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# Developing an ICT-Based Multiplication House Game for Elementary Mathematics: Validity, Practicality, and Learning Performanc

**Janet Trineke Manoy [1*], Shofan Fiangga [1], Nonik Indrawatiningsih [1], Nina Rinda Prihartiwi [1] and Sugi Hartono [1] and Hutkemri Zulnaidi [2]**

1 Department of Mathematics Education, Faculty of Mathematics and Natural Sciences (FMIPA), Universitas Negeri Surabaya (UNESA), Surabaya 60231, Indonesia.
2 Department of Mathematics and Science Education, Faculty of Education, Universiti Malaya, 50603 Kuala Lumpur, Malaysia.

* **Corresponding Author:** janetmanoy@unesa.ac.id.

**ABSTRACT:** This study aims to develop an ICT-based Multiplication House learning media that is valid, practical, and feasible for use in elementary school mathematics learning. This research employs a development research design using the Plomp model, which consists of four phases: initial investigation, design, realization, and evaluation. The study involved 20 third-grade students of SD Laboratory UNESA as research subjects. The instruments used include (1) validation sheets to assess the content, format, and language validity of the media, (2) observation sheets to examine student engagement during learning, (3) questionnaires to measure students' responses and practicality, and (4) learning outcome tests to evaluate students' mastery of multiplication concepts. The developed media is designed as an interactive educational game that encourages students to explore strategies and solve multiplication problems competitively. The novelty of this study lies in the integration of traditional multiplication house media into an ICT-based platform equipped with features such as automatic answer randomization, real-time feedback, turn-based interaction, and dynamic game evaluation, which promote higher student engagement and strategic thinking. The results show that the ICT-based Multiplication House media meets the validity criteria, with an average score of 80.3% from material experts and 78% from media experts, both categorized as valid. The media is also considered highly practical, indicated by an average student response score of 4.27 (very practical category). In terms of post-implementation learning performance, 85% of students achieved scores of ≥80 on the multiplication learning test, indicating that most students reached the predetermined mastery criterion. However, the relatively small sample size (n = 20) limits the generalizability of the findings and should be considered in interpreting the results. In conclusion, the ICT-based Multiplication House media is feasible for use in elementary mathematics learning, particularly in multiplication topics. This study implies that integrating game-based ICT media can support student engagement and facilitate multiplication learning activities. Future research is recommended to involve larger samples and diverse educational contexts to strengthen the generalizability and explore long-term impacts on students' mathematical thinking skills.

**Keywords**: ICT-based learning, Educational game, Elementary mathematics, Multiplication learning, Learning performance.

## I. INTRODUCTION

The industrial revolution 4.0 and 5.0 are industrial stages that focus on cyber-physical systems in which machines, sensors, and humans are interconnected through the Internet of Things (IoT) network [1]. The rapid advancement of information and communication technology (ICT) in the 21st century has significantly increased the use of digital devices in both professional settings and formal and non-formal education. The ease of accessing and exchanging information anytime and anywhere indicates that ICT continues to develop rapidly in society. Technology is becoming more compact, powerful, and affordable, making digital devices increasingly accessible and commonly used in daily life [2, 3]. This transformation demands innovation in educational practices, particularly in mathematics learning, to align with the characteristics of digital-era learners.

