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Unlocking Students' Success: Math Learning via Instagram Filter Innovations

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Abstract: Unlocking Students' Success: Math Learning via Instagram Filter Innovations. **Objectives:** This study investigates the impact of Instagram-based filter learning media on junior high school students' learning outcomes in mathematics, focusing on relations and functions. **Methods:** Using a quantitative methodology, the study employed a one-group pretest-post-test design to measure learning outcomes before and after interventions. Data were analyzed using paired t-tests and Cohen's d to assess both statistical and practical significance. **Findings:** The findings reveal that Instagram filters significantly improved students' mathematical understanding, with average scores increasing from 61,13 (pre-test) to 71,63 (post-test). The improvement was statistically significant ($p < 0,05$), with a large effect size (Cohen's $d = 1,02$), indicating a substantial impact of the intervention. Furthermore, the use of Instagram filters enhanced engagement and motivation, helping students grasp abstract concepts more effectively. In terms of specific indicators, for Conceptual Understanding, the pretest score was 26,00, and the post-test score increased to 30,38. The N-Gain for this indicator was 31,25%, indicating a moderate improvement in students' understanding of key concepts. For Procedural Knowledge, the pretest score was 24,00, and the post-test score increased to 27,75. The N-Gain for this indicator was 20,31%, showing low improvement in students' ability to apply mathematical procedures. For Problem-Solving Skills, the pretest score was 10,25, and the post-test score increased to 13,50. The N-Gain for this indicator was 33.33%, reflecting moderate improvement in students' ability to apply mathematical knowledge to solve real-world problems involving relations and functions. **Conclusions:** The results highlight Instagram's potential as an effective educational tool for mathematics. Instagram filters engage students while aligning with Indonesia's Merdeka Curriculum, promoting innovative, student-centered learning. This research offers valuable insights for educators looking to integrate interactive technologies into modern teaching methods.

Keywords: instagram filter, mathematics learning media, relations and functions.

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INTRODUCTION

The term "interactive learning" in educational technology refers to the process of integrating tools that enhance engagement and accessibility in teaching (Hans & Hans, 2015). These tools do more than simply deliver content; they actively involve students in the learning process, making it more participatory and meaningful. Interactive learning tools increase the relevance of educational materials by connecting them to real-world applications, thus allowing students to build on their prior knowledge and make meaningful

connections to new content. This approach not only enhances students' understanding but also fosters critical thinking, problem-solving skills, and sustained interest in learning. By examining students' needs and integrating motivation, subject matter, and content, interactive tools have the potential to transform traditional, lecture-based teaching methods into dynamic, student-centered learning experiences (Hutchinson & Waters, 1987).

In this context, Instagram has emerged as a powerful platform for enhancing learning engagement, particularly among today's digitally inclined generation. As one of the most popular social media platforms globally, Instagram is deeply embedded in students' daily routines, making it a familiar and appealing tool for educational purposes. Its widespread popularity presents a unique opportunity to reimagine how mathematics is taught and learned. By leveraging platforms like Instagram, educators can address the long-standing issue of motivational gaps in mathematics education. Social media applications capitalize on students' natural interest and familiarity, allowing learning to feel less like a chore and more like an engaging activity (Higgins et al., 2019; Mansah & Safitri, 2022; Saha et al., 2023). Specifically, the use of Instagram filters, powered by Augmented Reality (AR) technology, introduces a novel way to teach abstract and complex concepts in an interactive and visually stimulating manner. These filters superimpose digital elements onto real-world visuals, creating an immersive learning experience that can make challenging topics more accessible (Karundeng, 2020; Sukmawati, 2022; Youn, 2019).

