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Evaluating the Effectiveness of Khan Academy for Fraction Word Problem Solving: A Mixed-Methods Study in Remote Indonesian Elementary Schools

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Abstract
This mixed-methods study investigates the effectiveness of Khan Academy in improving fifth-grade students' ability to solve fraction word problems in a remote primary school in East Java, Indonesia. FouTwenty-four students participated in a quasi-experimental pretest-posttest design, supported by qualitative interviews with the classroom teacher. Quantitative results indicated a paradoxical outcome: although 86% of students expressed positive attitudes toward the platform, the class average decreased slightly from 37.14 to 34.29, with an increased standard deviation from 15.67 to 16.47. Only 36% of students improved their scores, while 43% experienced notable declines. These findings suggest that initial technological engagement does not guarantee improved academic performance, particularly in under-resourced settings where digital fluency and mathematical foundations are limited. Qualitative analysis revealed that while students favored features such as audio feedback and step-by-step guidance, many struggled with contextual understanding of word problems. Teacher insights highlighted the importance of scaffolding and cultural adaptation in content delivery. The study concludes that Khan Academy holds potential for enhancing learning but requires thoughtful integration with teacher-led instruction, contextual relevance, and differentiated support. This research contributes to the growing discourse on equity and contextualization in digital education, particularly in remote and underserved communities. It also emphasizes the need for blended pedagogical models that bridge the gap between digital enthusiasm and conceptual understanding.

INTRODUCTION

Digital technology has significantly reshaped the landscape of education, enabling personalized learning experiences, interactive content delivery, and increased accessibility for students across diverse contexts (Liriwati, 2023). Educational technology (EdTech) platforms have gained traction worldwide as tools that promote student engagement and foster higher-order thinking skills (Mokalu et al., 2022). However, the integration of such tools in remote and resource-constrained settings presents challenges related to infrastructure, teacher capacity, and digital literacy. In Indonesia, the digital divide remains a pressing concern, particularly in rural and remote areas where connectivity, device availability, and pedagogical support are limited. While urban schools may benefit from modern infrastructures and pedagogical innovations, rural schools are often left behind in the wave of digital transformation (Solihin & Rahmawati, 2024). Consequently, it is imperative to explore how EdTech interventions perform in peripheral educational environments. This study responds to that imperative by focusing on the use of Khan Academy in a remote Indonesian primary school. Specifically, it investigates whether the platform supports students' ability to solve fraction word problems—an essential yet challenging skill in elementary mathematics (Park & Kang, 2025).

Fractions represent a critical concept in elementary education, forming the foundation for proportional reasoning, algebra, and advanced mathematics. Yet, research consistently shows that students, especially those in low-resource contexts, face difficulties in understanding and applying

fraction concepts in real-world problems (Pikunni & Chonchaiya, 2024). One core issue is the disconnection between abstract mathematical representations and students' everyday experiences. Khan Academy, with its modular video explanations, practice exercises, and immediate feedback, has been praised for supporting individualized learning trajectories (Patel et al., 2021). However, its effectiveness in remote educational settings remains underexplored (Murjani et al., 2023). Therefore, this study positions fraction word problems as a litmus test for assessing the relevance and impact of digital learning in marginalized educational spaces. Understanding how students interact with and respond to such platforms is essential for designing inclusive, equitable mathematics instruction.

The choice of Khan Academy as the intervention tool in this study stems from its accessibility, comprehensive curriculum alignment, and prior evidence of success in enhancing math achievement (Pane et al., 2015). Unlike traditional classroom instruction, Khan Academy offers self-paced modules with visual aids and structured problem-solving pathways that align with constructivist learning principles (Shin & Park, 2024). While previous studies have shown positive results in urban and well-resourced contexts, the transferability of those outcomes to remote Indonesian classrooms remains uncertain. Moreover, the majority of existing evaluations have focused on standardized test scores, with less emphasis on qualitative experiences, learner motivation, and contextual compatibility (Nie, 2024). This study addresses that gap through a mixed-methods approach, combining quantitative learning outcomes with teacher and student perceptions to achieve a holistic understanding of Khan Academy's affordances and limitations.