In the field of education, many schools have implemented ICT (Information and Communication Technologies)-based learning. ICT-based learning refers to the use of computer and multimedia technology to enhance the effectiveness and interactivity of learning activities [4]. According to Mardhatillah et al. [5], ICT-based learning media plays a crucial role in modern education by improving students' learning experiences through various digital tools such as computers, internet platforms, and mobile applications. Moreover, Nurezki and Sauri [6], Sandi & Fernandy [7], Hidayat et al. [8], and Agustina [9] emphasize that ICT-based media can increase students' motivation by presenting learning materials in an engaging and interactive manner. However, the integration of ICT alone is not sufficient; it must be supported by appropriate pedagogical approaches that actively involve students in the learning process. One of the approaches that aligns with ICT-based learning is game-based learning. The application of ICT-based learning media can provide greater flexibility, accessibility, and interactivity, thereby increase student engagement and support lifelong learning [10, 11]. Learning media can be designed in the form of educational games that require students to think, plan, and make decisions actively, in contrast to passive learning where students merely receive information [12, 13]. Active learning strengthens conceptual understanding and higher-order thinking skills. According to Feng et al. [14], educational games are designed not only to deliver academic content but also to develop critical thinking, problem-solving, creativity, and social skills. Thus, integrating ICT with game-based learning provides a promising strategy to enhance mathematics learning.

One example of game-based learning media is the multiplication house. The multiplication house media is designed to facilitate students in understanding and memorizing multiplication operations. Wulandrio and Rahmawati [15] found that this media helps students recognize relationships between numbers and accelerates the learning of multiplication concepts. In addition, Dotan and Zviran-Ginat [16] reported that multiplication house games, typically designed as two-player activities, can increase students' motivation and engagement. Mathematics learning becomes more interesting when presented in a game format, which indirectly encourages students to memorize multiplication tables while also developing strategic thinking skills. Previous studies Efendi et al. [17], Kurniawati [18], and Enjelina et al. [19] consistently report that the use of multiplication house media contributes to improved student engagement and learning outcomes in multiplication topics. These studies indicate that students show higher participation and active involvement during learning activities, while also demonstrating better achievement in multiplication tasks. However, most of these studies utilize multiplication house media in a manual or non-digital form, which limits interactivity, adaptability, and integration with modern digital learning environments. Based on these limitations, there is a need to develop an ICT-based multiplication house media that not only digitizes the traditional game but also enhances its interactivity and cognitive engagement. The novelty of this study lies not merely in the digitalization of the traditional Multiplication House game, but in the integration of pedagogically oriented features that support conceptual understanding and active learning. Randomized answer positions encourage students to focus on multiplication reasoning rather than memorization, turn-based interaction promotes strategic decision making and peer engagement, and immediate feedback supports self-correction during learning activities. Therefore, this study aims to develop an ICT-based multiplication house learning media that is valid, practical, and feasible for use in elementary school students.

## II. MATERIAL AND METHOD

This study employed development research using the Plomp model, which consists of four phases: (1) initial investigation, (2) design, (3) realization/construction, and (4) test, evaluation, and revision. The model was selected because it provides a systematic framework for developing educational products through iterative design and evaluation processes. In the initial investigation phase, a needs analysis was conducted through classroom observations and informal interviews with mathematics teachers at SD Laboratory UNESA. The observations focused on students' participation during multiplication lessons, the learning media used by teachers, and difficulties encountered by students in understanding multiplication concepts. The interviews were conducted to identify instructional problems, teachers' needs, and expectations regarding the development of ICT-based learning media. The results of this phase indicated that students experienced difficulties in recalling multiplication facts, showed limited engagement during learning activities, and had minimal exposure to interactive ICT-based learning resources.

The design phase focused on planning the structure and pedagogical components of the ICT-based Multiplication House game. Several activities were carried out, including the preparation of a storyboard, design of the game interface and menus, development of game rules and learning scenarios, and preparation of validation instruments. The media was designed to support active learning through answer randomization, turn-based interaction, immediate feedback, and score-based evaluation. These features were intentionally incorporated to encourage students' engagement, strategic thinking, and conceptual understanding of multiplication. In the realization/construction phase, the initial prototype (Prototype I) of the ICT-based Multiplication House game was developed and integrated into a computer-based interactive application. The prototype was then submitted to material experts and media experts for validation. The experts evaluated the content accuracy, pedagogical suitability, usability, interface design, and technical functionality of the product. Suggestions and recommendations obtained from the validation process were used to revise the prototype, resulting in Prototype II, which served as the final version for implementation.

