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Development of Quick Count Math Educational Game–Based Media for Learning Integers

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ABSTRACT

In response to students' persistent difficulties in understanding integer operations and the limited use of engaging digital game–based media in mathematics classrooms, this study aims to develop "Quick Count Math," an educational game–based instructional medium on the topic of integers for seventh-grade junior high school students. The study employed a Research and Development (R&D) design using the Four-D model, which consists of the define, design, develop, and disseminate stages. The game is designed to support learning of integer operations (addition, subtraction, multiplication, and division) through interactive challenges, gradually increasing levels of difficulty, immediate feedback, and appealing visuals. The results indicate that "Quick Count Math" meets the criteria of validity, practicality, and effectiveness. Expert review yielded validity scores of 85% for media aspects and 100% for content aspects, both categorized as very high. In addition, the game was reported to be easy to use by students and was effective in improving their understanding and learning outcomes on the integer topic, with an effectiveness score of 86%. These findings suggest that "Quick Count Math" can serve as an engaging and effective alternative digital medium for teaching mathematics in seventh-grade junior high school classes.

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Introduction

The development of digital technology in the era of the Fourth Industrial Revolution has transformed the way people work, communicate, and learn. This revolution is characterized by the integration of the internet, cloud computing, artificial intelligence, and the Internet of Things across various sectors of life (Borba, 2009; Engelbrecht et al., 2020). The education sector cannot be separated from these changes, since schools are required to prepare students who are

technologically literate and adaptive to change (Hsieh et al., 2025; Rocha, 2020). Curriculum policies in Indonesia encourage the strengthening of STEAM-based learning that integrates science, technology, engineering, the arts, and mathematics (Pepin, 2021). This integration demands the use of more interactive, digital, and contextual media and learning resources in the classroom. Without innovation in the use of technology, instruction tends to remain lecture-based and struggles to meet twenty-first-century competence requirements.

Mathematics is one of the key subjects within the STEAM framework, yet students often perceive it as difficult and uninteresting (Lee et al., 2019; Marufi et al., 2021; Stohlmann, 2019). Various studies and school reports indicate that many students still struggle to understand basic concepts, particularly those related to integers (Whitacre et al., 2017). These difficulties affect learning motivation, contribute to mathematics anxiety, and lead to learning outcomes that do not meet curriculum targets (Bofferding, 2014). When instruction relies only on abstract explanations and routine textbook exercises, students tend to memorize procedures without understanding their meaning (S. Kumar et al., 2017). This situation is not aligned with the demand to develop critical thinking, creativity, and problem-solving skills that are central to twenty-first-century education. Therefore, teachers need to be supported with learning media that can make mathematics content, especially integers, more meaningful, engaging, and accessible to students.

Instructional media play an important role as an intermediary between abstract content and the concrete learning experiences that students undergo (Alqahtani & Powell, 2017). Experts state that instructional media include all forms of tools, technologies, or resources that help teachers present material in a more comprehensible way (Lee et al., 2019; Swidan, 2020; Taher et al., 2019). Well-designed media can foster learning interest, help visualize concepts, and clarify relationships among ideas (Borji et al., 2020). Media can also improve teachers' performance quality because they enable varied delivery strategies and reduce the dominance of one-way lecturing. In addition, appropriate media can facilitate communication between teachers and students, especially when the content is symbolic and complex, such as integer operations. Thus, selecting and developing instructional media is not merely an add-on, but a strategic component in designing effective mathematics instruction.

One form of instructional media that has developed rapidly is the educational game. Educational games combine elements of entertainment and learning so that students can learn while playing in a structured environment (Kärki et al., 2022; Nisa & Susanto, 2022). Research indicates that games designed with pedagogical goals can enhance students' attention, retention, and engagement with the content. Animation, challenges, and feedback in games help students remember material longer than with conventional, one-way teaching methods. Educational games also provide space for students to practice, make mistakes, and refine their strategies without feeling threatened by direct teacher evaluation. Given these characteristics, educational games have strong potential to be used as a means to strengthen understanding of mathematical concepts and to train thinking skills.

