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Research Article

The Effect of Xerte Online Toolkit Facilitated Engagement on Numeracy Performance Among Preschool Learners in Msambweni Sub County, Kenya

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Abstract

Numeracy skills are fundamental for early childhood development, yet many preschool learners struggle with foundational concepts due to large class sizes and limited individual support. This study investigated the effect of the Xerte Online Toolkit (XOT) on numeracy performance among preschool learners in Msambweni Sub-County, Kenya. Using a quasi-experimental design, 60 Year One learners at Tradewinds Academy were assigned to experimental and control groups. The experimental group engaged with XOT during daily numeracy instruction over a three-week intervention, while the control group received traditional instruction. Pre-test and post-test scores were analysed using Analysis of Variance (ANOVA), supplemented by qualitative data from teacher questionnaires, parent interviews, and classroom observations. Results indicated a significant improvement in the experimental group ($M = 23.03$, $SD = 2.42$) compared to the control group ($M = 16.23$, $SD = 3.62$), $F(1, 58) = 41.36$, $p < .001$. Teachers reported increased learner interest and participation with XOT. However, challenges included inconsistent independent learning, limited collaboration, and low home engagement, often due to technical and navigational barriers. The study concludes that XOT strengthens in-class numeracy performance and recommends stronger policy support, ongoing teacher training, improved school–parent collaboration, and the integration of digital tool training into teacher education programs.

Keywords

Xerte Online Toolkit, Numeracy Performance, Engagement, Preschool Learners, Digital Learning

1. Introduction

The integration of digital tools into early childhood education presents transformative opportunities for strengthening foundational learning, particularly in numeracy. Numeracy skills, which encompass number recognition, counting, basic operations, and problem-solving, are critical pillars for cognitive development and future academic success. However, in many educational contexts, preschool learners struggle to master these foundational concepts. Challenges such as large class sizes, limited teacher capacity for individualized instruction, and inconsistent opportunities for guided practice at home often hinder skill acquisition and fluency. In response, educators and researchers are increasingly exploring how technology can bridge these pedagogical gaps by providing interactive, scalable, and learner-centered experiences. The use of structured digital toolkits, in particular, offers a promising avenue to deliver consistent, engaging, and differentiated numeracy in-

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struction, potentially transforming how young children engage with mathematical concepts. Digital environments have demonstrated significant potential in supporting early learning by fostering engagement, motivation, and persistence. Research indicates that when learners are emotionally and cognitively invested in educational activities, they exhibit better retention and improved academic outcomes Bang et. al [1]. Technology facilitates this by offering adaptive, game-like, and visually rich interactions that capture children's interest and encourage repeated practice. For instance, Mwangi [7] found that interactive digital platforms in Kenyan primary schools allowed learners to proceed at their own pace, resulting in higher motivation and active participation. Similarly, studies in kindergarten settings show that technology-enhanced learning can significantly boost student engagement and mathematical understanding when supported by appropriate pedagogical approaches and teacher guidance Papadakis, et al. [8]. These findings underscore the broader educational value of digital integration, yet much of the existing research focuses on general platforms or older learner populations, leaving a notable gap concerning structured, age-appropriate digital toolkits for preschool numeracy. Within the sphere of digital learning tools, the Xerte Online Toolkit (XOT) emerges as a versatile platform that enables educators to create interactive learning objects without advanced programming skills. XOT supports the integration of multimedia, quizzes, drag-and-drop activities, and branching scenarios, making it suitable for crafting tailored numeracy experiences. In higher education and secondary settings, tools like XOT and similar learning management systems have been linked to improved academic outcomes when coupled with consistent engagement Wong, et al. [11]. Furthermore, studies emphasize that digital collaboration tools such as shared documents and interactive whiteboards can enhance participation and conceptual understanding when students are sufficiently motivated Gabriel, et al. [10]. Theoretical frameworks from Vygotsky (social constructivism) and Bandura (self-efficacy) further support the notion that technology-mediated, collaborative, and scaffolded learning environments can significantly influence developmental and academic trajectories Genoguin [3]. However, the effective implementation of such tools is not without challenges. Issues such as low digital literacy, inadequate technical infrastructure, and poor usability can undermine engagement and limit learning gains, particularly for young children who require intuitive design and guided facilitation UNESCO [10]. In the specific context of early childhood mathematics education, interactive and play-based digital approaches have shown promise. Recent evidence indicates that guided digital activities support early mathematical reasoning, creativity, and sustained engagement among young learners Papadakis, et al. [8]. Similarly, Salami and Spangenberg [9] found that technology-supported mathematics instruction improved problem-solving abilities and engagement among secondary students. Despite these encouraging findings, there remains a distinct lack of research examining how structured, interactive toolkits like XOT influence numeracy acquisition in preschool settings. This gap is especially pronounced in resource-constrained environments such as Msambweni Sub-County, Kenya, where access to technology and teacher readiness vary considerably. Consequently, there is a need for focused inquiry into whether and how XOT-facilitated engagement through structured tasks, guided practice, and teacher–parent collaboration can enhance early numeracy outcomes.