The need for such innovative methods is underscored by Indonesia's persistently low scores in the Program for International Student Assessment (PISA), which rank the country among the lowest in mathematics proficiency globally (OECD, 2019). This reflects deep-seated challenges in the education system, such as outdated teaching methodologies, low student engagement, and limited access to modern educational tools. To address these issues, the Merdeka curriculum introduced by the Indonesian government emphasizes the importance of tailoring the learning environment to meet individual interests, preferences, and abilities. This approach aligns seamlessly with Instagram's potential as a versatile and engaging teaching tool (Irawati et al., 2022). By integrating interactive technologies like Instagram filters, educators can align with the curriculum's objectives, creating a more personalized and enjoyable learning experience.

Previous studies have demonstrated the effectiveness of Instagram in enhancing learning outcomes across various disciplines, though gaps remain in its application to mathematics education. For example, research by Aisyah et al. (2023) explored Instagram's role in improving students' writing skills, revealing its potential to make learning more relatable and engaging. However, this study did not extend its findings to subjects requiring analytical reasoning, such as mathematics. Similarly, Deshinta (2020) developed Instagram-based learning media for function transformations, but the study lacked a focus on AR filters as a teaching tool. Karundeng (2020) examined the use of Instagram filters in accounting education, demonstrating their ability to simplify complex concepts and increase student motivation, though the study was limited to non-mathematical contexts. These gaps underline the necessity of evaluating Instagram filters specifically in teaching Relations and Functions, a foundational topic in secondary school mathematics. Addressing this gap can provide new insights into the potential of AR-enhanced learning tools.

Learning outcomes reflect the tangible results of the educational process, encompassing progress across cognitive, affective, and psychomotor domains (Setiawati, 2018). While

mathematics education traditionally prioritizes the cognitive domain, the affective and psychomotor domains play an equally significant role in shaping a well-rounded learning experience. The cognitive domain involves knowledge acquisition and critical thinking, the affective domain pertains to attitudes and emotional engagement, and the psychomotor domain encompasses hands-on skills and application. Instagram filters, by integrating interactive and contextual elements into educational content, have the potential to address all three domains simultaneously. By making abstract mathematical concepts more relatable and visually appealing, these filters can enhance cognitive understanding while also fostering a positive attitude toward the subject (Herawati, 2020). Furthermore, their interactive nature encourages active participation, bridging the gap between theoretical knowledge and practical application.

This research aims to explore the effectiveness of Instagram filters as a learning tool for teaching mathematics in secondary schools, with a specific focus on the topic of Relations and Functions. By addressing motivational and engagement challenges that often hinder students' success in mathematics, this study seeks to align teaching methods with students' technological inclinations and learning preferences. The findings of this research are expected to contribute significantly to innovative educational practices, providing a blueprint for integrating social media platforms into formal education. Ultimately, this study supports Indonesia's broader educational development goals, equipping students with the skills and competencies needed to thrive in the dynamic demands of the 21st-century workforce (Sitopu et al., 2024).

METHOD

Participants

The population of this study consisted of junior high school students in North Jakarta. A sample of 40 students was selected using a purposive sampling technique to ensure participants met specific criteria relevant to the research objectives. These criteria included enrollment in a class covering the topic of relations and functions in mathematics. To minimize selection bias, the sampling considered a balanced representation of gender and academic performance. The final sample comprised 27 male students (67,5%) and 13 female students (32,5%), all from grade 8. Purposive sampling was deemed suitable for its ability to focus on participants most likely to provide rich data related to the research objectives (Etikan et al., 2016).

Research Design and Procedures

This study adopted a one-group pretest-posttest experimental design to evaluate the effectiveness of Instagram filter-based learning media in mathematics education (Creswell & Creswell, 2017).

Mathematics Topic and Learning Objectives

The study focused on the topic of Relations and Functions, which is a key part of the junior high school mathematics curriculum. The study aimed to achieve three main learning objectives: conceptual understanding of relations and functions, procedural knowledge to solve problems involving functions, and the application of problem-solving skills to real-world scenarios. These objectives are aligned with the cognitive, affective, and psychomotor domains of learning outcomes, as described by Setiawati (2018). Indicators for the objectives were derived from curriculum standards, such as identifying the domain and range, determining function types, and solving application problems.