Several previous studies have developed educational games for mathematics learning and reported promising results. Nisa & Susanto (2022), for example, developed an educational game on geometric transformations and found that the resulting product met the criteria of validity, practicality, and effectiveness, making it feasible to use as a learning multimedia. Kärki et al. (2022) reported that the educational game she developed achieved an 85 percent success rate in use and was recommended as an alternative learning tool. Angeliki Kolovou et al. (2013) developed an educational game on integers and obtained very good ratings from content, media, and entrepreneurship experts, along with a high level of practicality in use. Overall, these findings indicate that educational games can help teachers present mathematics content in a more engaging and interactive way. However, upon closer examination, the main

Kognitif: Jurnal Riset HOTS Pendidikan Matematika
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focus of some of these games remains on achieving scores, completing levels, or determining final answers, rather than on making students' thinking processes visible and strengthening concepts in depth.

Further analysis of the designs of previous games reveals several important limitations. In one game, the character functions only as an indicator of successful level completion and does not directly contribute to understanding the mathematical concepts being learned. In another game, students who do not yet understand the concepts must rely on learning recommendations that appear after play, so concepts tend to be received passively rather than discovered independently. There is also a game that emphasizes only the determination of positive or negative answers without highlighting the calculation process and reasoning behind those answers (Bishop et al., 2014; Bofferding, 2014; Whitacre et al., 2017). These limitations indicate that there is still room to develop educational games that place stronger emphasis on concept discovery, mathematical representation, and formal reasoning. Such games are expected not only to entertain, but also to facilitate students in building durable conceptual understanding through exploratory and reflective activities.

Observations and interviews conducted by the researcher at a junior high school revealed that many students still have weak understanding of basic integer concepts. A total of 67.5 percent of students did not reach the Minimum Mastery Criterion on this topic, indicating a serious problem in the learning process. The mathematics teacher reported that during the Covid-19 pandemic, students became more accustomed to using mobile phones and accessing the internet, but this increased use of technology was not always accompanied by stronger conceptual understanding. Most learning activities were still dominated by routine tasks and written exercises, while interactive digital media were rarely used. The teacher also noted the absence of interactive learning media, such as educational games relevant to integer operations, that could attract students' interest to practice independently. These findings underline the need to develop interactive learning media that not only leverage students' interest in technology, but are also specifically designed to strengthen understanding of integer concepts.

Based on this rationale, the present study aims to develop mathematics learning media based on the Quick Count Math educational game on the topic of integers, particularly integer operations. Quick Count Math is designed as a single-player game so that students can focus on exploring and strengthening their own concepts without the pressure of direct competition. In this game, characters and visual objects serve not merely as ornaments, but as symbols and tools to represent integer operations. Players are guided to discover and understand concepts through gameplay instructions and repeated practice, making the process of obtaining answers more transparent. The game also provides opportunities for students to express algebraic forms that produce given numbers, so that their computational skills and mathematical thinking can be observed from the steps they take. The development of Quick Count Math uses the object-based software Construct 2, which facilitates the design of interactions and visuals within the game. The expected implication is the availability of an ICT-based alternative learning medium that can help teachers develop students' competencies on integer topics and improve the quality of mathematics instruction at the junior high school level.

Method

Type of Research

This study was conducted at SMP Negeri 3 Tondano, Indonesia. The research focused on the development and implementation of a mathematics learning medium based on the "Quick Count Math" educational game for the topic of integers. The development process and initial

trials were carried out within the regular mathematics teaching context at the school. The dissemination stage of the product was implemented in Grade VII classes at SMP Negeri 3 Tondano, where the game was used as an instructional medium during lessons on integer operations. The school setting represents a typical Indonesian junior high school with students who have diverse levels of mathematical ability and access to digital devices.

Participants

The participants in this study were students of SMP Negeri 3 Tondano. The main trial subjects were Grade VIII students, who used the Quick Count Math game as part of their mathematics learning activities on integer material. The game was designed as a single-player learning medium to help students understand integer operations. In addition to students, two experts were involved in the validation process. One media expert evaluated the design, layout, and technical quality of the game, while one subject-matter expert evaluated the accuracy and suitability of the mathematical content. The mathematics teacher at SMP Negeri 3 Tondano also participated in interviews to provide contextual information about the current learning process and the media used in the classroom.

