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The Impact of Digital Storytelling Tools on Mathematics Achievement in Secondary Education

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ABSTRACT:

This study examines how effective three storytelling teaching methods are. These methods include oral storytelling, AI-generated video storytelling using Narakeet, and augmented reality video storytelling with MetaSpark. The focus is on improving mathematics instruction for Class 7 students. Implemented in eight private schools in Delhi, the intervention engaged 16 mathematics pedagogy trainee teachers during their internship, who collectively instructed 561 students over three consecutive weeks. Each week addressed a distinct topic—Decimals, Fractions, and Ratio & Proportion—using one storytelling format. Employing a mixed-methods design, the study utilized standardized pre- and post-tests (MAT I–III) and student feedback instruments to evaluate learning gains and engagement.

Findings show that all three methods led to significant learning gains. However, AR storytelling resulted in the highest post-test improvements, engagement levels, and supervisor ratings. Clear instructional pace and clarity in instructional design were preferred for AI-produced videos, while oral storytelling maintained levels of cultural saliency and affective depth. The study highlights the teaching potential of blending storytelling with digital technologies for promoting conceptual mastery in mathematically dense material. Applications for teacher education involve incorporating digital storytelling skills in pre-service education to promote instructional creativity and student engagement.

Keywords: *Storytelling Pedagogy, Artificial Intelligence, Augmented Reality, Digital Pedagogy, Mathematics Education.*

1. INTRODUCTION:

With the constantly evolving context of schooling, teaching methodologies are in the process of significant transformation. The classical model of lecture-based teaching, though traditionally predominant, is finding it more and more difficult to address the needs of learners whose world is filled with highly visual, interactive,

and multimodal media in the course of their day-to-day lives. Modern learners demand that learning be alive, relevant, and enterprising—a demand that is perhaps fueled by their exposure to technological mediums in the world outside the classroom. This situation has motivated teachers and scholars to find methodologies that foster not merely the gain of knowledge but the cultivation of 21st-century abilities comprising creativity, communication, problem-solving, and critical thinking.

Of the teaching methods that honor these objectives, storytelling is particularly significant. It is at once timeless and versatile, providing a narrative structure by which abstract ideas may be translated into significant, transferable experiences. Within the learning context, storytelling consists of the deliberately applied use of narrative structure—character, place, conflict, plot, and resolution—to frame and deliver content (Haven, 2007). By placing information within a meaningful narrative, students are more able to visualize concepts, engage emotionally with course material, and hold knowledge for extended durations. It is especially effective in teaching mathematics, in particular, because abstract concepts are often hard to apprehend in a vacuum. Yet, conventional storytelling in classrooms is subject to some challenges. Teachers may have little time to design and present effective narratives in conjunction with central content demands. Moreover, holding student interest with text-based or solely spoken narratives is sometimes tricky in a world of diminished attention spans. These challenges are now in many instances being surmounted by digital and technology-enhanced storytelling, in which the narrative strength is combined with the cognitive and affective qualities of visual, audible, and interactive stimuli.

2. Storytelling as a Pedagogical Tool:

Storytelling has long benefited from its ability to increase cognitive engagement as well as conceptual comprehension. Egan (1986) highlighted that narratives are cognitive tools for making sense of abstract information and for organizing it. Bruner (1991) himself put forth that narratives have the effect of embedding learning in contexts that are relevant to learners, making it more memorable. Abidin et al. (2011) and Raines & Isbell (1994) in mathematics education established that contextualized narration enhanced conceptual clarity as well as problem-solving abilities.

The value of storytelling goes beyond cognitive benefit. It is also connected to reflective thinking, empathy, and culture building. McDrury and Alterio (2003) indicated that storytelling is a reflective practice for pre-service teachers, as they are able to interpret and learn from experience. Likewise, Mello (2001) indicated that storytelling fosters classroom unity and appreciation for culture, while Harandi (2015) connected storytelling with heightened student motivation and engagement. Nicolopoulou's (2010) longitudinal study confirmed the development of both cognitive and socio-emotional competencies as a result of storytelling. From a constructivist point of view, storytelling is in line with active meaning-making and knowledge construction principles. Dyson and Genishi (1994) and McCabe (1997) connected narrative proficiency with general scholastic achievement, while Mages (2008) indicated that storytelling is beneficial in terms of developing inferential thinking and logical orderings. These results support that storytelling must

not be reserved for language arts but be accepted as a cross-curriculum approach—especially in mathematics, as it has the capacity to make abstract concepts more human.