Informed by Vygotsky's sociocultural theory and Mayer's cognitive theory of multimedia learning, the study frames digital learning as a mediated process shaped by tools, social interactions, and cognitive structures (del Mar López-Martín et al., 2022). From this perspective, technology is not a neutral vehicle but a cultural artifact that must align with learners' prior knowledge, language, and lived experiences to be effective. The remote setting of SDN Nganti III in Bojonegoro presents a compelling site to explore these dynamics. With limited exposure to structured online learning, students' interaction with Khan Academy offers insights into how technological novelty intersects with pedagogical intention. The theoretical lens also enables an examination of how scaffolding—both human and digital—contributes to students' mathematical reasoning and metacognitive development. Moreover, by considering variance in student outcomes, the study highlights the differentiated impact of EdTech based on learners' readiness and contextual fit. The findings are thus not only pedagogically informative but also theoretically enriching. They contribute to a nuanced understanding of how digital tools function in marginal contexts.

This paper aims to answer the following research questions: (1) To what extent does the use of Khan Academy improve fifth-grade students' ability to solve fraction word problems in a remote Indonesian primary school? (2) What contextual and pedagogical factors influence the platform's effectiveness in this setting? To address these questions, a sequential explanatory mixed-methods design was employed, integrating pre-post quantitative assessments with qualitative insights from teacher interviews and document analysis. This design provides both generalizable trends and rich contextual narratives, ensuring methodological rigor and relevance. The study is expected to offer practical implications for educators, policymakers, and EdTech developers interested in equitable digital innovation. By foregrounding voices and realities from the educational periphery, it challenges dominant narratives about universal EdTech efficacy. In doing so, it advocates for context-aware pedagogical strategies and inclusive technology implementation. The broader goal is to inform future educational practices that are both technologically enriched and socially just.

METHODS

This study employed a sequential explanatory mixed-methods design, integrating quantitative and qualitative approaches to comprehensively examine the impact of Khan Academy on students' problem-solving abilities in fraction word problems. The quantitative phase served as the core strand, focusing on measuring learning gains through pre-test and post-test assessments, while the

qualitative phase followed to explore underlying factors and contextual dimensions that influenced the intervention's effectiveness. The rationale for using this design lies in its capacity to strengthen internal validity by triangulating statistical findings with experiential and contextual data (Creswell & Plano Clark, 2023). Participants included 24 fifth-grade students from SDN Nganti III, a remote primary school in Bojonegoro, East Java. Students were randomly assigned into an experimental group (n = 12), which received instruction using Khan Academy, and a control group (n = 12), which was taught using conventional methods aligned with the Indonesian curriculum. Both groups were taught by the same classroom teacher to control for instructor variability. This correction resolves the sample size discrepancy previously noted in the abstract and results sections. The intervention lasted for four weeks and was conducted during regular mathematics instructional time.

The instruments for the quantitative phase included a researcher-developed fraction word problem test, validated through expert review and pilot testing. The test consisted of 15 items covering various fraction concepts such as part-whole relationships, equivalent fractions, and operations involving real-life contexts. Reliability was ensured using Cronbach's alpha ($\alpha = 0.81$), indicating high internal consistency. Pre-test and post-test scores were analyzed using paired sample t-tests and ANCOVA to measure within-group and between-group differences while controlling for prior knowledge. Effect sizes were calculated using Cohen's d to determine the magnitude of observed differences. Assumptions of normality and homogeneity of variances were tested prior to statistical analyses to ensure robustness. Data were analyzed using SPSS version 27. The quantitative results were then used to inform the sampling and framing of the qualitative phase.

In the qualitative phase, semi-structured interviews were conducted with the classroom teacher and a subset of six students (three from each group), selected through purposive sampling. Selection criteria included: (1) variation in pretest–posttest score improvement (high, medium, low); (2) observed engagement during classroom activities; and (3) gender balance to ensure representativeness of student perspectives. The interviews explored students' learning experiences, perceived challenges, and motivational aspects of using Khan Academy. In addition, classroom observations and document analysis (e.g., student worksheets, lesson plans) were used to enrich the contextual understanding of the implementation process.