The test, evaluation, and revision phase involved a limited trial with 20 third-grade students of SD Laboratory UNESA. During this stage, students used the developed media in multiplication learning activities. Data were collected through observation sheets, student response questionnaires, validation sheets, and learning outcome tests. Student response questionnaires were administered to examine practicality and usability, while learning outcome tests were used to describe students' performance after using the media. The findings obtained from this phase were analyzed and used to evaluate the feasibility of the product in terms of validity, practicality, and post-implementation learning performance. The subjects of this study were 20 third-grade students (aged approximately 8–9 years) of SD Laboratory UNESA selected using purposive sampling, considering that they had learned basic multiplication concepts but still experienced difficulties in mastering multiplication operations.

The developed product is an ICT-based multiplication house learning media in the form of an interactive game application operated on a computer/laptop platform. The main features of the media include automatic answer randomization, turn-based gameplay, real-time feedback, score tracking, and automatic win detection. In practice, students take turns selecting numbers, calculating multiplication results, and placing their answers strategically on the game board to achieve winning conditions. The quality of the developed media was assessed based on the feasibility criteria proposed by Huizinga et al. [20], which include validity, practicality, and effectiveness, as these three aspects represent the fundamental indicators of educational product quality, covering content appropriateness, usability, and impact on learning outcomes.

The research instruments consisted of: (1) media validation sheets used to assess content, format, and language aspects, (2) teacher and student response questionnaires to measure practicality and usability, (3) observation sheets to examine student engagement during implementation, and (4) learning outcome tests to measure students' mastery of multiplication concepts. All instruments were reviewed by experts to ensure content validity, and limited trials were conducted to ensure clarity and reliability of the instruments. The development process produced Prototype I, which was then validated and revised based on expert feedback to produce Prototype II as the final product. This iterative process reflects the cyclical nature of the Plomp model, where revisions are continuously made until the product meets the expected quality criteria. The data analysis techniques used are as follows.

*1. VALIDITY ANALYSIS*

The validity of the ICT-based multiplication house media was assessed by two experts (material and media experts) using validation sheets covering content, format, and language aspects (consistently applied across validators). The steps to analyze step include:

1. Compiling validation data into a table.
2. Calculating the average score of each criterion.
3. Calculating the average score of each aspect.
4. Calculating the overall average score.
5. Interpreting the results based on a 4-point Likert scale (1 = invalid, 2 = less valid, 3 = valid, 4 = very valid), adapted from standard educational media evaluation criteria. The validity criteria are as follows: The validity criteria were interpreted based on the average validity score (AV). A score of $3 \leq AV \leq 4$ was categorized as valid, a score of $2 \leq AV < 3$ was categorized as quite valid, and a score of $1 \leq AV < 2$ was categorized as invalid.

These criteria are adapted from commonly used educational evaluation standards and are employed to determine whether the product meets minimum feasibility requirements. Revisions were carried out until the media reached the valid category.

*2. PRACTICALITY ANALYSIS*

The practicality of the media was determined based on both teacher and student responses, although student responses were emphasized as the primary users of the media. The analysis steps include (i) calculating the percentage of positive responses. (ii) Determining the average score of responses. (iii) Interpreting the results using a 5-point Likert scale.

The practicality criteria are as follows: The practicality criteria were interpreted based on the average practicality score (AK). A score of $4 \leq AK \leq 5$ was categorized as very practical, a score of $3 \leq AK < 4$ was categorized as practical, a score of $2 \leq AK < 3$ was categorized as quite practical, and a score of $1 \leq AK < 2$ was categorized as not practical.