The study followed a structured procedure. In the Preparation Phase, Instagram filters with interactive quizzes and augmented reality (AR) elements were developed based on previous

research by Karundeng (2020) and Gusti et al. (2023). In the Pretest Phase, a pretest was given to students to measure their baseline understanding of Relations and Functions. The pretest included standardized questions to assess key mathematical concepts and identify learning gaps, in line with formative assessment principles (Black & Wiliam, 1998).

During the intervention phase, students engaged with Instagram filter-based learning tools specifically designed to enhance understanding of Relations and Functions, as developed by Gusti et al. (2023). These filters were created using Spark AR technology, allowing for the integration of augmented reality (AR) elements with interactive quizzes. The filters were structured into three main segments: an introduction to the topic with user instructions, a series of multiple-choice questions on Relations and Functions, and a final result display based on students' performance.

The learning process began with students receiving a brief tutorial on using the Instagram filters. The introduction phase provided visual and audio guidance, which was instrumental in engaging students and preparing them for the interactive activities. For example, students were presented with questions requiring them to identify domains, ranges, and relationships within mathematical functions. Using the filters, students could select answers by tilting their heads, which made the interaction intuitive and engaging. Immediate feedback was displayed on the screen, along with motivational messages such as "Awesome" or "Good job" based on their performance (Figure 1).

The teaching process was enriched with visual elements, as shown in Figure 1, which depicts the Instagram filter interface during student interaction. Students were also actively involved in classroom discussions, where teachers facilitated by addressing misconceptions and guiding problem-solving sessions. Teachers observed students' progress closely and provided individualized feedback during review sessions to reinforce learning concepts. After the classroom sessions, students were encouraged to continue using the filters at home for self-practice.

In addition to classroom activities, Figure 1 showcases how students interacted with the filters during real-time problem-solving sessions. The inclusion of gamified elements and AR components, such as badges and scores, added an element of competition and achievement, further motivating students to actively participate. For example, students who answered more than 8 out of 10 questions correctly received the "All-Star" badge, as shown in Figure 1. Such features transformed traditional mathematics lessons into dynamic and enjoyable learning experiences.

This implementation highlights how the integration of AR and social media platforms like Instagram can make abstract mathematical concepts accessible and engaging for students. Teachers observed increased participation and enthusiasm as students explored mathematical problems through a medium they frequently use in their daily lives. The success of this method aligns with prior findings that emphasize the role of contextual and relatable learning tools in fostering deeper conceptual understanding (Higgins et al., 2019; Karundeng, 2020).

In the Post-test Phase, a post-test, identical to the pretest, was administered to assess students' progress. Post-tests are widely used to measure learning gains after educational interventions, as noted by Bloom et al. (1981).

Instruments

The study employed a test instrument designed to evaluate three key dimensions of mathematical competency: conceptual understanding, procedural knowledge, and problem-solving skills. Each dimension was assessed using multiple-choice questions tailored to the topic of Relations and Functions in mathematics.

