Improving Memory Retention in Mathematics: The Effectiveness of Digital Storytelling in Teaching Circle Geometry

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Abstract

This study examined the impact of digital storytelling on the retention of circle geometry concepts among secondary school students. Using a quasi-experimental pretest-posttest non-equivalent control group design, 132 senior secondary school students from four public schools in Nsukka Local Government Area, Enugu State, Nigeria, participated. Through multistage sampling, intact classes were assigned to either an experimental or control group. The experimental group received digital storytelling-based instruction, while the control group was taught using conventional methods. Data were gathered through the Geometry Achievement Test (GAT), administered as a pretest, posttest, and retention test four weeks post-intervention. The GAT demonstrated high internal consistency, with a Cronbach's Alpha reliability coefficient of 0.83. Data were analysed using SPSS (version 29), employing mean and standard deviation to address research questions and Analysis of Covariance (ANCOVA) to test hypotheses at a 0.05 significance level. Findings indicated that the experimental group achieved significantly higher retention than the control group, confirming the effectiveness of digital storytelling as a teaching tool in mathematics. Additionally, gender had no significant effect on retention outcomes. These results suggest that digital storytelling can enhance engagement and deepen understanding of complex mathematical concepts, providing a valuable method for educators. Based on the findings, recommendations were made, one of which is that educators should integrate digital storytelling into their instructional approaches to support student learning in mathematics.

Keywords: circle geometry, digital storytelling, mathematics performance, multimedia tools, retention, secondary school learners

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Introduction

The increasing integration of technology into education has opened new pathways for improving students' engagement and learning outcomes, particularly in subjects perceived as abstract and challenging, such as mathematics (Egara & Mosimege, 2023a, 2024a, 2024b). One of the persistent difficulties students face in mathematics is the inability to retain complex concepts, especially in areas like circle geometry (Nzeadibe et al., 2020; Osakwe et al., 2022), which require both spatial reasoning and an understanding of interrelated geometric properties. In Nigeria, as in many other countries, underachievement in mathematics remains a major concern due to the dominance of teacher-centred instructional approaches that often fail to promote active participation and long-term understanding (Mosia & Egara, 2024; Okafor, Enemuo, et al., 2023; Okafor, Nosike, et al., 2023; Okeke et al., 2025).

In response to these challenges, educators are exploring innovative teaching methods that blend pedagogy with digital technology to create more meaningful and memorable learning experiences (Egara et al., 2025; Egara & Mosimege, 2023b). One such method is digital storytelling, an instructional strategy that uses the elements of storytelling (such as characters, setting, conflict, and resolution) combined with multimedia tools like images, narration, music, animations, and videos to convey content in an engaging and relatable way. According to Guler and Duman (2021), digital storytelling allows learners to connect with abstract concepts by placing them within real-life or imaginative narratives that are easier to visualise, understand, and remember.

Digital storytelling is not just about storytelling using digital tools; it is a powerful educational approach that transforms traditional instruction into a dynamic and learner-centred experience (Nasir et al., 2024). For instance, in mathematics education, a teacher might use a digital story to introduce circle geometry through a scenario where characters solve real-life problems involving circular objects, such as designing a roundabout or calculating distances along arcs. This contextualisation can help students better grasp the relevance and application of mathematical concepts (Lawani, 2023; Tosun & Engin, 2023).

The benefits of digital storytelling in education are well-documented. It promotes active learning**,** stimulates interest**,** supports multiple learning styles, and enhances the retention of information by combining audio-visual stimulation with emotional and cognitive engagement (Büyükkarci & Müldür, 2022). It also encourages creativity, critical thinking, and communication skills among students who participate in creating or analysing digital stories (Tosun & Engin, 2023). However, challenges exist. These include the availability of technological infrastructure, especially in under-resourced schools, teacher competence and training in using digital tools, and the time-consuming nature of creating high-quality digital stories (Chaisriya et al., 2023). Additionally, without careful instructional planning, digital storytelling may risk shifting focus from learning objectives to entertainment, thus reducing its effectiveness in achieving educational outcomes (Robin, 2008). Despite these challenges, digital storytelling presents a valuable opportunity for addressing the limitations of conventional mathematics instruction. In Nigeria, where technological adoption in schools is still evolving, there is a pressing need for empirical studies investigating the practical effectiveness of digital storytelling in real classroom settings.

Several studies have examined digital storytelling's impact on students' retention, though mostly outside mathematics and at non-secondary levels. Dös (2015), working with

university students in Turkey, found that creating digital stories in various disciplines improved long-term knowledge retention, especially for complex topics. Similarly, Aktas and Yurt (2017) investigated digital storytelling in a university science course and observed improved achievement and retention compared to traditional methods. Özkaya and Coşkun (2019) studied 8th-grade students learning Turkish language concepts at the basic education level. Their findings showed that digital storytelling enhanced retention by simplifying abstract ideas. Using secondary school students in Thailand, Chaisriya et al. (2023) integrated digital storytelling into a language and communication course, emphasising its role in boosting metacognition and retention. Ginting et al. (2024) explored digital storytelling across disciplines in Indonesian universities and concluded that it improved retention and knowledge transfer.