Digital Storytelling: Extending the Narrative

The integration of technology has expanded storytelling into digital storytelling, blending narrative structure with multimedia elements such as images, animations, audio, and video. Robin (2008) and Sadik (2008) documented how digital storytelling improves engagement, comprehension, and collaboration. Yang and Wu (2012) found that multimedia-enhanced stories led to significantly better post-test performance compared to conventional instruction, while Ohler (2013) highlighted their role in fostering multiple literacies, including digital fluency and critical analysis. In mathematics and science education, digital storytelling has been shown to make abstract concepts more concrete. Banaszewski (2005) and Smeda et al. (2014) reported that multimedia narratives improved clarity and internalization of STEM concepts. Student-created digital stories also encouraged deeper reflection, creativity, and collaborative learning—important dimensions of modern pedagogy.

Immersive Storytelling: AR, VR, and AI Integration

New technologies have made possible immersive storytelling in virtual reality (VR), augmented reality (AR), and artificial intelligence (AI). Hung et al. (2012) concluded that VR storytelling expedited spatial thinking and visualization skills in mathematics, whereas Yilmaz (2016) suggested that narratives driven by AR enhanced conceptual understanding and long-term remembering. Chen and Tsai (2020) also suggested that AR narratives promoted problem-solving and interest. AR technologies, in general, have distinct advantages for teaching mathematics. Lin et al. (2018) suggested that AR apps for topics like ratios and proportions not only promoted interest but also increased performance in tests. These technologies help students interact with mathematical models in real time, bridging the gap between abstract theory and experiential learning.

AI-powered storytelling is another promising emerging strategy. Malkawi et al. (2020) observed that pacing and complexity in AI narratives could be adapted for various learning requirements. Pathak (2023) also established that math anxiety and clarity were mitigated by AI-based storytelling, particularly for learners with difficulties in numerical abstraction. Aloraini et al. (2021) added that interactive visuals in conjunction with AI narration provided personalized and effective learning in content-rich subjects. It is also possible with immersive environments for experiential learning, as Freitas and Neumann (2009) highlighted. Through the process of "learning by doing," students utilize various senses and thinking processes, so that abstract concepts in mathematics are better remembered. Liu et al. (2021) concluded that VR storytelling both elevated emotional investment and placed STEM content in contextualized scenarios that could not be achieved by traditional teaching.

For pre-service teachers, proficiency in storytelling, both conventional and digital, is coming to be regarded as a crucial competence. It prepares them to create lessons that captivate diverse learners, incorporate cultural background, and make use of contemporary tools. Pathak (2022) has exhibited the potential of

culturally responsive math storytelling in that local narratives are highly effective in reaching students and promoting deeper understanding. Integration of digital storytelling skills in pre-service teacher education equips novice teachers to manage blended and multimodal classrooms proficiently.

3. Rationale for the Present Study:

While the benefits of storytelling in education are well documented, there is limited comparative research on how oral, AI-generated, and AR-based storytelling performs relative to each other, particularly in mathematics education. Most studies address one format in isolation, leaving a gap in understanding how these approaches differ in terms of engagement, conceptual understanding, and learner preference. The present study addresses this gap by implementing three distinct storytelling interventions—oral storytelling, AI-generated video storytelling using Narakeet, and AR video storytelling using MetaSpark—in the teaching of mathematics to Class 7 students across multiple schools. By employing a mixed-methods design that combines pre- and post-tests with student feedback and supervisor evaluations, the study provides a nuanced understanding of the pedagogical potential and practical considerations of each approach. Findings from such research are particularly relevant for teacher education programs, which must prepare pre-service teachers to balance the cultural depth of oral storytelling with the clarity and scalability of AI tools and the immersive engagement of AR platforms. Integrating these competencies into teacher training can support the creation of mathematics classrooms that are both conceptually rigorous and deeply engaging.

