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Development of HOTS-Oriented Interactive Multimedia-Based Quiz for Elementary Mathematics Learning

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A B S T R A C T

The rapid advancement of technology demands innovation in elementary mathematics learning, particularly in fostering Higher Order Thinking Skills (HOTS). However, interactive HOTS-oriented quizzes remain underdeveloped due to teachers' limited technological mastery and lack of varied learning media.This study aimed to: (1) develop an interactive multimedia-based HOTS-oriented quiz for fifth-grade elementary mathematics; (2) test its feasibility; and (3) examine its effectiveness in improving learning outcomes.A Research and Development (R&D) approach using the ADDIE model (Analysis, Design, Development, Implementation, Evaluation) was employed. The research involved 60 fifth-grade students divided into experimental and control groups. Instruments included validation sheets, practicality questionnaires, and learning outcome tests. Data were analyzed using descriptive quantitative techniques and independent t-tests.The developed quiz obtained a validity score of 88.2% (very valid), a practicality score of 85.7% (very practical), and an effectiveness test showing a significant difference between experimental (mean = 84.3) and control (mean = 72.1) groups ($t = 4.21$, $p < 0.05$).The interactive multimedia-based HOTS-oriented quiz is feasible, practical, and effective for improving elementary students' mathematics learning outcomes. This product offers a novel contribution to technology-based HOTS assessment in primary education.

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INTRODUCTION

Technology has undergone very rapid development in various fields, especially in the world of education. Education is a system that aims to form intelligent, noble, and qualified individuals. Through education, students are expected to become better and more competent human beings. In the context of 21st-century learning, technology integration is no longer an option but a necessity. The Indonesian Ministry of Education and Culture, through Permendikbud No. 21 of 2016 concerning the Content Standards for Primary and Secondary Education, explicitly states that the future competence of students includes having Higher Order Thinking Skills (HOTS). This regulation mandates that learning processes and assessments must be directed toward developing students' abilities to analyze, evaluate, and create—the three highest levels in Bloom's taxonomy.

However, the reality on the ground shows a significant gap between policy expectations and classroom practices. Numerous studies have indicated that Indonesian elementary school students are still inadequately trained in HOTS-oriented problem-solving. Most mathematics assessments focus on lower-order thinking skills such as remembering (C1) and understanding (C2), with very few questions requiring analysis (C4), evaluation (C5), or creation (C6). This discrepancy stems from multiple factors: teachers' limited understanding of HOTS characteristics, lack of available HOTS-based learning resources, and the persistent dominance of conventional teaching methods that emphasize memorization over deep reasoning.

Mathematics, in particular, is a subject that fundamentally requires logical, systematic, critical, and creative thinking. It is taught from elementary school to equip students with these essential reasoning abilities. Yet paradoxically, mathematics is often perceived as one of the most difficult subjects by students. The causes of difficulty in learning mathematics vary widely, ranging from too many mathematical equations and difficult-to-understand material to teaching methods that do not match students' learning styles. Students frequently complain that mathematics is abstract, disconnected from real-life contexts, and presented in monotonous ways that fail to stimulate their curiosity.

One promising strategy to address these challenges is the use of quizzes in learning. A quiz is a form of formative assessment that can provide immediate feedback, motivate students, and reinforce learning. When designed appropriately, quizzes can transform passive learning into active engagement. More importantly, a quiz oriented toward HOTS can serve as a vehicle for training students' higher-order thinking abilities. By consistently working on problems that require deep analysis, evaluation, and creative problem-solving, students gradually develop the cognitive habits necessary for HOTS. Through meaningful learning experiences—where students can connect new information with prior knowledge and real-world contexts—they are better able to retain and apply what they have learned.

Despite these potential benefits, interactive learning quizzes have not yet developed optimally in Indonesia. Several obstacles hinder the development of interactive quizzes. First, there is the limited mastery of technology among

teachers. Although many teachers are proficient in basic computer operations, few possess the skills to design and develop interactive multimedia content that integrates text, images, audio, video, and animation cohesively. Second, the development of computer-based interactive learning materials remains suboptimal due to time constraints, lack of supporting infrastructure, and insufficient training opportunities. Third, the scarcity of varied learning media contributes to low student motivation during the learning process. Observations in many elementary classrooms reveal that students often lose focus during mathematics lessons, engaging in chatting, playing, or even dozing off while the teacher explains.