Instruments and Procedures

Several instruments were used to collect data in this study. An interview guide was used in a semi-structured interview with a mathematics teacher to obtain information about the learning process and the types of media commonly used at SMP Negeri 3 Tondano. Validation sheets were given to a media expert and a subject-matter expert to assess the validity of the Quick Count Math learning media, covering criteria related to content accuracy, presentation, language, and technical aspects of the game. Student response questionnaires were used to measure the practicality of the learning media; they used a 5-point Likert scale and were administered after students used the game. The media were considered practical if students reported that they were easy to use and helpful for learning. In addition, a learning achievement test was used to evaluate the effectiveness of the Quick Count Math game. The media were considered effective if at least 80% of the students achieved scores greater than or equal to the Minimum Mastery Criterion (KKM).

Procedures

This study employed a Research and Development (R&D) approach using the Four-D development model by Thiagarajan, Semmel, and Semmel, which consists of four stages: Define, Design, Develop, and Disseminate. In the Define stage, the researcher reviewed the curriculum and identified basic problems in learning integers, and conducted a subject analysis to identify the characteristics of the students involved in the trial. In the Design stage, the researcher selected an appropriate medium for presenting the learning material and determined the format of the Quick Count Math game, including content design and character selection; at this stage, the initial prototype of the game (Draft 1) was produced together with the research instruments, namely validation sheets, student response questionnaires, and learning achievement test items. In the Develop stage, the initial draft of the learning media was submitted to a media expert and a subject-matter expert for validation, and revisions based on their feedback resulted in Draft 2, which was then tried out with students as research subjects to collect data on practicality and effectiveness. In the Disseminate stage, the finalized version of the Quick Count Math game was implemented in Grade VII classes at SMP Negeri 3 Tondano as an alternative learning medium for teaching integers.

Kognitif: Jurnal Riset HOTS Pendidikan Matematika
https://doi.org/10.51574/kognitif.v5i4.2482 Volume 5, No 4, October - December 2025, pp. 1623– 1636

Analysis

Data analysis in this study used qualitative descriptive techniques and descriptive statistics. Qualitative descriptive analysis was used to describe the development process of the learning media and to summarize comments and suggestions from the experts and the teacher, while descriptive statistics were used to analyze numerical data obtained from validation sheets, student questionnaires, and achievement tests. The validity of the Quick Count Math media was assessed based on the scores given by one media expert and one subject-matter expert using the validation sheets, and these scores were converted into percentages to determine the validity category of the media. Practicality was evaluated through student response questionnaires using a 5-point scale, and the percentage of positive responses was calculated to determine whether the media were practical and easy to use from the students' perspective. Effectiveness was examined using the results of the learning achievement test by computing the percentage of students who achieved scores at or above the Minimum Mastery Criterion (KKM = 70). The Quick Count Math game was considered effective if the percentage of students reaching the KKM met at least the "fairly effective" criterion, with a target of 80% of students achieving mastery.

Results

Define Phase

At the initial stage, namely the Define phase, the first step in this research and development serves as a guideline and benchmark for designing the learning media. The analyses conducted include the following.

Initial–Final Analysis

Based on observations and preliminary data analysis in Grade VII at SMP Negeri 3 Tondano, the average score of students' daily tests on the topic of Integers was 62. Only 40% of students reached the Minimum Mastery Criterion (KKM), which was set at 70. During the learning process, students tended to be passive and showed low active participation. The teacher still relied on lectures and worksheets as the main learning media. This condition indicates the need for innovation in the learning process to improve students' motivation and learning outcomes. With the development of the Quick Count Math educational game as mathematics learning media, the average score of students' daily tests on the topic of Integers is expected to increase to at least 75. The percentage of students achieving mastery is expected to reach at least 80%. This learning media is also expected to increase students' activeness and learning motivation, and to create a more enjoyable and interactive learning atmosphere.