With more than 18 years of teaching experience as a teacher educator, the researcher has continually noted that mathematics is usually seen by students in schools as a difficult and abstract subject. The perception is especially strong in the period of middle school, when basic concepts like fractions, decimals, and ratio & proportion are initially introduced. A prior study from the class (Pathak, 2022) using the approach of classroom-based action research found that storytelling orally had considerably improved the conceptual knowledge and interest in mathematics of the students. Imbedding mathematical concepts in real-life narratives aided in making abstract concepts more relatable and easily understood.

Based on these results, the author investigated means of complementing conventional oral narration with digital tools that could provide rich visual and sonic enhancements. More recently (Pathak, 2024), video narratives in general—and particularly those designed with the assistance of AI-enhanced software like text-to-speech and slide-to-video translators—were determined to yield greater retention as well as better comprehension. These tools allowed for the design of pedagogically effective, eye-catching narratives while overcoming typical difficulties experienced by student teachers, including a lack of time and restricted technological expertise. This development of concepts motivated the present study, spurred by the inquiry: Which form of storytelling-the oral recitation, the AI-produced video, or the immersive AR-video—is best for teaching mathematics? Each has different affordances: oral storytelling is individually and culturally relevant, AI-produced videos have organized and predictable delivery, and AR storytelling has immersive, interactive properties. Through comparison in real-classroom contexts within internships by teachers, the study seeks to determine the pedagogical effectiveness, practicality, and acceptability for both pupils and teachers.

4. Research Objectives:

The present study aims to:

- Compare the effectiveness of three storytelling-based pedagogical approaches—oral storytelling, AI-generated video storytelling, and augmented reality (AR) video storytelling—in teaching key mathematics concepts (fractions, decimals, and ratio & proportion) to middle school students.
- Examine the impact of each storytelling method on students' learning gains, engagement levels, and conceptual understanding.
- Evaluate the feasibility and ease of implementation of oral, AI-generated, and AR storytelling approaches during pre-service teachers' internship teaching.
- Analyze student and supervisor perceptions of each storytelling format in terms of clarity, relevance, and overall learning experience.
- Identify the storytelling approach that offers the optimal balance between pedagogical effectiveness, resource efficiency, and learner engagement in mathematics education.

5. Methodology

This study employed a quasi-experimental design with a mixed-methods approach to examine the comparative effectiveness of three storytelling modalities—oral storytelling, AI-generated video storytelling, and augmented reality (AR) storytelling—in teaching mathematics to middle school students. The participants consisted of 561 students enrolled in Class 7 across different schools, taught by 16 trainee teachers specializing in the Pedagogy of Mathematics. The instructional intervention was structured over three consecutive weeks, with each week dedicated to a specific mathematics topic delivered through a distinct storytelling format: Decimals through oral storytelling, Fractions through AI-generated videos developed using Narakeet, and Ratio & Proportion through AR-prepared story videos created in MetaSpark Studio.

For each chapter, a set of five well-structured lesson plans was used to maintain consistency in pedagogical delivery and content scope. The primary quantitative measure of learning gains was an achievement test specifically designed for each topic (MAT I, MAT II, MAT III), comprising 20 marks per test. These were administered as pre-tests and post-tests to all participating students, enabling measurement of topic-specific learning progression attributable to each storytelling method. In addition to achievement tests, student perceptions were captured through a structured feedback form administered at the conclusion of each intervention week. This dual focus on measurable learning gains and authentic learner voices provided a holistic understanding of how each storytelling mode impacted students' comprehension, motivation, and engagement in mathematics. The methodological emphasis on students' performance and perceptions ensured that findings were grounded in the learner's perspective, aligning with the study's objective of evaluating storytelling as a pedagogical tool from the end-user standpoint.

Sample (Participants):

The study involved a diverse group of participants from teacher education and school settings in Delhi, ensuring a representative sample for meaningful analysis. The intervention was conducted across 8 private

schools, each participating with two sections of Class 7 students. A total of 561 students (approx. 70 per school) were taught by 16 trainee teachers pursuing a B.Ed. program with a specialization in Pedagogy of Mathematics. These trainee teachers were placed in the schools for their internship period. Additionally, the teaching practices and classroom interactions were supervised and evaluated by 16 supervisors—comprising 8 school mentors appointed by the schools and 8 teacher educators assigned by the teacher training institution. Each participant group brought a unique perspective, allowing for a comprehensive triangulation of data from learners, teachers, and evaluators.