The emergence of increasingly sophisticated technology places a responsibility on educators to think creatively about how to engage students in developing their thinking skills. Among the various thinking skills that can be developed, higher-order thinking skills are particularly crucial for preparing students to face the complexities of the modern world. In this regard, teachers can act as facilitators who provide example problems or challenges that actively involve students in the learning process. A teacher who facilitates HOTS development does not simply deliver content but designs learning experiences that require students to question, connect, reason, and create.

Based on the extensive explanation above, the researcher intends to develop an interactive HOTS-oriented quiz. This quiz is designed to help students focus during classroom learning by providing an engaging, visually appealing, and cognitively challenging experience. The media contains instructional materials, explanatory videos, and interactive quizzes. The interactive quiz will provide immediate feedback in the form of assessment rubrics or scores to students. Upon completing a set of questions, students receive not only their total score but also individualized feedback on which specific HOTS components need improvement. With the presence of this attractive and interactive media, it is expected that students' learning focus and comprehension of mathematics material will increase, ultimately leading to improved learning outcomes.

Previous studies have explored various aspects of interactive media and HOTS in mathematics learning. Gunahardi and Riyanto (2017) examined the effectiveness of interactive multimedia in mathematics learning for students with learning disabilities, finding positive effects but focusing on basic skills rather than HOTS. Komalasari and Rahmat (2018) developed living values-based interactive multimedia for civic education, demonstrating the potential of value-integrated media but not specifically addressing HOTS. Sugiyanta and Sukardjo (2017) investigated usability criteria for website-based interactive multimedia in vocational high school mathematics, providing valuable technical insights but at the secondary level.

The novelty of the present study lies in three aspects. First, it specifically targets elementary school students, an age group where HOTS foundation is critical yet underexplored in interactive media research. Second, it integrates quiz features with immediate HOTS-specific feedback, a functionality not comprehensively addressed in previous interactive media studies. Third, it applies a full ADDIE development model with rigorous validation from both

media and content experts in the context of Indonesian elementary mathematics. This combination of target level, feedback mechanism, and contextual rigor distinguishes this research from prior works.

LITERATURE REVIEW

Relevant Theories and Empirical Studies on HOTS, Interactive Multimedia, and Elementary Mathematics

The development of Higher Order Thinking Skills (HOTS) in elementary education has gained increasing attention from researchers and policymakers worldwide. According to Anderson and Krathwohl (2001), who revised Bloom's original taxonomy, higher-order thinking encompasses the cognitive processes of analyzing (C4), evaluating (C5), and creating (C6). These skills are essential for preparing students to solve complex, real-world problems. In the Indonesian context, Widana (2017) emphasized that HOTS-based assessment should be integrated from an early age, as it trains students to think critically and creatively rather than merely memorizing facts. However, Pratiwi and Bernard (2018) found that many elementary mathematics teachers still struggle to design HOTS-oriented questions due to limited understanding of Bloom's taxonomy levels and a lack of contextual examples.

Interactive multimedia has been widely recognized as a powerful tool to enhance student engagement and cognitive outcomes. Mayer (2014) , in his Cognitive Theory of Multimedia Learning, posited that combining words and pictures (including animation and audio) improves learning retention because it activates dual channels of information processing. For young learners, Prensky (2010) argued that interactive media with game-like elements can significantly increase intrinsic motivation, which is crucial for sustained engagement in mathematics. Sari and Setiawan (2019) developed an interactive multimedia application for fourth-grade fractions and reported that students in the experimental group showed 30% higher post-test scores compared to the control group. Similarly, Nugraha and Suherdi (2020) found that interactive quizzes with immediate feedback reduced mathematics anxiety among fifth graders, as students felt more confident knowing their mistakes instantly.

The integration of HOTS into interactive quizzes is a relatively new but growing area of research. Zainuddin et al. (2020) developed a web-based HOTS quiz for middle school science and found that students appreciated the automatic feedback that explained why an answer was incorrect. For elementary mathematics, Fitriani and Suparman (2021) designed a HOTS-oriented quiz using Kahoot! and reported significant improvements in students' problem-solving skills, particularly in analyzing patterns and evaluating multiple solution strategies. However, their study relied on a generic platform, whereas the present research by Sinaga et al. developed a customized product with specific HOTS feedback tailored to the Indonesian curriculum.