Subject Analysis

Based on interviews with the mathematics teacher, the following points can be concluded: (1) Students still experience difficulties in performing integer operations; (2) Students remain dependent on one-way, teacher-centered instruction; and (3) Students are less interested and quickly become bored with classroom learning. Based on the initial–final analysis and the subject analysis, the researcher developed an educational game-based learning media with a practical and attractive interface that is easy to access using smartphones, so that students can learn and review material they have not yet understood.

The evaluation of the Define phase indicated that the curriculum analysis and the analysis of student characteristics at SMP Negeri 3 Tondano for Grade VII mathematics require renewal in the learning process. It is necessary to design an educational game-based learning media, Quick Count Math, on integer material to be used as a learning exercise for students that is engaging and aligned with the learning criteria applied at the school. Based on these findings, the researcher proceeded to the Design phase.

Design Phase

After completing the curriculum analysis and the analysis of student characteristics, the next step was the Design phase. At this stage, the learning media to be developed were designed based on the results of the previous analyses, resulting in a prototype of integer learning media for Grade VII under the Merdeka Curriculum.

Development Phase

Based on the instructional design that had been prepared, it was then implemented as a mathematics learning medium on the topic of integers packaged in the form of an educational game. The educational game consists of four levels, namely addition, subtraction, multiplication, and division. Each level contains four sub-levels. After completing the planning stage, the next stage is development. The development stages are as follows.

Learning Media Validation

Product validation was carried out to obtain input from experts, namely a subject-matter expert and a media expert. Suggestions and comments regarding weaknesses and shortcomings of the product from the expert validators were used as a basis for revising the educational game so that it is suitable for use. The validation stage was conducted from October to November 2025. Validation was carried out by one media expert validator, who assessed the display aspects of the Quick Count Math educational game, and one subject-matter expert validator, who assessed the learning aspects, content, and evaluation items. The validation results from the media and material experts were then used as the basis for revising the learning media. Validation by media and material experts aimed to determine whether the media is suitable for use and to obtain suggestions for improvement. The results of the media and material expert validation are as follows.

Media Expert Validation

The media expert validation results show that the Quick Count Math educational game obtained an average score of 82 percent, which falls into the “very valid” category. The media expert’s assessment consists of five aspects. The integration aspect obtained an average of 80 percent (valid category), the balance aspect 94 percent (very valid category), the font aspect 75 percent (valid category), and the color aspect 80 percent (valid category).

Table 1. Media Expert Validation Results

No	Aspect	Average	Category
1	Integration	80%	Valid
2	Balance	94%	Very valid
3	Font	75%	Valid
4	Color	80%	Valid
	Overall result	82%	Very valid

Kognitif: Jurnal Riset HOTS Pendidikan Matematika
https://doi.org/10.51574/kognitif.v5i4.2482 Volume 5, No 4, October - December 2025, pp. 1623– 1636

Material Expert Validation

Based on the validation results from the material expert, the overall average score was 100 percent, which is in the "very valid" category. The material expert's assessment consists of two aspects. The material suitability aspect obtained an average of 100 percent (very valid category), and the language suitability aspect also obtained an average of 100 percent (very valid category).