Participant Groups	Total	Diversification
Trainee Teachers	16	• All from Pedagogy of Mathematics; • 2 per school (8 schools); • Gender: 4 Male, 12 Female; • Qualification: 6 Postgraduates, 10 Graduates
Students (Class 7)	561	• From 8 private schools; • Each school contributed 2 sections (approx. 32–36 students each); • Gender ratio: Boys – 51%, Girls – 49%

Table 1: Sample Diversification

Intervention Design

A detailed **Intervention Design with detailed timeline** for the study, outlining the preparatory phase, teaching intervention and evaluation tool deployment over a **5-week period** was prepared as Follow:

Week	Activities	Details
Week 1	Orientation & Training – Storytelling Approaches	❖ Orientation session for 16 trainee teachers on the research study objectives and intervention plans. ❖ Hands-on workshops on: • Traditional oral storytelling techniques (voice modulation, puppetry) • Creating AI-based videos using Google Slides & Narakeet • Developing AR story videos using MetaSpark Studio.
Week 2	Lesson Planning & Content Creation	❖ Trainee teachers collaboratively develop 5 lesson plans for each of the 3 chapters: • Decimals (Oral storytelling) • Fractions (AI-generated video storytelling) • Ratio & Proportion (AR-based storytelling). ❖ Final review and approval of lesson plans and digital content by mentors.
Week 3	Intervention 1: Oral Storytelling on Decimals	❖ 5 consecutive lessons conducted using oral storytelling in all 8 schools. ❖ **Pre- and Post-test (MAT I)** administered. ❖ Observations by supervisors using rubrics.
Week 4	Intervention 2: AI Video Storytelling on Fractions	❖ 5 consecutive lessons conducted using oral storytelling in all 8 schools. ❖ **Pre- and Post-test (MAT II)** administered. ❖ Observations by supervisors using rubrics.
Week 5	Intervention 3: AR Storytelling on Ratio & Proportion	❖ 5 consecutive lessons conducted using oral storytelling in all 8 schools. ❖ **Pre- and Post-test (MAT III)** administered. ❖ Observations by supervisors using rubrics. ❖ **Student Feedback Form**

Table 2: Intervention Design

This structured timeline ensured that trainee teachers were well-prepared, each intervention had equal instructional time, and data collection tools were applied consistently and systematically.

Intervention Tools

Tool	Format	Topic	Key Features	Resource Requirements	Pedagogical Strengths
Oral Story Telling	Live narration with voice modulation and gestures	Decimals	Voice-based, flexible, low-tech, adaptable in real-time	Minimal props (puppets, flashcards), no tech dependency	Builds expression, engagement, cultural relevance, active participation
AI-Based Video Storytelling (Narakeet)	AI-generated narrated video from slides	Fractions	Converts PPT/Slides to narrated videos, multi-language voiceovers, shareable	Computer, Internet, Google Slides/PowerPoint	Enhances visualization, supports self-paced learning, improves digital content creation skills
AR-Based Video Storytelling (MetaSpark Studio)	AR-enhanced recorded videos	Ratio & Proportion	Drag-and-drop AR creation, 3D models, animations, real-world overlays	Smartphone/PC, Internet, free MetaSpark account	Makes abstract concepts tangible, fosters immersive learning, boosts creativity and tech-integration |

Table 3: Intervention Tools Description

Data Collection Tools & their Analysis

1. **Tool I: Mathematics Achievement Tests (MAT) for Students**

Achievement Tests were framed in order to check the learning of mathematical concepts by the students after they had undergone three distinct storytelling-based teaching interventions. A distinct 20-mark test for each chapter, namely, “Decimals,” “Fractions,” and “Ratio & Proportion,” was formulated and administered as both pre-test and post-test in order to check learning gains. These tests were titled MAT-I (Mathematics Achievement Test-I for Decimals), MAT-II (for Fractions), and MAT-III (for Ratio & Proportion). These tests consisted of a variety of objective-type questions, short answers, and application-based questions that matched the cognitive levels specified in the Class 7 mathematics syllabus.