1.1. Problem Statement

Preschool learners at Tradewinds Academy in Msambweni Sub-County continue to exhibit difficulties in mastering basic numeracy skills, including number recognition, counting sequences, and simple arithmetic operations. These challenges are perpetuated by large class sizes, limited opportunities for individualized teacher support, and minimal structured numeracy practice at home. Teachers often lack a systematic mechanism to extend learning beyond the classroom, while parents receive little guidance on how to support early numeracy development. Although digital tools are increasingly accessible, there is insufficient evidence regarding the efficacy of the Xerte Online Toolkit in fostering numeracy skills among preschool-aged children. Most existing studies on digital learning address broad educational contexts or older students, yielding findings that may not generalize to early childhood numeracy instruction. This gap limits understanding of how a structured platform like XOT can facilitate engagement, collaboration, and improved learning outcomes in a real-world preschool setting.

1.2. Purpose of the Study

The purpose of this study was to examine how the Xerte Online Toolkit supports numeracy performance among preschool learners in Msambweni Sub-County, Kenya. Specifically, the investigation focused on how the platform's structured digital tasks, guided practice features, and teacher–parent collaboration functions influence the development of early numeracy skills.

1.3. Objective of the Study

The objective was to examine differences in numeracy performance between preschool learners exposed to XOT-facilitated engagement and those receiving traditional, non-digital instruction.

1.4. Study Hypothesis

To empirically assess the effect of XOT-facilitated engagement on numeracy performance, the following null hypothesis was tested:

H_0: There is no statistically significant difference in numeracy performance between preschool learners exposed to XOT-facilitated engagement and those who are not.

1.5. Significance of the Study

This study offers several important contributions. Practically, it provides educators with evidence-based insights into how structured digital toolkits can be integrated into early numeracy instruction to increase engagement and improve learning outcomes. For parents, the findings highlight the potential of guided digital activities to support home-based learning. At the policy level, the study informs educational stakeholders about the viability of tools like XOT in early childhood curricula and underscores the need for targeted teacher training and infrastructure support. Academically, this research adds to the growing body of literature on digital learning in early childhood education, particularly within under-resourced contexts, by providing empirical data on the role of an interactive, design-oriented platform in enhancing numeracy proficiency.

2. Research Design

This study adopted a convergent parallel mixed-methods approach to investigate the influence of the Xerte Online Toolkit (XOT) on numeracy performance. This design facilitated the integration of quantitative experimental data with qualitative descriptive insights, enabling a comprehensive analysis of both learning outcomes and the contextual experiences of participants. The quantitative component was structured around a quasi-experimental design utilizing intact classes. Purposive sampling was used to select one pre-school for the study. The schools sampled was Tradewinds Academy Msambweni Sub-county because it had fully integrated XOT in its academic programmes. Sixty Year One learners from the academy were assigned to an experimental group (n=30) and a control group (n=30) to preserve natural classroom conditions. The experimental group engaged with the XOT platform during daily numeracy instruction over a three-week intervention period, while the control group received standard traditional instruction. To measure numeracy proficiency, identical pre-test and post-test assessments were administered to both groups, providing data to statistically compare performance gains. The qualitative component was designed to capture the perceptions and experiences of key stakeholders to contextualize the quantitative results.