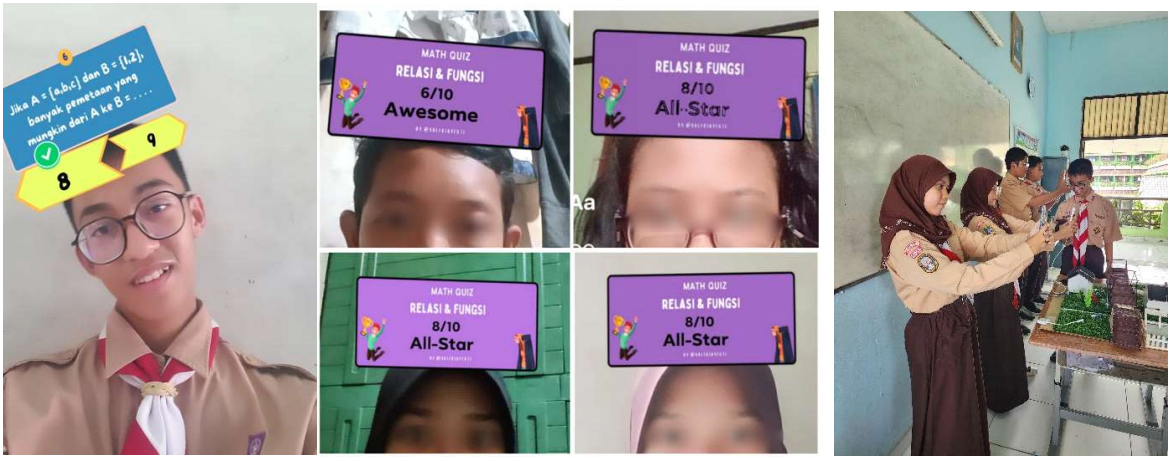

Figure 1. Students tried the Instagram filter

Dimensions and Indicators

The first dimension, conceptual understanding, aimed to measure students' grasp of the fundamental concepts related to relations and functions, such as domain, range, and types of functions. The indicators for this dimension included identifying the domain and range of a relation and distinguishing between different types of functions. The instrument contained eight items designed to assess these concepts, one example being: "*Given the relation {(1, 2), (3, 4), (5, 6)}, identify its domain and range*."

The second dimension, procedural knowledge, evaluated students' ability to apply algorithms and procedures to solve mathematical problems in a systematic manner. This dimension involved indicators such as calculating the output of a function for a given input and determining the slope and intercept of a linear function from its equation. Similar to the conceptual understanding dimension, eight items were included to assess procedural knowledge. An example question was: "*Given the set A = {1, 2, 3, 4} and the set B = {2, 4, 6, 8}, a relation R is defined as R = {(x, y) | y = 2x}. Which of the following represents the relation R in set notation?*"

The third dimension, problem-solving skills, focused on evaluating students' ability to apply mathematical concepts to real-world scenarios and solve non-routine problems. The indicators for this dimension included formulating a function to model a real-world situation and solving word problems involving relations and functions. This dimension was assessed through four items, with an example question: "*In a garden, there are four types of ornamental plants to be planted in five garden boxes. The relationship between the garden boxes and the types of plants is defined as a function. Determine whether this relationship is injective (one-to-on), surjective (onto), or bijective (both one-to-one and onto)?*"

Basis and Adaptation of the Instrument

In terms of the basis and adaptation of the instrument, the test items were adapted from validated instruments in previous research. The conceptual understanding items were inspired by studies on mathematics education frameworks (Setiawati, 2018). The procedural knowledge items followed guidelines from Karundeng (2020) on designing algorithm-based mathematics assessments. Finally, the problem-solving skills items were adapted from Sýrakaya & Alsancak Sýrakaya (2022), with a focus on the application of mathematics in real-life contexts.

Subsequently, the instrument was developed and administered to students who had previously studied the topic of Relations and

Functions. Validity testing results indicated that 23 out of 40 questions were valid, with a calculated r value greater than the critical r value (r tabel = 0,312). However, only 20 questions were selected for the final instrument, aligning with the indicators of the Relations and Functions material. These questions were designed to assess conceptual understanding (8 questions), procedural skills (8 questions), and problem-solving abilities (4 questions). The test instrument also demonstrated high reliability (α = 0,843), indicating its suitability for evaluating the intended variables or attributes with a high level of consistency.

Development, Validity, and Reliability

The test was developed to align with Indonesia's national mathematics curriculum and expert recommendations. Each item was reviewed by mathematics educators to ensure content validity. The instrument's reliability was evaluated in a pilot study with 40 students, yielding a Cronbach's Alpha of 0,87, indicating high internal consistency.