For validity and reliability, all three tests were validated by a panel consisting of 8 experienced mathematics teachers, each from one of the 8 participating schools. These masters examined the tests for content coverage, congruence in learning outcomes, language clarity, and grade-suitedness. A process of test-retest reliability was initiated with a sample size consisting of 40 from a non-participating group of Class 7. The resultant reliability coefficients from the calculations of test-retest were 0.81 for MAT-I, 0.84 for MAT-II, and 0.79 for MAT-III, demonstrating a very high level of consistency and reliability in the means of measurement.

Test	Pre Test Scores		Post Test Scores		t-value	p- value
	Mean	SD	Mean	SD		
MAT-I (Decimals)	6.93	1.94	12.28	2.97	35.55	0.000
MAT-II (Fractions)	7.63	2.03	14.00	2.43	48.12	0.000
MAT-III (Ratio & Proportion)	7.27	1.92	14.92	2.60	55.34	0.000
Comparative Analysis of Post-Test Scores						
Post MAT-I Vs Post MAT-II					-10.58	0.000
Post MAT-II Vs Post MAT-III					-6.16	0.000
Post MAT-I Vs Post MAT-III					-15.83	0.000

Table 4: MAT Analysis for Students

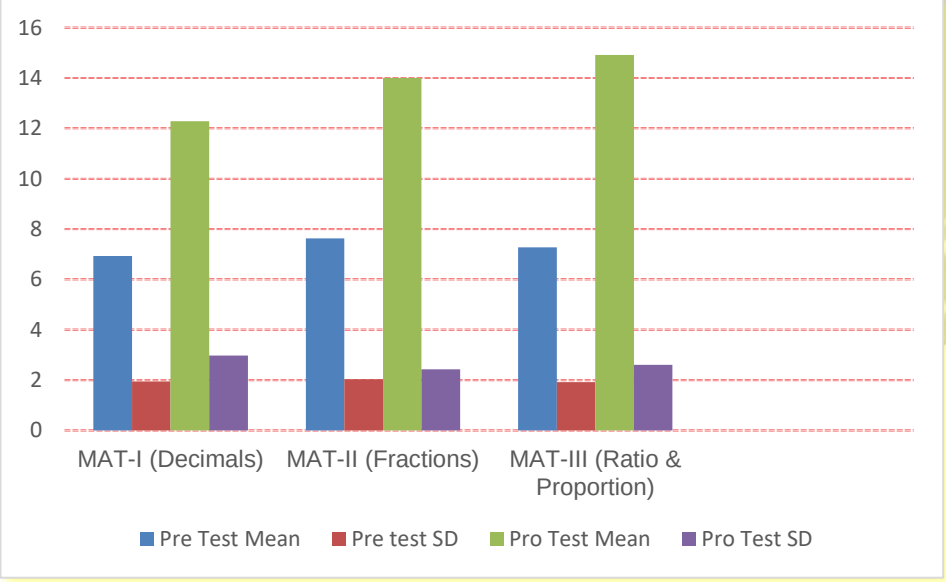

Chart-1

Interpretation

The findings indicate that all three storytelling-based interventions—Oral Storytelling (MAT-I), AI-generated Video using Narakeet (MAT-II), and Augmented Reality Story Videos (MAT-III)—were effective in enhancing students' mathematical understanding. Significant improvements in mean scores were observed

from pre- to post-tests across all groups, with p-values below 0.001, demonstrating strong statistical significance. Oral storytelling in MAT-I proved valuable in contextualizing decimals through relatable, real-world narratives; however, its overall impact was less pronounced than the other two approaches.

A comparative analysis of post-test outcomes revealed that MAT-III (AR storytelling on Ratio & Proportion) produced the highest mean score (14.92), followed by MAT-II (AI-based video on Fractions) at 14.00, and MAT-I (Oral storytelling on Decimals) at 12.28. These differences were statistically significant, with the greatest gap observed between MAT-I and MAT-III (t = -15.83), underscoring the superior effectiveness of the AR intervention. The immersive, interactive features of AR appear to substantially strengthen both comprehension and retention of complex mathematical concepts.