*3. LEARNING PERFORMANCE ANALYSIS*

Students' learning performance was examined using a learning outcome test administered after the implementation of the ICT-based Multiplication House media. The analysis focused on describing students' achievement levels following the learning activities. The percentage of students achieving the predetermined mastery criterion (score ≥ 80) and the average test score were calculated. These results were used to provide descriptive information regarding students' performance after using the developed media. Since this study did not employ a pretest-posttest design, control group, or inferential statistical analysis, the findings should be interpreted as post-implementation learning performance rather than evidence of learning improvement or causal effectiveness.

## III. RESULT AND DISCUSSION

The following are the results of the development of ICT-based multiplication house media.

*1. INITIAL INVESTIGATION PHASE*

At this stage, a needs analysis was conducted through classroom observations and informal interviews with teachers to identify problems in mathematics learning, particularly in multiplication topics. The findings indicate that learning activities were predominantly teacher-centered, with limited use of instructional media, and relied mainly on textbooks or worksheets (LKS). Approximately 70–80% of students showed low engagement during multiplication lessons, as indicated by passive participation and difficulties in recalling multiplication facts. In addition, ICT had not been optimally integrated into classroom instruction, resulting in less interactive learning experiences.

Based on these findings, the development of ICT-based learning media is necessary to support more interactive and engaging learning environments. Furthermore, the developed media incorporates several pedagogically oriented innovations, including (i) Dynamic problem variation through randomized answer positions, which prevents rote memorization and encourages conceptual understanding. (ii) Turn-based interaction that promotes strategic thinking and peer interaction. (iii) Immediate feedback mechanisms to support self-correction and formative learning. (iv) However, some features (e.g., automatic activation of correct answers) were revised after expert feedback to ensure that students remain actively engaged in the thinking process and are not overly guided by the system.

*2. DESIGN PHASE*

The ICT-based multiplication house media was developed as an interactive game application designed to support active learning principles and student-centered instruction. The design was guided by principles of game-based learning and user interface simplicity, ensuring that the media is easy to use for elementary school students while maintaining cognitive engagement. Rather than focusing on technical implementation (e.g., coding tools), the design emphasizes learning interaction, where students (i) select multiplication problems, (ii) calculate results independently, (iii) place answers strategically on the game board and compete to achieve specific winning patterns.

This design aligns with constructivist learning theory, where students actively construct knowledge through interaction and problem-solving. This stage is the design stage, where the multiplication house media will be integrated with ICT. The stages of media creation are as follows.

*2.1 Main Menu Design*

Main menu design was created with the help of the Canva application, and there are several important elements, including: the title of the multiplication house application, the agency logo (UNESA logo and the UNESA Mathematics Department logo), and supporting images or elements (Figure 1).


FIGURE 1. Main Menu of ICT-based Multiplication House

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### *2.2 Game Information Design*

The creation of the game information design was carried out with the help of the Canva application. In this section, several important elements are displayed, including information about the rules and how to play the multiplication house application, agency logos (UNESA logo and UNESA Mathematics Department logo), and supporting images (Figure 2).


FIGURE 2. Information menu on the ICT-based multiplication house.

The ICT-based Multiplication House media was designed based on game-based learning principles and student-centered learning approaches. The design process focused not only on transforming the traditional Multiplication House game into a digital format but also on integrating pedagogical features that support conceptual understanding, active participation, and meaningful learning experiences. The media consists of a main menu, game information menu, and interactive game board. The main menu provides access to learning activities, while the information menu explains the rules and objectives of the game. The core component of the media is the interactive multiplication game, in which students solve multiplication problems while competing to achieve specific winning patterns.