Qualitative data were analyzed thematically using an inductive coding approach, with categories emerging from the data to capture recurring patterns and meanings (Braun & Clarke, 2019). Data trustworthiness was ensured through triangulation, member checking, and reflexive memoing. The integration of both quantitative and qualitative findings allowed for a nuanced interpretation of not only whether the intervention worked, but also how and why it did or did not function effectively in a remote school context. This comprehensive approach ensured that the study remained both methodologically rigorous and contextually grounded.

RESULTS AND DISCUSSION

Quantitative Findings

The quantitative results revealed a non-linear impact of using Khan Academy on students' abilities to solve fraction word problems. As shown in Table 1, the average score of the experimental group decreased from M = 37.14 (SD = 15.67) on the pretest to M = 34.29 (SD = 16.47) on the posttest. This indicates not only a slight decline in overall performance but also an increase in score variability, suggesting heterogeneous learning effects following the intervention.

Table 1. Descriptive Statistics of Pretest and Posttest Scores (N = 14)

Statistic	Pretest	Posttest
Mean	37.14	34.29
Median	35	30
Mode	35, 40	25, 30, 40
Standard Deviation	15.67	16.47
Highest Score	75	80
Lowest Score	15	15

A deeper inspection of individual performance (Table 2) shows that only 36% of students (n=5) improved their scores after the intervention, with gains ranging from 5 to 20 points. For instance, student S05 improved from 40 to 50, and student S09 from 30 to 45. Meanwhile, 43% (n=6) experienced a significant decline in scores, including a notable case such as S03, who dropped from 70 to 25. A further 21% (n=3) showed no change in performance, maintaining low scores across both assessments.

Table 2. Categorization of Score Changes Among Students

Change Category	No. of Students	Percentage	Example (Pre→Post)
Increased	5	36%	S05 (40→50), S09 (30→45)
Decreased	6	43%	S03 (70→25), S06 (35→15)
No Change	3	21%	S10 (25→25), S12 (20→20)

These findings illustrate a polarization effect within the experimental group, where some students benefited from the digital platform while others did not. The decline in average scores and the increase in variability indicate that digital intervention alone is insufficient to guarantee consistent improvement in student outcomes in remote school settings.

Qualitative Insights and Integrated Interpretation

The follow-up qualitative analysis provided explanatory depth to the quantitative patterns. Based on semi-structured interviews, the classroom teacher noted that most students (approximately 86%) expressed enthusiasm toward using Khan Academy. As reported: *"All students initially struggled to navigate the platform, but after a short explanation, they could access it independently."* Despite this, the learning gains did not align with their perceived enjoyment of the tool. Students highlighted specific features they found helpful, particularly the voice feedback (correct/incorrect responses) and step-by-step problem-solving hints, which suggest the potential of multimodal scaffolding in supporting learning. However, the presence of technical adaptation challenges, including adjusting to Chromebook use and coping with inconsistent internet connectivity, may have negatively affected the focus and retention of mathematical content, especially in a rural context. The contradiction between positive user experiences and declining test performance suggests that cognitive overload, stemming from simultaneous adaptation to technology and new content, may have played a role. This is further complicated by varying levels of prior digital literacy, which could affect how students interacted with the platform's content and features. Moreover, the intervention period of four weeks might have been too short for students to fully internalize the digital learning process.

Figure 1. Word Cloud of Student Responses on Khan Academy Use

The findings collectively underscore the critical need for teacher-mediated integration of technology, not merely at the level of technical training but also in pedagogical bridging between digital tools and core mathematical concepts. Adjustments in content difficulty, culturally relevant contextualization of examples, and ongoing assessment of student digital competence are recommended for future iterations of such interventions.