While these studies affirm the benefits of digital storytelling, no known studies have investigated its application in mathematics, particularly in circle geometry at the senior secondary school level. Similarly, gender-based differences in retention outcomes within this context remain unexplored. This clear gap highlights the need for subject-specific and localised research, which the present study seeks to address. This study aims to investigate the effectiveness of digital storytelling in improving students' retention of circle geometry concepts and to determine whether gender plays a role in retention when this instructional method is employed. Thus, the study seeks to address the following questions:

1. What is the effect of digital storytelling on the retention scores of senior secondary school learners in circle geometry, compared to the conventional method?
2. What is the effect of gender on the retention scores of learners taught circle geometry using digital storytelling?

Based on the research questions, the study tested the following null hypotheses at a 0.05 level of significance:

1. There is no statistically significant difference in the retention scores between learners taught circle geometry through digital storytelling and those taught using the conventional method.
2. There is no statistically significant difference in the retention scores of male and female learners exposed to digital storytelling in learning circle geometry.

Theoretical Basis

This study is grounded in Richard E. Mayer's *Cognitive Theory of Multimedia Learning* (2009), which posits that learners understand and retain information more effectively when presented using visual and auditory channels. The theory is based on three key assumptions: that learners process information through two separate channels (dual-channel), each with limited capacity, and that meaningful learning occurs when learners actively engage with content by selecting, organising, and integrating information. Digital storytelling aligns well with this theory, combining narration, visuals, and text to stimulate both channels simultaneously. In the context of teaching circle geometry, this multimedia approach helps learners form mental models of abstract concepts, improving comprehension and long-term retention. Thus, the theory supports the study's focus on enhancing memory retention by integrating digital storytelling in mathematics instruction.

Methods

A quasi-experimental pretest-posttest non-equivalent control group design was adopted. The experimental group received instruction on circle geometry using digital storytelling, while the control group was taught conventionally. Pretests, posttests, and a retention test (administered four weeks later) were used to assess achievement and long-term retention. The population comprised all SSS 1 students in Nsukka LGA, Enugu State. Using multistage sampling, 132 students from four public secondary schools with requisite digital facilities were selected. Schools were randomly assigned to experimental (n = 68) and control (n = 64) groups using intact classes. Data were collected using a 30-item Geometry Achievement Test (GAT), covering key circle geometry theorems. A Table of Specifications guided item alignment with curriculum objectives. The GAT served as pretest, posttest, and retention test. Three experts validated the GAT and lesson plans; a pilot test produced a KR-20 reliability of 0.83.

The study followed a three-phase approach: pretest, intervention, and posttest (including a delayed retention test). Before the intervention, a two-week training was provided to participating teachers. Those in the experimental group were trained on digital storytelling tools (e.g., Canva, Sway, GeoGebra) and strategies like role-play, interactive storytelling, and gamified assessment. Control group teachers received a refresher on conventional teaching methods. All teachers held at least a B.Sc. (Ed) in Mathematics and had a minimum of five years of experience. Students first completed a GAT to establish baseline knowledge. During the five-week intervention, both groups were taught the same circle geometry topics across four weekly periods but with different methods. The experimental group used digital storytelling to introduce topics, engaged with interactive tools, created digital stories, and completed gamified assessments. The control group received traditional instruction using chalkboard explanations, textbook examples, and past WAEC questions. Each week focused on a specific concept in circle geometry, including theorems on angles at the centre and circumference, angles in the same segment, angles in a semicircle, cyclic quadrilaterals, and the alternate segment theorem. After the intervention, the GAT was re-administered as a posttest. Four weeks later, a delayed retention test (with reshuffled GAT items) assessed long-term retention. Data collected were analysed using SPSS version 29. Mean and standard deviation addressed research questions. ANCOVA at $\alpha = 0.05$ tested hypotheses, controlling for pretest scores. Shapiro-Wilk tests confirmed normality for achievement ($W = 0.98$, $p = .421$) and retention ($W = 0.97$, $p = .315$).

Results

The presentation of findings is in line with the research questions and hypotheses.

Research Question One

What is the effect of digital storytelling on the retention scores of senior secondary school learners in circle geometry, compared to the conventional method?

The analysis reveals that learners taught with digital storytelling (n = 68) achieved a higher mean posttest score (M = 93.37, SD = 5.87) and retention score (M = 95.97, SD = 3.67), with a mean gain of 2.6. In contrast, the conventional group (n = 64) had lower posttest (M = 64.70, SD = 6.85) and retention scores (M = 64.08, SD = 6.73), showing a slight decrease of

0.62. This indicates that digital storytelling positively affected learners' retention of circle geometry concepts. The test of Hypothesis 1 would ascertain this finding.