Table 2. Material Expert Validation Results

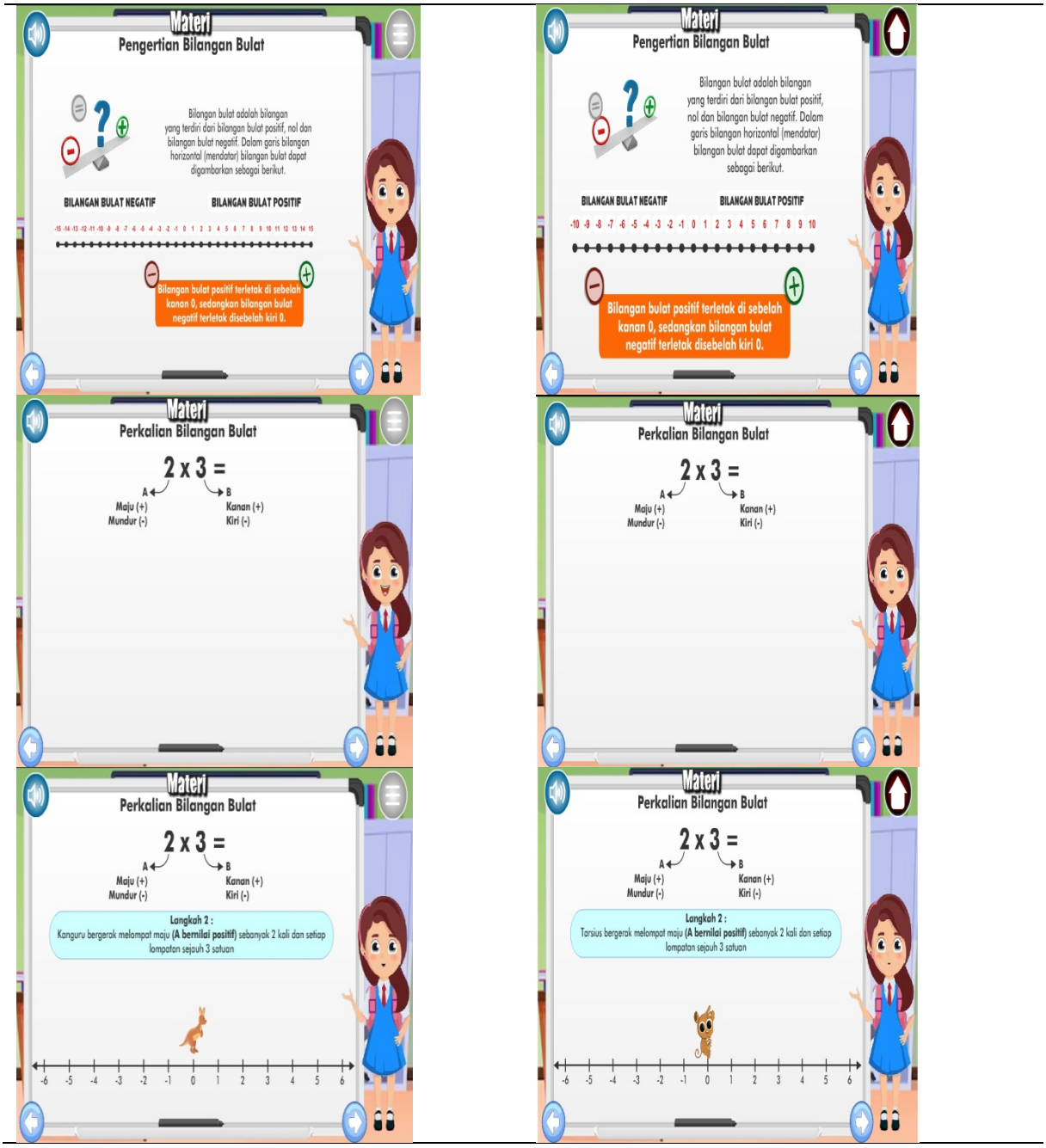
No	Aspect	Average	Category
1	Material suitability	100%	Very valid
2	Language suitability	100%	Very valid
	Overall result	100%	Very valid

Design Revision

After the product design was validated by the media expert and material expert, the researcher revised the product based on the suggestions and comments from the validators on the developed product. The suggestions and comments from the validator team are as follows.

Table 3. Design Revisions

Before Revision	After Revision
	
	



Try-out

The validated learning media was then tried out on students who became the research subjects. The try-out was conducted using the game that contains material and items that also function as a test given to students. The product was tried out on students of SMP Negeri 3 Tondano, involving 8 students for the small-scale try-out and 26 students for the large-scale try-out. The purpose of the try-out was to determine whether the product is attractive enough to be used as one of the students' learning resources by distributing questionnaires for the students to complete.