Data Analysis

The The data analysis followed a structured approach to assess the effectiveness of the intervention. First, a normality test was conducted using the Shapiro-Wilk test to determine whether the pretest and post-test scores were normally distributed (Shapiro & Wilk, 1965). This test helped assess the suitability of parametric statistical methods for further analysis. Next, a paired t-test was applied to compare the pretest and post-test scores, which allowed the researcher to identify any significant differences between the two sets of scores (Cohen, 2013). To quantify the practical significance of the intervention, an effect size analysis was conducted using Cohen's d, with a value greater than 0,8 indicating a large effect size. Additionally, descriptive analysis was performed to calculate the mean, standard deviation, and percentage improvements, providing a comprehensive understanding of the results (Higgins et al., 2019). All data analyses were conducted using SPSS software, ensuring accuracy and alignment with established educational research standards.

■ RESULT AND DISCUSSION

The results of the research demonstrate the substantial impact of using Instagram filter-based learning media in teaching Relations and Functions at Junior High School in North Jakarta. This improvement highlights the effectiveness of the intervention reflecting the current educational shift towards integrating technology and innovation, highlighted by studies conducted by Asefer and Abidin (2021), Taormina and Baraldi (2023), and Van Laar et al. (2020). This approach aligns with the need for adapting educational practices to the evolving requirements of 21st century skills, particularly in mathematical competencies.

The normality of the data was assessed using the Shapiro-Wilk test, as it is suitable for small sample sizes (Shapiro & Wilk, 1965). The results indicated that the pretest scores had a p-value of 0,077, and the post-test scores had a p-value of 0,169. Since both p-values were greater than the significance threshold of 0,05, it was concluded that the data for both pretest and post-test scores were normally distributed. This fulfills the assumption of normality required for subsequent parametric statistical analyses, such as the paired t-test.

The figure 2 display the average pretest and post-test scores for each of the three indicators: Conceptual Understanding, Procedural Knowledge, and Problem-Solving Skills. The scores for each indicator were assessed separately to provide a clearer understanding of how the intervention impacted students in different aspects of mathematics learning.

The analysis revealed improvements across all assessed dimensions of mathematical

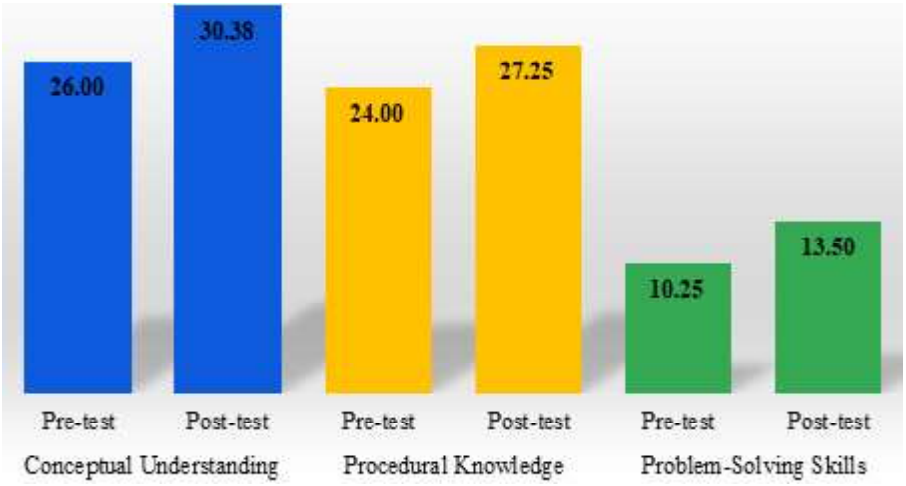

Figure 2. Average of pre-test and post-test scores for each indicator

competency. For Conceptual Understanding, the pretest score had an average of 26,00, while the post-test score increased to 30,38. This result indicates a notable improvement in students' understanding of basic mathematical concepts, including domain, range, and types of functions. In the dimension of Procedural Knowledge, the pretest average was 24,00, with the post-test score rising to 27,25. This increase reflects an enhancement in students' ability to effectively apply mathematical procedures. Finally, for Problem-Solving Skills, the pretest score averaged 10,25, while the post-test score improved to 13,50. This result demonstrates the positive impact of the Instagram filter-based learning on students' ability to solve real-world problems involving relations and functions.