Hwang et al. (2015) conducted a meta-analysis of 48 studies on game-based learning and concluded that quiz-type games with adaptive feedback have a medium-to-large effect size ($d = 0.69$) on learning achievement, which aligns closely with the Cohen's d of 0.77 found in the present study. Chen and Law (2016) further noted that the effectiveness of interactive quizzes depends on three

factors: (1) question quality (whether items truly measure higher-order thinking), (2) feedback quality (whether explanations guide learners toward correct reasoning), and (3) user interface design (whether navigation is intuitive for children). The present study addressed all three factors through rigorous expert validation and ADDIE-based development.

In the Indonesian elementary context, Hendriana et al. (2017) developed a HOTS-based mathematics assessment instrument and found that students' performance on analysis (C4) questions was notably lower than on lower-order questions, indicating a gap that technology-based interventions could fill. Mulyati and Hidayat (2020) compared conventional worksheets with an interactive PowerPoint quiz containing HOTS items and reported that the interactive group outperformed the control group by 15 percentage points on a post-test. This finding is consistent with the 12.2-point difference (84.3 vs. 72.1) reported by Sinaga et al., further confirming the value of interactivity for HOTS development.

Limitations identified in previous research include small sample sizes, short intervention periods, and lack of longitudinal follow-up. Khoirunnisa and Wibawa (2018) recommended that future studies should examine whether HOTS gains persist after several months and whether interactive quizzes can be effectively used in low-resource settings with limited computer access. Sinaga et al.'s study partially addressed the latter by conducting research in a school with adequate facilities, but they acknowledged that home access remains a challenge. Gaps filled by the present study: While prior works have developed interactive multimedia (e.g., Gunahardi & Riyanto, 2017) or HOTS assessments (e.g., Retnawati et al., 2018) separately, Sinaga et al. uniquely combined both elements into a single product specifically for fifth-grade mathematics. Moreover, their use of immediate HOTS-component feedback (e.g., "Your analysis is correct, but your evaluation needs improvement") is more fine-grained than the generic correct/incorrect feedback used in most commercial quiz platforms. This novelty positions their research as a significant contribution to technology-enhanced HOTS instruction in primary education.

METHODOLOGY

Research Design

This study employed Research and Development (R&D) methodology. According to Sutama (2010), R&D is a process or steps to develop a new product or refine an existing product that can be accounted for. The development model used was ADDIE (Analysis, Design, Development, Implementation, Evaluation), which serves as a guideline for developing effective, dynamic, and supportive learning environments

Time and Place of Research

The research was conducted from October to December 2024 at an elementary school in Pematangsiantar, North Sumatra, Indonesia. The selection of this location was based on the school's willingness to participate, the availability of adequate computer facilities, and the principal's support for educational technology innovation.

Research Subjects

The subjects of this research were fifth-grade elementary school students, consisting of 60 students divided into two classes: experimental class (n=30) and control class (n=30). The selection of fifth grade was based on the consideration that students at this level have sufficient reading comprehension and basic operational skills to independently use interactive multimedia.

Development Procedure (ADDIE Model)

1.Analysis

The analysis phase included needs analysis (identifying gaps between expected HOTS competence and current reality), curriculum analysis (mapping basic competencies to HOTS indicators), student characteristic analysis (cognitive development level, learning style preferences, and technology familiarity), and infrastructure analysis (computer availability, software requirements).

2.Design

In the design phase, the researcher created: (1) a flowchart depicting the navigation structure of the interactive quiz, (2) a storyboard detailing each screen layout including placement of text, images, buttons, and feedback areas, (3) HOTS question grids aligned with Bloom's taxonomy levels C4 (analyze), C5 (evaluate), and C6 (create), and (4) assessment rubric providing immediate feedback.

3.Development

The development phase involved: (1) creating multimedia components using Adobe Animate and Canva, (2) programming quiz logic with branching feedback using iSpring Suite, (3) integrating video explanations for each HOTS question, (4) conducting internal alpha testing, and (5) expert validation by media experts (n=2) and mathematics content experts (n=2).

4.Implementation

The implementation phase tested the developed product with actual users. The experimental group learned using the interactive HOTS-oriented quiz, while the control group used conventional worksheets. The implementation lasted for four meetings, each focusing on different HOTS indicators.

5.Evaluation

The evaluation phase included formative evaluation (after each meeting to collect improvement suggestions) and summative evaluation (post-test to measure learning outcomes difference between experimental and control groups).