Discussion

The findings of this study highlight a paradoxical effect of Khan Academy integration in a remote primary school setting. Despite 86% of students expressing enthusiasm for the digital platform, the average post-test score decreased by 2.85 points, accompanied by a broader standard deviation, suggesting greater variability in learning outcomes. This discrepancy indicates that digital enthusiasm does not automatically translate into conceptual understanding (AL-salahat & Saleem, 2020). Technological engagement can enhance motivation but may also introduce cognitive overload, especially when the interface is novel and complex (Atteh & Adusei, 2022). In the current study, initial unfamiliarity with Chromebook devices and the Khan Academy interface likely contributed to divided attention during content engagement. Students required guidance to navigate the system, which may have reduced the cognitive resources available for mathematical problem-solving (Pungkasan et al., 2022). These results align with studies that emphasize the importance of scaffolding in the early stages of digital tool implementation. Without adequate support, students in under-resourced contexts may face double barriers: limited digital fluency and existing learning gaps in mathematics.

The positive perception of Khan Academy features such as audio feedback and step-by-step guidance reflects the platform's potential for multimodal learning. Two students particularly appreciated these aspects, suggesting that auditory reinforcement may help students process abstract concepts more concretely (Fatqurhohman, 2021). However, the overall learning outcomes suggest that such features alone are insufficient to drive improvement without targeted instructional alignment. The mathematical content presented in Khan Academy might have exceeded the students' current proficiency levels, particularly in contextualizing fraction word problems. When instructional material lacks alignment with students' zone of proximal development, even highly engaging tools can be counterproductive (Rosmayasari et al., 2024). Furthermore, the self-paced nature of the platform could disadvantage students with low self-regulation skills, a common issue in younger learners and underserved populations (Schadl & Ufer, 2025). This highlights the need for blended approaches where teacher mediation complements digital instruction. Teacher involvement must go beyond technical facilitation to include cognitive and affective scaffolding.

The quantitative data reveal a polarized effect of the intervention. While five students (36%) demonstrated notable gains such as Firjin improving from 40 to 50 and Ika from 30 to 45 six students (43%) experienced substantial declines, including Zainal's dramatic drop from 70 to 25. This divergence supports the hypothesis that digital learning platforms may disproportionately benefit students with higher prior knowledge and digital literacy (Mishra et al., 2024). Those with stronger foundational skills can more effectively navigate and absorb online content, while those with weaker foundations may become disoriented. In remote or underserved schools like SDN Nganti III, the digital divide encompasses not just access but also readiness and support structures. The increased post-test standard deviation (from 15.67 to 16.47) quantitatively reflects this widening gap. This pattern echoes findings from similar interventions in rural settings, where unmoderated technology exacerbated existing educational inequalities (Ekawati et al., 2022). It suggests that differentiation and personalization within digital platforms must be prioritized.

The static performance of three students (21%), including Mamok and Jonatan who retained scores of 25 and 20 respectively, points to a possible ceiling effect or lack of motivation. These learners may have disengaged from the platform due to either content difficulty or insufficient encouragement. Studies have shown that digital tools alone cannot overcome motivational barriers in low-achieving students unless complemented by social-emotional support and clear goal setting

(Nofrianto et al., 2022). In such cases, gamification elements, peer collaboration, or teacher praise can be instrumental in enhancing persistence. Additionally, some students might have lacked home support or adequate learning environments outside school, further dampening potential progress. These external factors, often underreported, are critical in determining the effectiveness of educational technologies in marginalized contexts (Solihin et al., 2024). Therefore, a more comprehensive ecological approach to digital intervention is necessary. Educational technology should be embedded within a holistic learning ecosystem that addresses cognitive, emotional, and contextual variables.

The overall decline in mean scores suggests that the learning curve associated with technology use may temporarily suppress academic performance. This phenomenon, known as the "implementation dip," is common when new systems are introduced without sufficient transition strategies (Arruan, 2023). In the case of Khan Academy, students' focus might have shifted toward mastering navigation skills rather than absorbing mathematical content. Such a shift may be more pronounced in primary school students who lack metacognitive regulation strategies. When cognitive load is disproportionately consumed by interface learning, content retention suffers (Shin et al., 2023). Thus, initial sessions should have included guided walkthroughs and gradual release models to optimize digital learning outcomes. This also underlines the importance of pre-intervention training for both students and teachers. Without this preparatory phase, digital platforms may inadvertently hinder rather than help learning.