Although AI-narrated video lessons offered clarity, structure, and consistency, they lacked the interactivity and sensory depth provided by AR. Oral storytelling, while culturally resonant and pedagogically valuable for building conceptual connections, was comparatively limited in its engagement of multiple modalities. Taken together, the evidence highlights AR storytelling as the most impactful strategy for teaching mathematics within internship-based teacher education, balancing conceptual rigor with immersive learner engagement.

2. **Tool II: Student Feedback Form (SFF)**

The Student Feedback Form, administered at the end of the third week, was designed to capture students' subjective experiences and preferences regarding the three storytelling-based teaching interventions: Oral Storytelling (MAT-I), AI-generated Video (MAT-II), and Augmented Reality-based Story Videos (MAT-III). The tool consisted of two parts. The first part included four Likert-scale items measuring key dimensions such as Engagement, Clarity, Interest, and Overall Preference for each method, rated on a 5-point scale (1 = Very Low to 5 = Very High). The second part featured four open-ended questions aimed at collecting qualitative insights into students' perceptions. Questions included prompts like, "Which method helped you understand the topic the most and why?", "Which activity did you enjoy the most?", "What challenges did you face in any of the methods?", and "What suggestions do you have to improve the classes?"

To ensure the tool's quality and relevance, it underwent content validation by a panel of 5 experts, including two mathematics education specialists, one language and communication expert, and two experienced school teachers. They reviewed the instrument for clarity, age-appropriateness, and alignment with the objectives of evaluating pedagogical effectiveness. Based on their feedback, minor modifications were made to improve item phrasing and clarity. The final version of the tool was pilot-tested on a group of 40 students from a non-participating section of Class 7. The internal consistency reliability, calculated using Cronbach's alpha, was found to be 0.87, indicating high reliability of the Likert-scale items. This feedback tool not only provided insights into the students' learning experience but also served as an important triangulation measure alongside achievement tests and teacher reflections.

Quantitative Feedback Table (Average Likert Ratings from 561 Students)

Dimension	Oral Storytelling	AI Video-Narakeet	AR Video-MetaSpark
Engagement	3.5	4.0	4.6
Clarity	3.7	4.2	4.5
Interest	3.6	4.1	4.7
Overall Preference	3.4	4.0	4.6

Table 5: Quantitative Student Feedback Analysis

Qualitative Feedback Table

Question	Oral Storytelling		AI Video- Narakeet		AR Video- MetaSpark	
	Common Statements	Top 3 Frequent Words (%)	Common Statements	Top 3 Frequent Words (%)	Common Statements	Top 3 Frequent Words (%)
Which method helped you understand the topic the most and why?	• *"It was easy to imagine the story."* • *"The teacher made decimals feel like real-life situations."*	Story (65%), Easy (52%), Relatable (38%)	• *"The video explained step by step."* • *"The voice helped me focus on the concept."*	Visual (72%), Clear (60%), Step-by-step (44%)	• *"I could see and interact with the math objects."* • *"The animation made it easy to solve problems."*	Interactive (68%), Real (64%), Engaging (59%)
Which activity did you enjoy the most?	• *"It was fun to hear the story with puppets."* • *"I liked the way the teacher changed voices."*	Voice (48%), Puppets (43%), Funny (35%)	• *"It felt like watching a cool YouTube video."* • *"I liked how the text and voice matched."*	Voice-over (66%), Animation (52%), Cool (41%)	• *I felt like I was inside the story."* • *"The colors and movement were amazing!"*	Immersive (75%), Colors (61%), Game-like (58%)
What challenges did you face in any	• *"Sometimes I couldn't follow the numbers*	Imagine (44%), No-visual (38%),	• *"The pace was too fast in some parts."*	Fast (41%), Audio-issue	• *"My phone didn't support the app."*	Device (52%), Scan (48%),

of the methods?	*without a board."* • *"It was hard to imagine complex parts."*	Confusing (30%)	• *"Once, the audio didn't play properly."*	(36%), Skipped (28%)	• *"It was hard to scan the code sometimes."*	Glitch (35%)
What suggestions do you have to improve the classes?	• *"Use more visual aids with the story."* • *"Add videos or images to support the narration."*	Visual (59%), Add-images (45%), Combine (40%)	• *"Allow us to pause the video."* • *"Include subtitles for better clarity."*	Pause (51%), Subtitles (48%), Control (37%)	• *"Give more time to explore the AR scenes."* • *"Add a quiz at the end of AR lessons."*	Explore (64%), Quiz (52%), More-time (49%)