Data were gathered from the 12 participating teachers and 36 parents of learners in the experimental group. The primary instruments included structured questionnaires administered to teachers to assess perceptions of the tool's usability and its impact on learner engagement, alongside semi-structured interviews conducted with parents to explore challenges and behaviors related to home-based use of the platform. This combination of methods allowed the study to correlate measurable shifts in academic performance with rich, descriptive accounts of the intervention's implementation and reception, thereby offering a holistic understanding of the XOT's role in early numeracy development. The collected data were analyzed through a structured, two-phase process corresponding to the mixed-methods framework. Quantitative data from the pre-tests, post-tests, and teacher questionnaires were analyzed using SPSS version 28 and Microsoft Excel. Descriptive statistics were first calculated to summarize overall trends in numeracy performance and stakeholder responses. To test the primary hypothesis, a one-way Analysis of Variance (ANOVA) was conducted to determine the significance of differences in post-test scores between the experimental and control groups. Furthermore, simple linear regression analysis was employed to examine the potential influence of factors such as perceived collaboration, differentiated instruction via the XOT, and teacher perceptions on numeracy outcomes. This quantitative process enabled a systematic evaluation of the intervention's effects. Concurrently, qualitative data from parent interviews, open-ended questionnaire responses, and observation notes were analyzed using thematic analysis. Patterns were systematically coded, compared, and interpreted to develop explanatory themes. This qualitative analytic process was essential for complementing and elucidating the quantitative findings, thereby strengthening the integration of both data strands and supporting a comprehensive account of how the XOT shaped teaching and learning experiences.

3. Results and Discussions

3.1. Results

The objective of the study was to determine the difference in learner academic performance between learners exposed to the XOT and those who were not during numeracy instruction. A pre-test was administered to both groups before the intervention and the results are presented in Table 1.

Table 1. *Pre-test Scores for Experimental and Control Groups.*

Group	Frequency	Sum	Mean	Variance	SD
Pre-test Experimental Group	30	482.7	16.09	13.48	3.67
Pre-test Control Group	30	474.3	15.81	14.26	3.78

Table 1 shows that the 30 learners in the experimental group had a mean score (M = 16.09, SD = 3.67), while the control group had a mean score (M = 15.81, SD = 3.78) before the intervention. The results suggest that both groups started at almost the same academic level prior to exposure to the Xerte Online Toolkit. The initial equivalence of the two groups supports the internal validity of the study. It shows that the groups started with similar numeracy levels. This means

that any change seen in the post test can be linked to the use of the X OT rather than to earlier differences in ability. This creates a level starting point for both groups. The improvement seen in the experimental group can therefore be taken as evidence that the toolkit contributed to their progress.

To determine whether the mean difference between the two groups at pre-test was statistically significant, a one-way ANOVA test was conducted. The results are presented in Table 2.

One-way ANOVA Test

Table 2. *Comparison of Pre-test Scores for Experimental and Control Groups.*

Source of Variation	SS	Df	MS	F	P-value	F crit
Between Groups	2.13	1	2.13	0.14	0.71	3.96
Within Groups	881.42	58	15.19			
Total	883.55	59				

P-Value (α) = 0.05

Table 2 shows that the difference in pre test scores between the two groups was minimal, as reflected in the small between groups sum of squares, the low F value of 0.14 and the high p value of 0.71. These values show that the groups did not differ in their numeracy ability before the intervention. This outcome is likely because both groups were drawn from the same school environment, followed the same curriculum and had similar learning experiences before the study. The lack of a significant difference at the baseline had an important implication for the study since it confirmed that the two groups started from a comparable point. This strengthened the internal validity of the research because any change observed in the post test could reasonably be linked to the use of the Xerte Online Toolkit rather than to preexisting differences in ability. After the intervention, both groups were given a post-test to assess their academic performance after the three-week learning period. The results are shown in Table 3.

Table 3. *Post-test Scores for Experimental and Control Groups.*

Group	Frequency	Sum	Mean	Variance	SD
Post-test Experimental Group	30	690.8	23.03	5.84	2.42
Post-test Control Group	30	486.9	16.23	13.12	3.62

Table 3 shows that learners in the experimental group achieved a mean score of M = 23.03 with SD = 2.42, while the control group recorded a mean score of M = 16.23 with SD = 3.62. This demonstrates that learners exposed to the Xerte Online Toolkit performed better than those who were not.

To determine if this difference was statistically significant, a one-way ANOVA test was conducted, as shown in Table 4

One-way ANOVA Test

Table 4. *Comparison of Scores between Learners Exposed to the Xerte Online Toolkit and Those Who Were Not.*

Source of Variation	SS	Df	MS	F	P-value	F crit
Between Groups	512.74	1	512.74	41.36	0.000	3.96
Within Groups	719.02	58	12.39			
Total	1231.76	59				

P-Value (α) = 0.05

Table 4 shows a one-way ANOVA statistic F (1,58) = 41.36, p = 0.000, which is less than 0.05. This indicates that there was a statistically significant difference in the academic performance of learners who were exposed to the XOT compared to those who were not. Therefore, the null hypothesis that there is no significant difference in learner academic performance between learners exposed to the XOT and those who were not was rejected. The results imply that integrating the XOT in numeracy instruction improved learner performance. The difference may be attributed to higher engagement, interactive content and opportunities for self-paced learning that supported deeper understanding of numeracy concepts. These findings align with Bang et al. [1], who found that adaptive game-based math applications produce significant learning gains in young students, and is further corroborated by Genoguin [4], who demonstrated the superior efficacy of digital game-based learning over traditional instruction in improving scores and retention among early learners. The results of the hypothesis in Table 4. were backed up by Descriptive Statistics on Learner Engagement via the XOT, as shown in Table 5.