Several pedagogically oriented features were incorporated into the design. First, the answer randomization feature dynamically changes the position of answer options in every game session. This feature was designed to prevent students from relying on memorization of answer locations and encourage them to calculate multiplication results independently. By requiring students to continuously identify the correct answer, the game promotes conceptual understanding rather than repetitive recall. Second, the game adopts a turn-based interaction system in which two players alternately select numbers and determine multiplication results. This mechanism encourages students to think strategically before making decisions because each move influences subsequent opportunities and game outcomes. Such interaction is expected to increase cognitive engagement and maintain students' attention throughout the learning process. Third, the media provides immediate feedback after each student action. Correct answers are directly acknowledged by the system, while incorrect responses require students to reconsider their calculations. This feature supports formative learning by allowing students to identify and correct their own mistakes during gameplay, thereby facilitating self-regulated learning. Fourth, the game incorporates a two-player competitive format. Competition is used as a motivational element to increase participation and engagement. Through interaction with peers, students are encouraged to remain actively involved in solving multiplication problems while simultaneously developing confidence in their mathematical abilities.

The design of the ICT-based Multiplication House media was guided by constructivist learning principles, where students actively construct mathematical understanding through interaction, exploration, and problem-solving activities. Therefore, the development process emphasized pedagogical functionality and learning support rather than technical implementation details.

### *2.3 The Multiplication House Application is Ready to Play*

After exporting, we can then open the Multiplication House application in the place where the application is stored on the laptop/computer (Figure 3). Then, validation was carried out to the experts. The first validation was validation to the material experts and media experts below.


FIGURE 3. Multiplication house game.

*A. Material Expert Validation*

**Table 1.** Results of material expert validation.

| Validation Aspects | Validator 1 | Validator 2 | Average Score |
|---|---|---|---|
| Pedagogical Aspects | 19 | 16 | 17,5 |
| Curiosity Aspect | 10 | 10 | 10 |
| Usability Aspect | 20 | 15 | 17,5 |
| **Total Average Score** | | | 45 |

Based on Table 1, the results of material expert validation show that the ICT-based multiplication house media obtained an average score of 80.3%, categorized as valid. The percentage was calculated by converting the total score into a percentage using the formula: (obtained score / maximum score) × 100%. Qualitative feedback from experts highlighted the need to clarify game instructions, ensure alignment between multiplication problems and answer options and encourage students to calculate answers independently rather than relying on provided options.

*B. Media Expert Validation*

**Table 2.** Media expert validation results.

| Validation Aspects | Validator 1 | Validator 2 | Average Score |
|---|---|---|---|
| Technology Aspects | 19 | 19 | 19 |
| Child User Aspects | 26 | 25 | 25,5 |
| Control Aspects | 9 | 7 | 8 |
| **Total Average Score** | | | 52,5 |

Based on Table 2, the media expert validation results show an average score of 78%, also categorized as valid. Experts suggested improvements in user guidance and interface clarity, adding a timer to increase challenge, and providing more flexible interaction (e.g., allowing students to explore before system restriction). Although only two validators were involved, the validation process combined quantitative scores with qualitative feedback to improve the product iteratively. Future studies are recommended to involve more experts and apply advanced validity measures such as Aiken's V or CVI.

*3. PRODUCT REALIZATION/TRIAL PHASE*

The developed media was implemented in a class of 20 third-grade students. The learning activity was conducted using a shared display (LCD projection), where students interacted with the game collectively.

Observation results indicated increased student participation, as reflected in more frequent responses, peer discussions, and active involvement during gameplay. However, the use of a single device limited individual interaction, which should be considered as a limitation of this study. The study did not employ a pretest–posttest design; therefore, the findings focus on post-implementation performance rather than measuring learning gains.

*4. EVALUATION PHASE*

The final stage of this development research is evaluation, conducted periodically at each stage of analysis, design, and realization/trial. The evaluation stage is also conducted to determine student responses, measure practicality, and the evaluation phase was conducted to examine student responses, practicality, and post-implementation learning performance after using the developed media. Assessment of student responses is conducted by giving each participant a response questionnaire that has been designed with a score range of 1 to 5 for each statement. The results of the student response questionnaire can be seen in Table 3 below.