Kognitif: Jurnal Riset HOTS Pendidikan Matematika
https://doi.org/10.51574/kognitif.v5i4.2482 Volume 5, No 4, October - December 2025, pp. 1623– 1636

Table 4. Small-Scale Try-out Results

No	Aspect	Analysis	Small Group Try-out (Students 1–8)					
			1	2	3	4	5	6
1	Content quality	ΣScore	18	17	16	15	17	16
			4.6	4.5	4.2	4.0	4.5	4.2
		Average	4.275					
		Criteria	Very interesting					
2	Display	ΣScore	7	7	6	6	7	6
			4.5	4.5	4.0	4.0	4.5	4.0
		Average	4.41					
		Criteria	Very interesting					
3	Language	ΣScore	8	7	6	6	7	6
			5.0	4.5	4.0	4.0	4.5	4.5
		Average	4.55					
		Criteria	Very interesting					

Based on Table 4, in the small-scale try-out, the content quality aspect obtained an average score of 4.275 with the criterion “very interesting”. The display aspect obtained an average score of 4.41 with the criterion “very interesting”. The language aspect obtained an average score of 4.55 with the criterion “very interesting”. The small-scale try-out of the developed educational game received good responses from students and met the “very interesting” criterion. This means that the learning media developed by the researcher is attractive for use as learning media on integer operations for students of SMP Negeri 3 Tondano. The next step was a field try-out involving 28 students. The field try-out results show that the content quality aspect obtained an average score of 4.45 with the criterion “very interesting”. The display aspect obtained an average of 4.21 with the criterion “interesting”. The language aspect obtained an average of 4.46 with the criterion “very interesting”.

Based on student responses in the small-scale try-out and the field try-out, the media received positive responses with criteria in the “very interesting” range. Therefore, the mathematics learning media based on the Quick Count Math educational game is suitable for use in classroom learning. To measure the effectiveness of the game, a learning test was administered to 26 students. Test data were obtained from students’ work on the evaluation items in the Quick Count Math educational game, and were categorized based on the Minimum Mastery Criterion (KKM). The KKM applied for grade VII students at SMP Negeri 3 Tondano is 70. The test results are presented in the following table.

Table 5. Learning Mastery Results

Description	Number of students	Percentage
Mastery	22	86%
Not mastered	4	15%

Based on the data above, the percentage of students who achieved mastery is 86 percent, and the percentage of students who did not achieve mastery is 15 percent. This shows that the mathematics learning media based on the Quick Count Math educational game developed by the researcher is very effective.

Dissemination Phase

Dissemination phase was implemented in all Grade VII classes at SMP Negeri 3 Tondano. The learning media, developed in the form of an Android-based application, was handed over to the mathematics teacher in each class along with a brief orientation on its features and suggested use in classroom instruction and independent study. Teachers were encouraged to integrate the Quick Count Math game into their regular lessons on integer operations and to use

it as supplementary practice both during and after class. In addition, the application file was stored and documented at the school level so that it can be reused, shared with future cohorts, and potentially adopted by other mathematics teachers in the school.

Discussion

The development of Quick Count Math through the Four-D R&D model highlights the importance of a systematic pathway from needs analysis to classroom implementation. In the Define and Design phases, curriculum requirements, student characteristics, and the nature of integer concepts guide every design decision, so the game does not stand apart from the syllabus but grows out of it. This alignment is crucial in contexts where teachers often rely on lectures and worksheets, because it offers a concrete example of how digital media can be integrated without abandoning curricular demands (Freeman et al., 2020; Ratnayake et al., 2020; Swidan, 2020). The use of Construct 2 as the authoring tool also illustrates how relatively accessible technologies can be harnessed to produce interactive media that fit school realities (Freeman et al., 2020; Rocha, 2020; Zambak & Tyminski, 2020). Rather than treating technology as an add-on, the project embeds pedagogical considerations into the structure of the game, from task sequencing to feedback mechanisms. In this sense, Quick Count Math functions not only as a product but also as a model of how schools can approach the design of digital learning tools in a structured and research-based way.

From a pedagogical perspective, Quick Count Math reflects core principles of constructivist and game-based learning. Students interact with integer operations through tasks that require them to manipulate representations, make decisions, and observe the consequences of their choices in real time (Bishop et al., 2014; Bofferding, 2014; Whitacre et al., 2017). This interaction differs from traditional paper-based exercises, where feedback is often delayed and limited to right or wrong markings. In the game environment, feedback can be immediate, informative, and embedded in the flow of activity, which supports the development of procedural fluency while also reinforcing conceptual understanding. The presence of levels and sublevels creates a graded challenge structure that can maintain engagement and provide a sense of progression. Such features are consistent with theoretical claims that meaningful game-based learning occurs when cognitive demand, feedback, and challenge are carefully balanced. Thus, the design of Quick Count Math can be read as an operationalization of these principles for the specific domain of integer operations at the junior high school level.