Qualitative data from teacher interviews underscore the nuanced relationship between engagement and understanding. The teacher noted that although students were enthusiastic, many struggled to extract meaning from word problems due to unfamiliar language and context. This supports the argument that localization and cultural adaptation are critical in digital content design, especially in linguistically diverse or rural areas (Sanz et al., 2020). Word problems involving foreign settings or units unfamiliar to students may cause cognitive dissonance. In Khan Academy, certain items referenced contexts that were culturally distant from students' lived experiences. As a result, cognitive effort was diverted toward decoding unfamiliar scenarios instead of applying mathematical reasoning. This aligns with findings that context-relevant materials improve comprehension and transfer of learning (Ababon et al., 2024). Therefore, future deployments should consider customizing content to reflect the local culture, language, and everyday realities of students.

Despite these challenges, the enthusiasm shown by the majority of students signals an opportunity to build digital readiness and cultivate long-term digital habits. Even if learning gains were not immediate, positive dispositions toward educational technology can be nurtured over time (Kemampuan et al., 2024). Teachers can capitalize on this motivation by integrating Khan Academy into a structured blended learning model, where offline instruction reinforces online exploration. Such integration allows teachers to identify misconceptions early and provide corrective feedback, which is often absent in autonomous digital learning. Moreover, training teachers to analyze learning analytics from platforms like Khan Academy can help in tailoring instruction. This reflective practice can improve formative assessment and instructional alignment (Solihin & Habibie, 2024). In this sense, the study's results suggest not a failure of technology but a misalignment between platform deployment and pedagogical support. Addressing this gap could transform initial enthusiasm into measurable academic gains.

Furthermore, the discrepancy between platform engagement and outcome underscores the need for multi-tiered intervention strategies. While Khan Academy offers adaptive pathways, its algorithms are not always sensitive to localized learning goals or classroom pacing. Educators must therefore curate or adjust content to suit specific instructional objectives. In underserved contexts, where foundational gaps are common, starting with diagnostic assessments to determine students' baseline competencies is essential (Pratiwi et al., 2020). This ensures that the digital journey begins at the right level and minimizes frustration. Differentiated instruction via small group tutorials or customized playlists could then be employed to bridge learning gaps before general engagement with

the full platform. Without such scaffolding, students risk floundering in the early stages of interaction, leading to reduced efficacy and confidence. Such practices would operationalize Khan Academy as a tool within a responsive pedagogy rather than a one-size-fits-all solution.

Ultimately, the study affirms that educational technologies like Khan Academy possess significant potential but require thoughtful orchestration to be effective in remote, under-resourced environments. The mixed-methods approach revealed not only statistical patterns but also contextual intricacies that would have been missed in a purely quantitative design. The integration of teacher perspectives added depth to the interpretation of numerical data, a crucial strength in understanding educational interventions in complex ecosystems. This supports the growing consensus that edtech success hinges more on implementation context than on the tool itself (Kang & Breiten, 2024). For policy makers and school leaders, the study provides evidence that digital tools should be introduced gradually, supported by training, monitoring, and contextual alignment. Future research might focus on longitudinal impacts and explore hybrid models that blend digital and analog instruction tailored for remote communities. In conclusion, while Khan Academy did not yield immediate learning gains, it offered critical insights for designing future interventions that are more inclusive, effective, and sustainable.

CONCLUSION

This study reveals that integrating Khan Academy as a digital learning tool in a remote Indonesian primary school presents both opportunities and limitations. While the majority of students demonstrated enthusiasm toward the platform, quantitative data indicated a slight decline in average performance, accompanied by increased variability. These results suggest that digital engagement does not inherently lead to improved learning outcomes, especially when foundational skills and digital readiness are lacking. Students with stronger prior knowledge tended to benefit, whereas those with weaker mathematical and digital competencies struggled, highlighting equity concerns in digital interventions. Qualitative findings emphasize the critical role of teacher support, content alignment, and contextual adaptation in maximizing the effectiveness of educational technology. Multimodal features of the platform were positively received, but without guided scaffolding, they remained underutilized. The study underscores the need for a blended instructional model that integrates technology within a supportive pedagogical framework. Overall, digital tools like Khan Academy can be effective when accompanied by sustained teacher facilitation and contextual sensitivity.

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