**Table 3.** Average score of student response questionnaire.

| Indicator | Average Score |
|---|---|
| Learning media is easy to use | 4,1 |
| Practical learning media to use | 4,05 |
| Satisfaction felt after using learning media | 4,15 |
| Fun learning media is used in learning activities | 4,78 |
| **Total Average Score** | 4,27 |

Based on Table 3, the results of the student response questionnaire show an average score of 4.27, categorized as very practical. In addition to the mean score, the responses were relatively consistent across indicators, indicating that students perceived the media as easy to use, enjoyable, and helpful in learning multiplication. However, the analysis is limited to descriptive statistics (mean scores) without further analysis such as standard deviation or reliability testing (e.g., Cronbach’s Alpha). In addition, although teacher responses were collected, the analysis in this study primarily focused on student responses as the main users of the media. This is relevant to the research results of Inwanti and Setiawan [21] that IT-based learning can arouse students' enthusiasm in participating in learning, on the other hand, interest causes someone to be happy in doing something, including in this case being happy to learn. In addition, ICT-based learning media is very practical, making it easier for students in the learning process both inside and outside the classroom.

To examine students’ learning performance after using the ICT-based multiplication house media at the end of mathematics learning a test of 10 questions was given consisting of 5 story questions about multiplication and 5 multiplication questions in a hexadecimal manner. The results of the students' tests after implementing ICT-based multiplication house learning media can be seen in Figure 9 below.

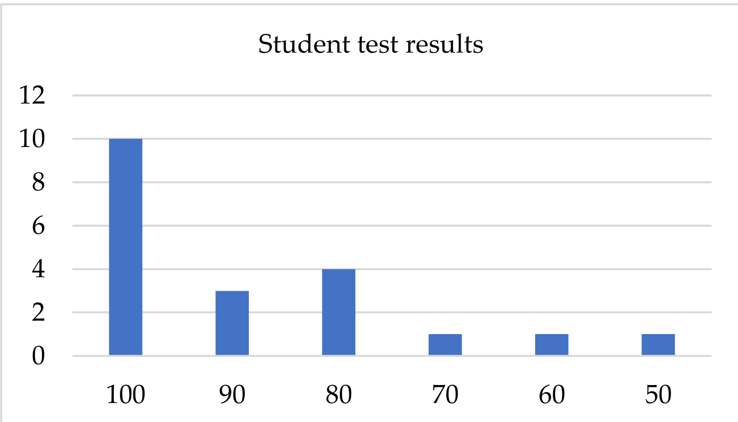


FIGURE 4. Test results after implementing ICT-based multiplication house learning media.

Based on Figure 4 above, the effectiveness of the media was evaluated based on students' learning outcomes after using the media. The results indicate that most students achieved the predetermined mastery criterion, with 85% obtaining scores of at least 80. These findings describe students' performance after using the media but should not be interpreted as evidence of learning gains or causal effects because no pretest or comparison group was employed. However, several limitations should be noted: the absence of a pretest limits the ability to measure learning improvement, the test consisted of only 10 items, which may not comprehensively represent students' abilities, the use of the term "hexadecimal multiplication" is revised to standard multiplication problems to align with elementary school curriculum, and no inferential statistical analysis (e.g., N-gain or significance testing) was conducted.

The results of the study also indicate that the ICT-based Multiplication House media developed in this research meets the criteria of being valid, practical, and effective for teaching multiplication in elementary school mathematics. These findings support the assertions of Sandi and Fernandy [7], who emphasized that ICT-based learning media can enhance both the effectiveness and learning experience of students. The validity of the media, as evidenced by expert evaluations 80.3% from content experts and 78% from media experts demonstrates that the integration of pedagogical elements, technology, and child-centered control features in the media design aligns well with the principles of modern educational media development. Moreover, the practicality of the media, which received highly positive responses from students (average score of 4.27), is consistent with the views of Kaboodvand et al. [10], who stated that the use of interactive media can boost student engagement and provide flexibility in the learning process. Furthermore, the media's effectiveness, shown by 85% of students achieving scores of ≥80 in the learning outcome test, indicates that the game-based approach implemented in the application suggests that students were able to demonstrate satisfactory mastery of multiplication concepts after using the media. This finding aligns with the theories of Hartono [22] and Welbers et al. [13], which argues that educational games can foster critical thinking, problem-solving, and student creativity. Innovative features such as automatic win checking, turn-based gameplay, and dynamically shuffled answer boards strengthen the cognitive and strategic aspects of the game, encouraging students to actively think and make decisions rather than merely memorizing. Therefore, the developed media shows potential as a learning tool that supports student engagement and multiplication practice but also supports active learning in line with 21st-century educational approaches.