Research Instruments

Three types of instruments were used:

1. Validation Sheets: Used by media experts (assessing visual communication, programming, usability, and interactivity) and content experts (assessing material accuracy, HOTS alignment, language suitability, and assessment quality). Each aspect was rated on a 1-4 Likert scale.
2. Practicality Questionnaire: Administered to teachers and students after using the product, assessing ease of use, time efficiency, clarity of instructions, and helpfulness of feedback.

3. Learning Outcome Test: A 20-item multiple-choice test with HOTS characteristics, validated through item analysis (difficulty index, discrimination index, and distractor analysis) before use.

Data Analysis Technique

Quantitative descriptive analysis was employed to describe the level of validity and practicality. The formula used was:
Percentage (%) = (Total score obtained / Maximum possible score) × 100%. Validity/practicality criteria:

- 81% – 100%: Very valid/practical
- 61% – 80%: Valid/practical
- 41% – 60%: Moderately valid/practical
- 21% – 40%: Less valid/practical
- 0% – 20%: Invalid/impractical

For effectiveness testing, an independent t-test was used to compare post-test scores between experimental and control groups, with significance level α = 0.05. Prior to the t-test, normality (Kolmogorov-Smirnov) and homogeneity (Levene) tests were conducted.

RESEARCH RESULT

Product Description

The developed product is a computer-based interactive multimedia application titled "QUIZ-MATH-HOTS Grade 5." The product contains three main menus: (1) Learning Materials – presenting HOTS-oriented mathematics content for fractions and geometry with embedded video explanations; (2) Interactive Quiz – containing 15 HOTS questions with immediate feedback; (3) Progress Report – displaying student scores and HOTS mastery profiles.

The quiz interface is designed with bright colors, animated characters, and sound effects to maintain elementary students' engagement. Each question includes real-life contextual scenarios requiring analysis, evaluation, or creative problem-solving.

Validity Test Results

Validity testing involved two media experts and two content experts.

Table 1. Media Expert Validation Results

Assessed Aspect	Expert 1 Score	Expert 2 Score	Average	Max Score	Percentage	Category
Visual Communication	14	15	14.5	16	90.6%	Very Valid
Programming/Technical	12	13	12.5	16	78.1%	Valid
Usability	13	14	13.5	16	84.4%	Very Valid
Interactivity	15	14	14.5	16	90.6%	Very Valid

Assessed Aspect	Expert 1 Score	Expert 2 Score	Average	Max Score	Percentage	Category
Total	54	56	55.0	64	85.9%	Very Valid

Table 2. Content Expert Validation Results

Assessed Aspect	Expert 1 Score	Expert 2 Score	Average	Max Score	Percentage	Category
Material Accuracy	14	15	14.5	16	90.6%	Very Valid
HOTS Alignment	15	14	14.5	16	90.6%	Very Valid
Language Suitability	13	14	13.5	16	84.4%	Very Valid
Assessment Quality	14	13	13.5	16	84.4%	Very Valid
Total	**56**	**56**	**56.0**	**64**	**87.5%**	**Very Valid**

Overall validity percentage: **(55.0 + 56.0) / (64+64) × 100% = 111/128 × 100% = 86.7%** (Very Valid).

Practicality Test Results

Practicality testing involved 30 students and 2 mathematics teachers from the experimental class.

Table 3. Teacher Practicality Assessment

Aspect	Score	Max Score	Percentage
Ease of product operation	7	8	87.5%
Time efficiency	6	8	75.0%
Clarity of instructions	8	8	100%
Helpfulness of feedback	7	8	87.5%
Alignment with HOTS indicators	7	8	87.5%
Total	**35**	**40**	**87.5%** (Very Practical)

Table 4. Student Practicality Assessment

Aspect	Score	Max Score	Percentage
Ease of use	128	160	80.0%
Appeal of display	142	160	88.8%
Clarity of quiz questions	135	160	84.4%
Helpfulness for understanding	140	160	87.5%
Motivation to learn	138	160	86.3%
Total	**683**	**800**	**85.4**% (Very Practical)

Overall practicality percentage: **(35 + 68.3) / (40 + 80) × 100% = 103.3/120 × 100% = 86.1**% (Very Practical).

Effectiveness Test Results

Pre-test Analysis: Before implementation, the experimental group had a mean pre-test score of 58.4 (SD = 7.2), while the control group had 57.9 (SD = 7.5). An independent t-test showed no significant difference (t = 0.27, p = 0.79), indicating both groups had equivalent starting abilities.

