conceptual rigor while integrating narrative elements into mathematics instruction. This suggests that the program effectively supported the balance between creativity and mathematical precision—an outcome often identified as challenging in prior research (Edelman, 2017; Prendergast et al., 2019).

Participants also demonstrated an emerging ability to adapt instruction to learners' developmental levels, indicating an awareness of the importance of aligning narrative structures with students' cognitive

characteristics. This finding supports the view that the pedagogical value of storytelling depends not only on engagement but also on its coherence with learners' prior knowledge and developmental readiness (Cotti & Schiro, 2004; Whitin & Wilde, 1992).

At the same time, the findings reveal important limitations. Moderate levels of originality and learner involvement suggest that participants may still rely on familiar narrative patterns and more teacher-centered approaches, rather than fully exploiting the potential of storytelling for interactive and inquiry-based learning. Similarly, the relatively low use of multiple representations highlights an ongoing challenge in integrating visual, symbolic, and verbal forms to support deeper conceptual understanding.

These patterns indicate that, while participants developed a foundational competence in narrative-based lesson design, they may adopt more "secure" or conventional strategies when applying new pedagogical approaches. This tendency has been noted in previous research and may reflect the complexity of combining creativity with mathematical and pedagogical demands.

Importantly, the presence of several high-quality lesson plans demonstrates the transformative potential of structured and well-supported training. In cases where participants engaged more deeply with the design process, storytelling was not used merely as a contextual addition but as a central organizing principle for mathematical reasoning. This suggests that, with sustained guidance, feedback, and opportunities for iterative practice, preservice teachers can move toward more sophisticated and pedagogically meaningful uses of narrative.

Overall, these findings highlight both the effectiveness of the training program in supporting initial skill development and the need for continued, practice-oriented learning experiences that can further foster creativity, multimodal representation, and student-centered instructional design.

Limitations and Directions for Future Research

While the findings of this study provide valuable insights into the role of targeted training in supporting preservice teachers' use of storytelling in mathematics education, several limitations should be acknowledged.

First, due to COVID-19 restrictions, the lesson plans designed by participants were not implemented in actual classroom settings. As a result, the study was unable to examine how storytelling-based instruction functions in authentic teaching contexts or to capture its impact on students' engagement, conceptual understanding, and learning outcomes. This limitation is particularly important given that the findings revealed a gap between participants' conceptual understanding and their confidence in implementation. Future research should therefore investigate the enactment of narrative-based mathematics lessons in real classrooms, focusing on both teacher practices and student responses.

A second limitation concerns the relatively small and context-specific sample, which consisted of preservice teachers enrolled in a single university course. While this context allowed for an in-depth exploration of participants' learning processes, it limits the generalizability of the findings. Future studies involving larger and more diverse samples would enable more robust conclusions and facilitate the examination of individual differences in pedagogical development.

In addition, the study focused on the outcomes of a short-term training program. Although the results indicate positive shifts in attitudes, knowledge, and instructional design, it remains unclear whether these developments can be sustained over time and transferred into long-term teaching practice. Longitudinal research is therefore needed to examine how preservice teachers' competencies evolve as they gain classroom experience.

Future research could also explore variations in program design, including comparisons between different models of professional development, as well as the integration of storytelling into more advanced mathematical topics and across a wider range of educational levels. Such studies would contribute to a more comprehensive understanding of how narrative-based approaches can be effectively incorporated into mathematics education.

Conclusion

This study contributes to the growing evidence base on the role of storytelling in mathematics education by demonstrating how a structured, research-informed training program can support preservice teachers in integrating narrative into their instructional practice. The findings show that the program fostered positive attitudes, strengthened theoretical understanding, and supported the transfer of storytelling principles into pedagogically coherent lesson designs. At the same time, the results revealed areas requiring further development, particularly in relation to creativity, learner engagement, and the use of multiple representations.

Beyond these findings, the study offers a more integrated understanding of preservice teacher development by combining attitudinal data, qualitative reflections, and the analysis of lesson plans. In doing so, it highlights a critical gap between

positive orientations toward storytelling and the ability to implement it effectively in instructional design. This insight extends existing research by showing that pedagogical acceptance does not necessarily translate into pedagogical competence without structured support.

Overall, the study underscores the pedagogical value of sustained, practice-oriented professional development that bridges theory and classroom application. Its findings have important implications for teacher education, suggesting that targeted training in narrative-based pedagogy can act as a catalyst for innovation, engagement, and conceptual depth in mathematics teaching and learning.

AI Disclosure Statement

The authors used AI-assisted language tools during the preparation of this manuscript for language refinement, proofreading, and formatting support. All conceptualization, data analysis, interpretation of findings, and final decisions regarding the content of the manuscript were conducted solely by the authors.

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