The results show significant improvements across all three indicators, highlighting the effectiveness of the Instagram filter-based learning approach in enhancing students' mathematical abilities.

Table 3. Descriptive statistics

	N	Minimum	Maximum	Mean
Pre-test	40	45	75	61.13
Post-test	40	50	100	71.63

Figure 3 provides a clear perspective on the distribution of improvement scores after intervention with Instagram-based learning media filters. It represents the percentage contribution of pre-test and post-test scores to the total improvement observed. With 47,2% of the contributions coming from pre-test scores and 52,8% from post-test scores, the chart emphasizes that more than half of the increase in total scores can be attributed to post-intervention assessments. This visualization emphasizes the important role played by educational interventions in improving student learning outcomes, demonstrating the effectiveness of integrating social media tools in an educational context.

To conduct an independent sample *t*-test, Cohen's *d* is calculated by determining the difference between the mean scores of the two groups and dividing this difference by the pooled standard deviation. The resulting Cohen's d value of 1,0248 reflects a large to very large effect size, indicating a substantial impact of the intervention.

This suggests that the use of Instagram filters significantly enhances post-test scores, highlighting its effectiveness in producing meaningful and statistically significant improvements in student outcomes.

The percentage contribution of the pre-test and post-test scores reveals that the pre-test accounted for 46,0% of the overall results, while the post-test accounted for 54,0%. This distribution highlights the improvement in students' performance following the intervention, with the post-test results surpassing the pre-test scores and reflecting the effectiveness of the instructional approach used in the study.

Figure 3 and Figure 4 show that the maximum number of values produced is 60, the standard deviation is 8,203. The post test results have more varied data with a standard deviation value of 13,32 and the value that becomes the mode is 65.

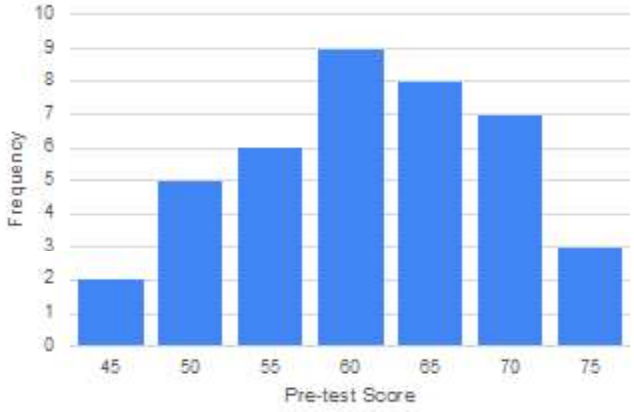

Figure 3. Histogram of pre-test

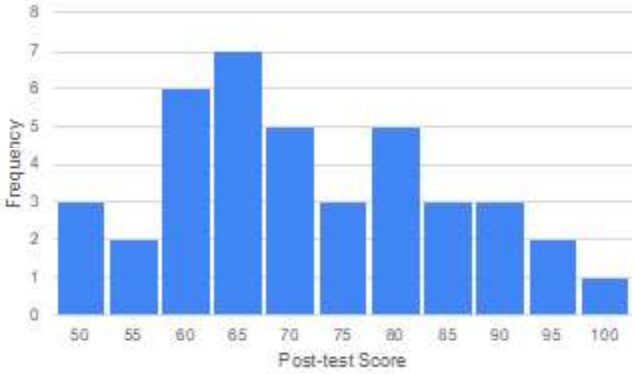

Figure 4. Histogram of post-test

The normalized gain (n-gain) as shown in Figure 5 was calculated for each of the three indicators: Conceptual Understanding, Procedural Knowledge, and Problem-Solving Skills. Figure 5 show the N-gain for each indicator: Conceptual Understanding, Procedural Knowledge, Problem-Solving Skills.