Hypothesis One

There is no statistically significant difference in the retention scores between learners taught circle geometry through digital storytelling and those taught using the conventional method.

The ANCOVA results reveal a significant difference in retention scores between students taught circle geometry using digital storytelling and those taught by the conventional method ($F(1, 127) = 77.976$, $p < .05$). This indicates that digital storytelling substantially improves retention compared to traditional instruction. With a moderate effect size (partial eta squared = .380), the instructional method accounts for 38% of the variance in retention scores. Consequently, the null hypothesis is rejected, confirming that the teaching approach significantly influences learners' retention.

Research Question Two

What is the effect of gender on the retention scores of learners taught circle geometry using digital storytelling?

Male learners taught circle geometry using digital storytelling had a posttest mean score of 93.30 (SD = 5.43) and a retention mean score of 95.39 (SD = 3.95), showing a mean difference of 2.09. Female learners scored slightly higher, with a posttest mean of 93.43 (SD = 6.33) and a retention mean of 96.51 (SD = 3.34), resulting in a mean difference of 3.08. Both groups demonstrated strong retention of the concepts, with females exhibiting a marginally greater improvement over time. The test of hypothesis two will confirm whether this observed difference in retention between male and female learners is statistically significant.

Hypothesis Two

There is no statistically significant difference in the retention scores of male and female learners exposed to digital storytelling in learning circle geometry.

The ANCOVA analysis revealed no significant difference in retention scores between male and female learners taught circle geometry through digital storytelling ($F(1, 127) = 0.524$, $p = .470$). This indicates that gender does not significantly impact students' retention of the material. Consequently, the null hypothesis is not rejected, affirming that retention scores are similar for male and female learners in this instructional context.

Discussion

The study examined the effect of digital storytelling on the retention of senior secondary school learners in circle geometry, compared to the conventional teaching method. As reported by the first hypothesis, the findings revealed that learners taught circle geometry using digital storytelling had significantly higher retention scores than those taught with the conventional method. This indicates that digital storytelling effectively enhances learners' retention of geometric concepts. This positive effect might be attributed to the multimedia nature of digital storytelling, which engages learners through visual, auditory, and narrative

components. Such multimodal learning helps simplify complex or abstract ideas, making them more relatable and easier to internalise. The narrative structure also promotes deeper cognitive engagement and motivation, which is essential for long-term retention.

The finding aligns with earlier research by Dös (2015) and Aktas and Yurt (2017), who found that digital storytelling enhanced retention among university students. Özkaya and Coşkun (2019) reported similar effects with 8th graders in language learning. Chaisriya et al. (2023) noted improved metacognition and retention at the secondary level, while Ginting et al. (2024) confirmed its effectiveness across university disciplines. Collectively, these studies support digital storytelling as a strong tool for enhancing student retention. The results align with the Cognitive Theory of Multimedia Learning (Mayer, 2009), which suggests that learning improves when information is presented through visual and auditory channels. Digital storytelling leverages this by integrating narrative and multimedia elements, facilitating effective encoding and retrieval of geometric concepts.

Regarding gender, the study found no significant difference in retention scores between male and female learners taught with digital storytelling. This suggests that the method is equally effective across genders, supporting inclusive pedagogy. Although no prior studies specifically explored gender differences in retention using digital storytelling, our findings align with the Cognitive Theory of Multimedia Learning (Mayer, 2009)**.** This theory posits that learners, regardless of gender, process information more effectively when content is presented through well-integrated verbal and visual channels. Digital storytelling leverages this principle by reducing cognitive overload and enhancing engagement, allowing all learners to retain complex mathematical concepts more efficiently. Thus, the instructional design, rather than gender, is the key factor influencing retention.

Conclusion

This study investigated the effect of digital storytelling on senior secondary school learners' retention in circle geometry. Findings revealed that learners taught with digital storytelling significantly retained the circle geometry concepts more than those taught with the conventional method. Additionally, gender did not significantly influence retention outcomes, suggesting that digital storytelling is an inclusive instructional approach. These results underscore the potential of digital storytelling to enhance conceptual understanding and long-term retention in mathematics, particularly in abstract topics like circle geometry. While the findings indicate that digital storytelling can effectively enhance retention in circle geometry across gender, these results should be interpreted cautiously. The study's focus on a limited geographic region and a single mathematical topic means the conclusions may not apply universally. Broader studies are needed to confirm these outcomes across varied settings and mathematical domains. Despite these limitations, the findings offer important educational implications. Teachers and curriculum planners should integrate digital storytelling into mathematics instruction as an evidence-based strategy for enhancing students' retention of complex concepts. Since retention supports long-term academic success, especially in abstract topics like circle geometry, embedding multimedia tools can improve learning outcomes. Educational stakeholders, including policymakers, should consider professional development programs that train teachers in digital storytelling techniques. Future research should explore a broader range of mathematical topics and include qualitative data to understand better how digital storytelling facilitates retention across diverse learner groups.

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