The novelty of this study lies in the development of the Multiplication House media, which not only digitizes a traditional game but also integrates elements such as automatic feedback, randomized number visualization, and a score-based evaluation system into a single interactive platform. This innovation sets the developed media apart from previous multiplication learning tools, which tended to rely solely on drill-and-practice methods with limited cognitive engagement [23]. Through this approach, students do not merely learn by repetition but also engage in exploration, prediction, and reflection on the strategies used, thereby fostering a deeper conceptual understanding [24, 25]. Furthermore, this development aligns with the demands of digital-era learning and offers practical contributions to the creation of adaptive, enjoyable, and cognitively stimulating mathematics media for young learners [26, 27]. Although the initial objective included improving critical thinking and problem-solving skills, the results primarily measured learning outcomes (cognitive scores). Therefore, future research should incorporate specific instruments to assess higher-order thinking skills to ensure alignment between objectives and evaluation.

## IV. CONCLUSION

Based on the results of the development process, the ICT-based Multiplication House media meets the criteria of validity, practicality, and effectiveness for use in elementary mathematics learning, particularly in multiplication topics. The media is considered valid, supported by expert evaluations with an average score of 80.3% from material experts and 78% from media experts. The practicality of the media is indicated by a very positive student response, with an average score of 4.27 on a Likert scale, reflecting strong acceptance and ease of use. Furthermore, the effectiveness of the media is demonstrated by 85% of students achieving a score of ≥80 in the post-test, suggesting effectiveness in supporting students' conceptual understanding of multiplication. These findings indicate that the developed media successfully addresses the research objective of producing an ICT-based learning tool that is feasible and supports active and engaging mathematics learning. Beyond numerical results, the integration of game-based elements and interactive features enables students to participate more actively, encourages strategic thinking, and facilitates a more meaningful learning experience compared to conventional approaches.

Practically, this study implies that ICT-based game media can be used as an alternative instructional tool for teachers to enhance student motivation and engagement in mathematics learning. Theoretically, this study contributes to the development of ICT-based learning media by demonstrating how traditional learning tools can be transformed into interactive digital formats that align with student-centered and game-based learning principles.

However, this study has several limitations, including the relatively small sample size (n = 20), the absence of a pretest to measure learning gains, and the limited scope of assessment focusing primarily on learning outcomes rather than higher-order thinking skills. Therefore, the findings should be interpreted with caution. Future research is recommended to involve larger and more diverse samples, apply more rigorous experimental designs (e.g., pretest–posttest), and incorporate additional instruments to measure critical thinking and problem-solving skills. Further development of the media is also suggested, particularly in enhancing individual interactivity and adaptive features to support personalized learning.

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## Author Contributions

Janet Trineke Manoy and her contributions is conceptualization, methodology and data collection; Shofan Fiangga and his contributions is manuscript writing and data analysis; Nonik Indrawatiningsih and her contributions is interpretation of results, and manuscript editing; Nina Rinda Prihartiwi and her contributions is analyzes research data that has been collected; Sugi Hartono and his contributions is research data analysis and helps input research; Hutkemri Zulnaidi and his contributions is research data analysis and assisted in the preparation and writing of the research article.

## Conflicts of Interest

The authors declare no competing interests are still not.

## Data Availability Statement

Data are available from the authors upon request.

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