For Conceptual Understanding, the pretest score was 26,00, and the post-test score increased to 30,38. The N-Gain for this indicator was 31,25%, indicating a moderate improvement in students' understanding of key concepts such as domain, range, and types of functions.

For Procedural Knowledge, the pretest score was 24,00 and the post-test score increased to 27,75. The N-Gain for this indicator was 20,31%, showing low improvement in students' ability to apply mathematical procedures. It

highlights the need to strengthen instructional strategies, such as guided practice or step-by-step demonstrations, to boost procedural fluency.

For Problem-Solving Skills, the pretest score was 10,25, and the post-test score increased to 13,50 The N-Gain for this indicator was 33,33%, reflecting moderate improvement in students' ability to apply mathematical knowledge to solve real-world problems involving relations and functions. This indicates that while students are developing critical thinking and application skills, there is room for improvement to push these outcomes toward higher levels.

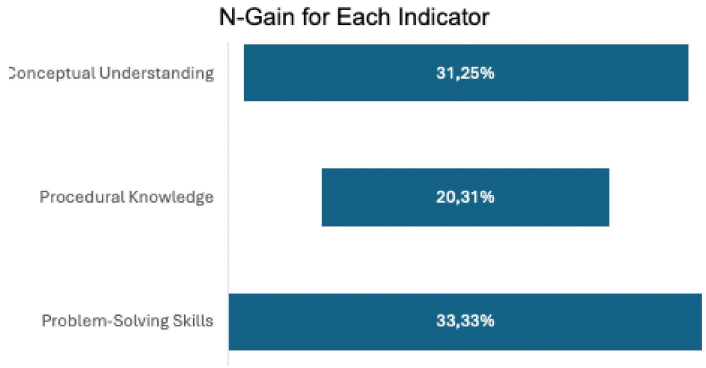

Figure 5. N-Gain for each indicator

Regarding the post-test results, there was greater variability compared to the pretest. The standard deviation for the post-test scores was 13,32, indicating a wider spread of scores among students. The mode of the post-test scores was 65, which represented the most frequently occurring score among students.

The research revealed a significant improvement in student performance, with the average scores showing an increase from the pre-test to the post-test. This positive change is in line with the observations of Higgins et al. (2019) and Mansah and Safitri (2022), who recognized the potential of social media to boost student motivation and engagement, particularly in mathematics. Further supporting this, research by Rahmawati et al. (2020) and Setyowati et al. (2022) underscored the profound impact of Instagram on Secondary Schoolstudents, suggest that its use in mathematics education could lead to more interactive and engaging learning experiences, potentially enhancing understanding and retention of mathematical concepts.

The validity of these findings is reinforced by expert analysis and statistical evaluation using the t-student distribution. A normality test verified that the sample was from a normal distribution, with a standard deviation in score differences of 11,73. The paired nature of the data necessitated the use of the t-student distribution to assess the significance of the differences observed between pre-test and post-test scores. Table 4 shows a t-test value below 0,05, indicating that there is a statistically significant difference attributed to the given intervention. indicating that the post-test scores were substantially higher than the pre-test scores. The correlation between pre-test and post-test scores is 0,922. This is a very high value, indicating that there is a strong positive relationship between the pre-test scores and the post-tests.

Table 4. Table of paired samples test

	N	Correlation	Sig
Pre-test & Post-Test	40	0.922	0.0000

The results of this study demonstrate the effectiveness of Instagram filter-based learning media in improving students' understanding of Relations and Functions in mathematics. The intervention, which leveraged augmented reality (AR) filters, showed that students exhibited moderate improvements across three key areas: Conceptual Understanding, Procedural Knowledge, and Problem-Solving Skills. These findings suggest that integrating technology into traditional teaching methods can engage students more effectively and enhance their learning outcomes.