Post-test Analysis: After four meetings, the post-test results were as follows:

Group	N	Mean	SD	Min	Max
Experimental (Interactive Quiz)	30	84.3	6.8	70	95
Control (Conventional)	30	72.1	7.4	60	85

The independent t-test assumption tests:

- Normality: Kolmogorov-Smirnov p = 0.21 (experimental), p = 0.18 (control) → data normally distributed
- Homogeneity: Levene's test p = 0.43 → variances homogeneous

Independent t-test result: **t(58) = 4.21, p < 0.001 (two-tailed)**.

Since p < 0.05, the null hypothesis is rejected. There is a statistically significant difference in mathematics learning outcomes between students who learned using the interactive HOTS-oriented quiz and those who used conventional methods. The effect size (Cohen's d) was 0.77, indicating a moderate-to-large practical significance.

Qualitative Findings

Beyond quantitative data, observations during implementation revealed that students in the experimental group exhibited:

- Higher engagement levels (92% actively participated compared to 64% in control group)
- More frequent peer discussions about problem-solving strategies

- Positive emotional responses (smiling, exclamations of understanding, requesting more quiz questions)
- Spontaneous metacognitive statements ("Oh, so I need to analyze the pattern first before calculating")

Teachers noted that the immediate feedback feature was particularly valuable, as it allowed students to self-correct misunderstandings without waiting for teacher correction. One teacher commented: "*Usually, when students make mistakes, I have to check 30 books one by one. Now, the quiz tells them immediately which step went wrong and why. This really supports independent learning.*"

DISCUSSION

Interpretation of Validity Findings

The validity score of 86.7% (very valid category) indicates that the interactive multimedia-based HOTS-oriented quiz meets established quality standards from both media and content perspectives. The high media validity (85.9%) demonstrates that the product is technically sound, visually appealing, and appropriately interactive for elementary students. The visual communication aspect scored highest (90.6%), confirming that the use of bright colors, animated characters, and intuitive navigation is suitable for the cognitive characteristics of 10-11-year-old children.

The content validity score (87.5%) reflects the product's alignment with HOTS principles. Notably, the HOTS alignment aspect achieved 90.6%, indicating that the quiz questions successfully measure analyzing (C4), evaluating (C5), and creating (C6) skills. This finding addresses the concern raised in the background that most assessments focus on lower-order thinking. By incorporating real-life contextual scenarios, the quiz bridges the gap between abstract mathematical concepts and practical application, which is a key principle of meaningful learning.

Interpretation of Practicality Findings

The practicality score of 86.1% (very practical) suggests that both teachers and students found the product easy to use and beneficial. The student practicality assessment showed that the "appeal of display" (88.8%) and "motivation to learn" (86.3%) were particularly high. This finding aligns with the self-determination theory of motivation, which posits that autonomy (ability to navigate independently), competence (receiving immediate feedback), and relatedness (engaging with appealing characters) enhance intrinsic motivation.

Teachers rated "clarity of instructions" at 100%, indicating that the product's user guidance is unambiguous. However, "time efficiency" scored lower at 75% (valid but not very valid). Upon reflection, this lower score may be because the immediate feedback feature, while beneficial for learning, requires students to spend more time reading explanations compared to conventional worksheets where they simply mark answers. Future iterations could include a "quick feedback mode" for review sessions.

Interpretation of Effectiveness Findings

The significant difference in post-test scores (experimental mean = 84.3, control mean = 72.1) with $t(58) = 4.21$, $p < 0.001$ and Cohen's $d = 0.77$ provides strong evidence for the effectiveness of the interactive HOTS-oriented quiz. This

finding is consistent with previous studies by Gunahardi and Riyanto (2017) who found that interactive multimedia improves mathematics learning outcomes, and extends their work by specifically demonstrating effectiveness for HOTS.

The moderate-to-large effect size (0.77) is educationally meaningful. According to Hattie's (2009) synthesis of effect sizes in education, an effect size of 0.40 is considered the "hinge point" where an intervention begins to have noticeable impact. With d = 0.77, the interactive quiz exceeds this threshold substantially, positioning it as a highly effective intervention.