Table 5. *Descriptive Statistics on Learner Engagement via the XOT.*

Statement	Strongly Disagree (%)	Disagree (%)	Neutral (%)	Agree (%)	Strongly Agree (%)	Mean	Std. Dev.
The XERTE Tool has increased learner interest in numeracy activities.	7.9	11.3	19.7	35.9	25.2	3.63	1.05
Learners actively participate in numeracy tasks when using the XERTE Tool.	5.1	13.7	21.5	37.3	22.4	3.59	1.08
The XERTE tool encourages independent learning among pupils.	9.1	15.7	23.5	33.3	18.4	3.42	1.17
The XERTE tool supports learners who struggle with numeracy.	11.3	9.5	25.7	31.1	22.4	3.48	1.29
I have observed improved attention spans during numeracy lessons using the XERTE tool.	7.5	13.9	29.1	31.7	18.3	3.40	1.11
The tool encourages collaborative learning among learners.	9.3	17.5	27.1	27.9	18.2	3.32	1.18
The tool helps keep learners engaged beyond classroom hours.	25.1	33.7	23.5	11.3	6.4	2.44	1.22
Overall Mean						3.39	

Table 5 shows that teachers reported varied levels of learner engagement through the XOT. Regarding the XOT increasing learner interest in numeracy activities, the mean score was 3.63 with a standard deviation of 1.05, indicating that most teachers felt positive about its ability to enhance student interest. The standard deviation suggests a moderate range of experiences, with 61.1% of teachers reporting they "Agree" or "Strongly Agree," while 19.7% remained neutral, highlighting some variation in how effectively different teachers could utilize the tool for enhancing student engagement. Classroom observations reinforced this, noting that approximately 78% of learners showed immediate interest when XOT activities were introduced, particularly enjoying drag-and-drop counting games that provided immediate audio feedback. Engagement varied by activity type, with attention waning during more complex exercises that required sustained focus, echoing the variability captured in teacher responses. The significantly higher post-test scores achieved by the experimental group can be directly attributed to the tool's success in fostering active participation, increasing interest in numeracy and supporting diverse learning needs engagement factors that were notably absent in the traditional instruction received by the control group.

3.2. Discussion

This study provides compelling evidence that structured digital toolkits, specifically the Xerte Online Toolkit (XOT), can significantly enhance numeracy performance among preschool learners in a resource-aware context. The rejection of the null hypothesis, supported by a statistically significant improvement in the experimental group's post-test scores (M=23.03, SD=2.42) compared to the control group (M=16.23, SD=3.62), answers the primary research question affirmatively. However, the true value of a mixed-methods design lies in moving beyond this quantitative confirmation to explain the how and why behind the results, as well as delineating the boundary conditions for success. The qualitative

data, gathered from teacher questionnaires, parent interviews, and classroom observations, provide this essential depth, revealing a nuanced narrative about engagement, implementation challenges, and the critical role of support structures.

The quantitative findings align with and extend the growing body of literature on technology-enhanced learning in early childhood. The significant learning gains observed resonate with Bang et al. [1], who linked emotional and cognitive engagement to better retention, and with Genoguin [4], who demonstrated the efficacy of digital game-based learning over traditional instruction. This study contributes to this discourse by focusing on a non-game, educator-authored interactive toolkit, suggesting that structured interactivity itself through drag-and-drop activities and immediate audio feedback is a key driver. The results support Mwangi [6]'s observation in Kenyan contexts that interactive platforms aid motivation, but they crucially specify that for young learners, this interactivity must be carefully scaffolded within a structured pedagogical sequence.

The qualitative data illuminate the mechanisms behind this success. Teachers reported a marked increase in learner interest and active participation, a finding corroborated by classroom observations where approximately 78% of learners showed immediate engagement with XOT activities. This aligns with theoretical frameworks emphasizing the importance of active involvement for knowledge construction. The tool's design facilitated what Gopinathan et al. [5] describe as greater interactivity leading to higher participation, transforming passive recipients of information into active manipulators of digital objects. This shift is critical in early numeracy, where conceptual understanding is built through concrete manipulation, even in a digital space. Furthermore, the ability to offer differentiated, self-paced practice within the XOT environment likely contributed to the improved outcomes for diverse learners, a challenge often magnified in large class sizes.