The data from this study align with previous research by Reyes et al. (2019) and Saha et al. (2023), which emphasize the importance of using contextual and relevant learning materials. These studies highlight how content that is relatable to students can significantly improve their engagement and academic performance. By incorporating Instagram filters, which are part of students' daily digital experiences, this study tapped into a learning approach that connects academic concepts with familiar, interactive tools. This approach supports the findings of Higgins et al. (2019), who noted that integrating interactive digital platforms into education not only enhances students' motivation but also deepens their understanding of the subject matter.

The use of Instagram filters, as demonstrated in this study, fills a notable gap in the literature. While studies such as Zahra et al. (2021) and Sukmawati et al. (2022) explored the use of Instagram filters for language learning and increasing awareness through interactivity and enjoyment, respectively, they did not focus on mathematical content nor integrate augmented reality as a core component for teaching mathematics. Furthermore, Karundeng (2020) highlighted the potential of Instagram filters in accounting education, but its application was limited to a different field. This study, therefore, contributes a novel application of Instagram-based learning media in teaching mathematics, specifically at the secondary school level. The significant improvement in students' performance in relations and functions demonstrates that Instagram filters can be an effective tool in mathematics education.

Despite the promising results, there are several limitations that must be considered. First, the sample size of 40 students may not fully represent the broader student population, limiting the generalizability of the findings. While the results were significant for the sample, a larger sample size would provide more robust data and allow for more generalizable conclusions. Future studies should focus on diversifying the sample to include students from various demographic backgrounds and educational levels to evaluate the broader applicability of Instagram filters in different educational contexts.

Additionally, this study focused solely on one specific mathematical topic Relations and Functions. The effectiveness of Instagram filter-based learning media in teaching other mathematical concepts, such as algebra, geometry, or calculus, remains unexplored. Future research could extend the use of Instagram filters to a wider array of mathematical topics to determine whether the positive effects observed in this study are consistent across other areas of mathematics. Moreover, it would be valuable to explore the long-term impact of using such digital learning tools to assess whether improvements in students' understanding are sustained over time.

When compared with other studies, the results of this study are consistent with findings from Appel et al. (2020), who also found that social media tools, like Instagram, can improve student motivation and engagement, especially in disciplines traditionally viewed as challenging, such as mathematics. However, unlike other studies that focused more on motivation or general engagement, this study provides concrete evidence of improved academic performance,

particularly in students' understanding of abstract mathematical concepts, which adds a new dimension to the existing literature.

In conclusion, this research demonstrates the potential of Instagram filters as an innovative educational tool that can significantly enhance students' understanding of mathematical concepts, particularly in secondary education. The use of AR-based tools like Instagram filters opens new avenues for making mathematics more engaging and accessible, thereby fostering deeper learning and improving student outcomes. Future research, especially with larger and more diverse samples and expanded subject areas, will further clarify the long-term benefits of integrating social media and AR technologies into formal education.

■ CONCLUSION

In conclusion, this research highlights the effectiveness of aligning teaching methods with students' technological preferences to enhance engagement and understanding in the digital age. By integrating Instagram filter-based learning media into mathematics education, the study demonstrates how modern tools can make abstract concepts more accessible and relevant, addressing the challenges of traditional pedagogical methods. This innovative approach contributes to advancing educational development in Indonesia, offering a practical solution to improving student outcomes and adapting to the rapidly evolving technological landscape.

Moreover, this research underscores the importance of bridging the gap between traditional teaching methods and modern technological trends, providing a framework for educators to effectively integrate digital tools into their curricula. While the findings are promising, further studies could explore the long-term impact of such interventions and their applicability across other subjects and educational contexts. This study sets a foundation for continued innovation in teaching practices, paving the way for more inclusive and dynamic learning environments that meet the diverse needs of students in the 21st century.

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