Table 6: Qualitative Student Feedback Analysis

Interpretation

The quantitative feedback collected through Likert-scale ratings on four dimensions—Engagement, Clarity, Interest, and Overall Preference—demonstrated a clear progression in student experience from MAT-I (Oral Storytelling) to MAT-III (AR-based MetaSpark). AR storytelling emerged as the most preferred intervention, achieving the highest mean scores across all dimensions, particularly in Engagement (4.6) and Interest (4.7). These results reflect the strength of AR in creating immersive and interactive learning experiences. AI-generated video lessons via Narakeet (MAT-II) also performed well, especially in Clarity (4.2) and Overall Preference (4.0), indicating that the combination of structured narration and visual support effectively aided student comprehension. In contrast, Oral Storytelling (MAT-I), though appreciated, received comparatively lower ratings, pointing to its limitations in sustaining attention and conveying abstract concepts without multimedia reinforcement.

The qualitative data further substantiated these findings. Students frequently described MAT-III as "fun," "real," and "interactive," with several likening it to "being inside a math video game." MAT-II was commended for its step-by-step clarity and supportive narration, while MAT-I was valued for its relatability and the warmth of live narration. However, its lack of visual aids was consistently noted as a drawback, particularly by students who struggled to visualize abstract concepts. AI-generated videos occasionally faced issues of pacing and technical interruptions, while AR was sometimes hindered by device compatibility and scanning difficulties. Despite these challenges, students overwhelmingly expressed enthusiasm for AR's immersive qualities, which they viewed as outweighing its limitations.

Taken together, both quantitative and qualitative evidence highlight AR storytelling as the most impactful approach, offering highly engaging and meaningful learning experiences. AI video-based storytelling served as an effective middle ground, balancing clarity with accessibility. Oral storytelling, while

pedagogically rich and culturally resonant, was perceived as the least effective in a digital-first learning context. These insights are particularly valuable for informing teacher training and lesson design, underscoring the importance of integrating innovative digital tools alongside traditional pedagogies.

Conclusion

This study demonstrates that storytelling, when strategically integrated into mathematics pedagogy, serves as a powerful catalyst for enhancing conceptual understanding and student engagement. All three methods examined—Oral Storytelling, AI-generated Video Storytelling, and AR-based Video Storytelling—produced significant learning gains, though with distinctive strengths. Oral storytelling humanized abstract concepts by anchoring them in student's lived experiences, reinforcing cultural relevance and narrative immersion. AI-generated video storytelling contributed visual clarity and structured explanations, supporting step-by-step comprehension. Most notably, AR-based storytelling proved to be the most effective intervention, combining immersive visuals, interactivity, and narrative coherence to achieve the highest levels of student performance and engagement.

The implications for teacher education are substantial. Pre-service teachers should be equipped not only with traditional storytelling competencies but also with the ability to design and implement digital storytelling through AI and AR platforms. Training programs would benefit from incorporating hands-on workshops in AI-driven content creation and AR-based lesson design, ensuring that teachers can adapt these tools to diverse learning contexts and varying levels of technological infrastructure. While AR offers the most substantial learning gains, AI-generated videos represent a scalable and cost-effective alternative, particularly in resource-limited environments. Oral storytelling, enhanced with simple visual aids or low-tech props, remains an accessible, culturally resonant option in classrooms where digital access is constrained.

These findings point to the importance of differentiated pedagogical training. Teacher education must prepare future educators to make context-sensitive choices regarding storytelling modalities, aligning them with curricular goals, available resources, and learner needs. Embedding student feedback analysis within training further ensures that lesson designs remain engaging, responsive, and pedagogically robust. Ultimately, the study underscores that uniting the enduring appeal of storytelling with the sensory and cognitive affordances of emerging technologies can transform mathematics learning into a more meaningful, interactive, and enduring educational experience.

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