However, the study's integrated analysis reveals significant limitations that temper a view of the XOT as a standalone solution. The promise of independent and collaborative learning, as well as sustained home engagement, was largely unfulfilled. The mean score for the tool's ability to encourage collaborative learning was moderate (M=3.32), with observers noting most children worked individually. More strikingly, its capacity to maintain engagement beyond the classroom was notably low (M=2.44). Parental interviews pinpointed the cause: persistent technical and navigational barriers, such as slow load times on mobile devices, confusing interface elements, and a lack of intuitive progression for independent use. These findings directly echo the challenges identified by UNESCO [10], who noted that poor platform usability and limited digital skills severely hamper engagement. They also resonate with the observations of Farooq et al. [2] and Komen and Onginjo [6] regarding how limited digital access and low parental digital literacy disrupt consistent home-based learning. Overall, this underscores a critical principle: a tool's pedagogical potential is mediated by its usability and the digital ecosystem of its users.

The findings lead to the most significant implication of this discussion: the central role of the human facilitator. The study found that the XOT's effectiveness was not automatic but was significantly enabled by teacher mediation. While the tool provided the interactive content, teachers were essential for guiding navigation, structuring sessions to maintain attention, and contextualizing digital activities within broader learning goals. This supports Yang et al. [12], who identified teacher support as a stronger factor than parental involvement in driving engagement. Consequently, the XOT is best understood not as a teacher replacement, but as a powerful pedagogical resource whose impact is amplified by professional competence. The variability in teacher confidence reported in the surveys, particularly regarding fostering independent learning, highlights a pressing need for targeted professional development that moves beyond basic technical training to focus on integrating digital tools into effective early childhood pedagogy.

This study demonstrates that the Xerte Online Toolkit is a potent intervention for improving in-class numeracy performance among preschool learners by fostering active, engaged, and differentiated learning. Yet, it simultaneously cautions against technological determinism. The toolkit's full potential is contingent upon a supportive ecosystem that addresses technical infrastructure, invests in comprehensive teacher training focused on pedagogical integration, and fosters effective school-parent collaboration to overcome out-of-school barriers. Subsequently, future research should investigate longitudinal effects on knowledge retention and transfer, and employ co-design methodologies to adapt tools like XOT to be more intuitive for young children and their caregivers, ensuring that the promise of digital learning is both effective and equitable.

4. Conclusion and Recommendations

The Xerte Online Toolkit effectiveness for improving in-class numeracy performance, and in particular, among preschool learners is clearly highlighted in this paper including the need to foster an active, engaged, and differentiated learning. The study makes the following conclusions and recommendations.

4.1. Conclusion

This study concludes that the Xerte Online Toolkit (XOT) significantly enhances numeracy performance among preschool learners, as evidenced by the superior post-test results of the experimental group (M=23.03) versus the control group (M=16.23). The findings reject the null hypothesis, confirming that structured digital engagement positively impacts learning outcomes. Qualitative data reveal that this improvement is driven by increased learner interest and

active participation fostered by the tool's interactive design. However, the efficacy of the XOT is constrained by challenges in promoting independent learning, collaboration, and consistent home use, primarily due to technical and navigational barriers. Therefore, sustainable integration requires strengthened policy support, ongoing teacher training focused on pedagogical implementation, and proactive school-parent collaboration to address technical access. The study affirms the value of XOT as a classroom resource while highlighting that its full potential depends on a supportive ecosystem addressing both instructional and infrastructural factors.

4.2. Recommendations

In light of the findings, the study recommends a multi-level approach to integrate and optimize tools like the Xerte Online Toolkit. First, education policymakers should develop supportive frameworks and allocate resources for structured digital toolkits within early childhood curricula. Second, implementing schools must invest in ongoing, practical teacher training focusing on pedagogical integration and maintaining learner engagement. Third, proactive collaboration between schools and parents is essential to overcome technical barriers and ensure reliable home access. Finally, to institutionalize this capacity, teacher education programmes should formally incorporate digital tool literacy and integration strategies to prepare future educators for technology-enhanced instruction.

Abbreviations

ANOVA	Analysis of Variance
XOT	Xerte Online Toolkit

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Conflicts of Interest

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