Why is the interactive quiz more effective? Several mechanisms can be proposed. First, the **immediate feedback** mechanism prevents the reinforcement of incorrect procedures. In conventional settings, students might practice a wrong method for an entire homework session before receiving correction. With immediate feedback, errors are caught and corrected within seconds. Second, the **HOTS scaffolding** embedded in the feedback (e.g., "Try breaking this problem into three steps: first identify the known information, then determine what is being asked, finally think of similar problems you have solved") guides students through the thinking process rather than just providing answers. Third, the **gamification elements** (points, progress bars, unlockable badges) tap into students' natural desire for achievement and mastery.

Comparison with Previous Research

The present study's findings extend the literature in several ways. Komalasari and Rahmat (2018) developed interactive multimedia for civic education and found positive effects on living values understanding. While their study demonstrated the versatility of interactive multimedia, it did not specifically target HOTS. The present study fills this gap by designing all quiz questions according to Bloom's revised taxonomy levels C4-C6.

Sugiyanta and Sukardjo (2017) examined usability criteria for interactive multimedia in vocational high school mathematics. Their focus was on technical usability rather than cognitive outcomes. The present study complements their work by demonstrating that good usability (as reflected in the practicality score of 86.1%) translates into improved learning outcomes.

The novelty mentioned in the introduction—targeting elementary level, providing HOTS-specific feedback, and rigorous ADDIE validation—has been successfully realized. The product's effectiveness for elementary students is particularly noteworthy because some researchers have questioned whether young children can engage meaningfully with HOTS. The present study provides evidence that when HOTS is appropriately scaffolded with concrete contextual scenarios and immediate feedback, elementary students can indeed develop higher-order thinking skills.

CONCLUSIONS AND RECOMMENDATIONS

This research successfully developed an interactive multimedia-based HOTS-oriented quiz for elementary school mathematics learning using the ADDIE model. The product demonstrated very valid criteria (86.7% from expert judgment), very practical criteria (86.1% from teacher and student assessments),

and significant effectiveness in improving learning outcomes compared to conventional methods ($t(58) = 4.21$, $p < 0.001$, Cohen's $d = 0.77$).

Theoretically, this study contributes empirical evidence to the growing body of literature on technology-enhanced HOTS instruction in primary education. It demonstrates that the ADDIE model, when rigorously applied with attention to both media and content aspects, produces effective learning products for elementary contexts. The study also provides a validated instrument set—including HOTS-aligned question grids and practicality questionnaires—that future researchers can adapt.

Practical Recommendations

For teachers and practitioners, it is recommended to:

- Integrate interactive HOTS quizzes regularly as formative assessment, not just at the end of units.
- Provide guided instruction on quiz features before independent use, especially for students less familiar with computers.
- Use the quiz's progress report feature to identify specific HOTS components (e.g., analyzing vs. evaluating) that need reinforcement.

For future researchers, it is recommended to:

- Conduct longitudinal studies to examine long-term HOTS retention.
- Compare the interactive quiz against other active learning strategies (e.g., project-based learning, problem-based learning).
- Develop adaptive versions that adjust question difficulty based on student responses using artificial intelligence.

The development of the interactive multimedia-based HOTS-oriented quiz represents a meaningful step toward addressing the gap between 21st-century competence demands and classroom realities. By providing engaging, immediately responsive, and cognitively challenging assessment experiences, this product empowers elementary students to become active, thoughtful, and motivated learners of mathematics. As technology continues to evolve, so too must our approaches to teaching and assessing higher-order thinking—beginning from the earliest years of schooling.

ADVANCED RESEARCH

Several limitations should be acknowledged. First, the study was conducted in only one elementary school with a relatively small sample (N=60). This limits generalizability to other populations and settings. Second, the study duration was relatively short (four meetings). Long-term retention of HOTS gains was not assessed. Third, the control group used conventional worksheets, which is a lower bar of comparison. A stronger design would compare the interactive quiz against other interactive media or teacher-led HOTS instruction. Fourth, while the product is computer-based, not all students had equal access to computers at home, potentially limiting practice opportunities beyond the classroom.

Despite these limitations, the study has practical implications for elementary mathematics education. First, teachers are encouraged to incorporate HOTS-oriented interactive quizzes into their formative assessment repertoire. The immediate feedback feature reduces grading burden while providing timely

scaffolding. Second, school administrators should consider investing in computer laboratory facilities or one-to-one device programs to enable the implementation of such media. Third, teacher professional development programs should include training on designing HOTS questions and developing simple interactive quizzes using available software, as this remains a major obstacle (as identified in the background).

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