The study also speaks to the role of digital games in addressing motivational issues that are common in mathematics classrooms. Many students experience mathematics as abstract, repetitive, and disconnected from their interests, which often leads to passive participation and low persistence. By embedding practice in a game format, Quick Count Math seeks to transform routine exercises into structured challenges that invite active involvement. Game elements such as progression through levels, clear goals, and immediate feedback can enhance attention and persistence, especially for students who usually disengage when faced with conventional problem sets (Angeliki Kolovou et al., 2013; Kärki et al., 2022; Nisa & Susanto, 2022). At the same time, the design avoids excessive decorative features that might distract from the mathematical content, so the focus remains on core skills in integer operations. This balance between motivational appeal and content focus is critical if educational games are to function as more than entertainment with superficial links to the curriculum.

At the level of school practice, Quick Count Math offers insight into how digital learning media can be integrated into everyday instruction in resource-constrained settings. The choice to develop an application that can run on commonly available devices, such as smartphones or school computers, responds to infrastructure realities in many Indonesian schools (Günster &

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Weigand, 2020). Teachers do not need a complete change in their lesson structure but can embed the game within existing teaching sequences, for example as a reinforcement activity after explanation or as a formative assessment tool (Martínez et al., 2020). The dissemination of the application to all Grade VII mathematics teachers illustrates a school-wide strategy rather than an isolated innovation in a single classroom. This opens opportunities for professional dialogue among teachers about how to plan lessons, manage class time, and support students who progress at different speeds while using the game. In this way, the product becomes a starting point for broader pedagogical reflection and collaboration at the school level.

The implications of this study extend beyond the specific context of integer operations at one junior high school. Quick Count Math can be seen as a prototype for how similar game-based media might be developed for other mathematical topics, such as fractions, algebraic expressions, or geometry, particularly within the framework of the Merdeka Curriculum. Future work could explore co-design processes that involve teachers and students more deeply in defining tasks, narratives, and feedback structures, so that the media reflect classroom realities even more closely. Comparative studies between different types of digital tools, such as simulations, interactive worksheets, and games, could also clarify which features are most influential for different learner profiles. In addition, longitudinal studies that track students over longer periods would provide insight into whether gains attributed to game-based media can be sustained and transferred to new topics. Through such extensions, the present study can serve as a foundation for a broader research agenda on the role of educational games in supporting meaningful and motivating mathematics learning in diverse school contexts.

Conclusion

This study developed the Quick Count Math educational game as an interactive medium for learning integer operations at the junior high school level using a Research and Development (R&D) approach with the Four-D model. The development process produced a game that integrates curriculum-aligned content, clear explanations, and practice items within a single-player digital environment designed to support students in exploring and strengthening their understanding of integers. The findings show that Quick Count Math meets high criteria of validity, practicality, and effectiveness. Experts judged the content, language, and media design to be appropriate for classroom use, students responded positively to the game and found it engaging and easy to use, and most learners achieved the expected level of mastery in the integer topic after using the media. These results indicate that Quick Count Math can serve as a feasible alternative to conventional materials and can support the integration of game-based learning into mathematics instruction. The study also provides a validated design that can inform the future development of educational games for other mathematical topics and broader school contexts.

Conflict of Interest

The authors declare that there is no conflict of interest.

Authors' Contributions

The first author, F.M., contributed to data collection, research instrument preparation, instrument validation, theoretical development, methodology, data organization and analysis, as well as the interpretation of findings. The second and third authors, A.L.F.T. and S.J.A.S.,

contributed to reviewing and refining the manuscript and ensured that the final version of this article was read and approved. The percentage contributions to the conceptualization, preparation, and revision of this manuscript are as follows: F.M.: 60%, I.D.: A.LF.T0%, and S.J.A.S.: 20%.

Data Availability Statement

The authors state that the data supporting the findings of this study will be made available by the corresponding author, [F.M.], upon reasonable request.

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