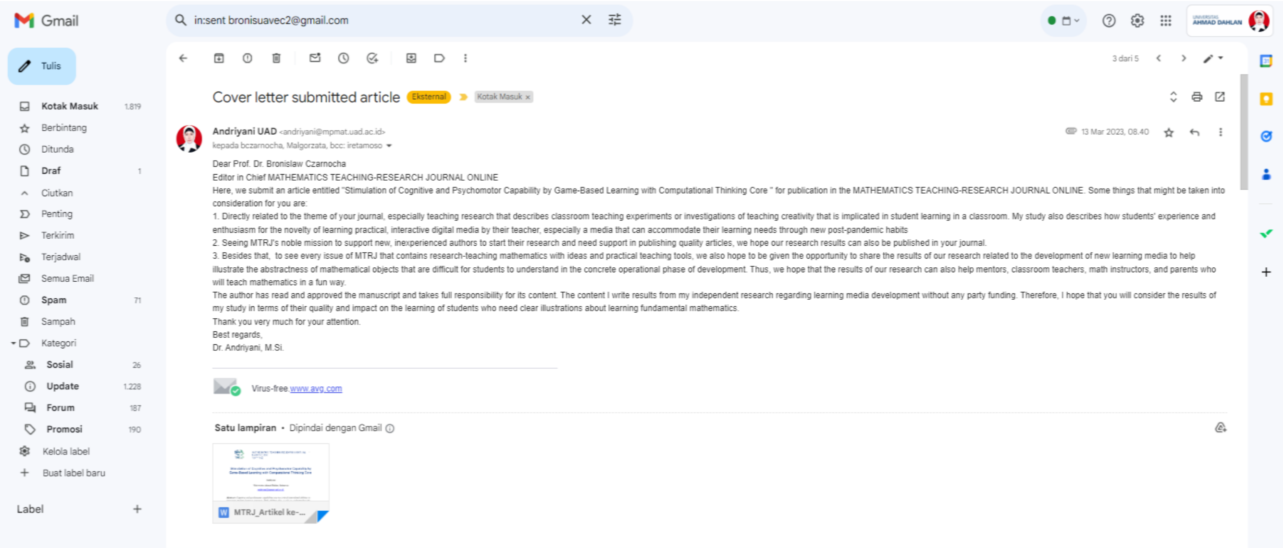
KORESPONDENSI

Artikel disubmit pada 13 Maret, 2023.



Cover letter submitted article

Andriyani UAD <andriyani@mpmat.uad.ac.id>
kepada bczarnocha, Malgorzata, bcc: iretamoso
13 Mar 2023, 08.40

Dear Prof. Dr. Bronislaw Czarnocha
Editor in Chief MATHEMATICS TEACHING-RESEARCH JOURNAL ONLINE
Here, we submit an article entitled "Stimulation of Cognitive and Psychomotor Capability by Game-Based Learning with Computational Thinking Core " for publication in the MATHEMATICS TEACHING-RESEARCH JOURNAL ONLINE. Some things that might be taken into consideration for you are:
1. Directly related to the theme of your journal, especially teaching research that describes classroom teaching experiments or investigations of teaching creativity that is implicated in student learning in a classroom. My study also describes how students' experience and enthusiasm for the novelty of learning practical, interactive digital media by their teacher, especially a media that can accommodate their learning needs through new post-pandemic habits
2. Seeing MTRJ's noble mission to support new, inexperienced authors to start their research and need support in publishing quality articles, we hope our research results can also be published in your journal.
3. Besides that, to see every issue of MTRJ that contains research-teaching mathematics with ideas and practical teaching tools, we also hope to be given the opportunity to share the results of our research related to the development of new learning media to help illustrate the abstractness of mathematical objects that are difficult for students to understand in the concrete operational phase of development. Thus, we hope that the results of our research can also help mentors, classroom teachers, math instructors, and parents who will teach mathematics in a fun way.
The author has read and approved the manuscript and takes full responsibility for its content. The content I write results from my independent research regarding learning media development without any party funding. Therefore, I hope that you will consider the results of my study in terms of their quality and impact on the learning of students who need clear illustrations about learning fundamental mathematics.
Thank you very much for your attention.
Best regards,
Dr. Andriyani, M.Si.

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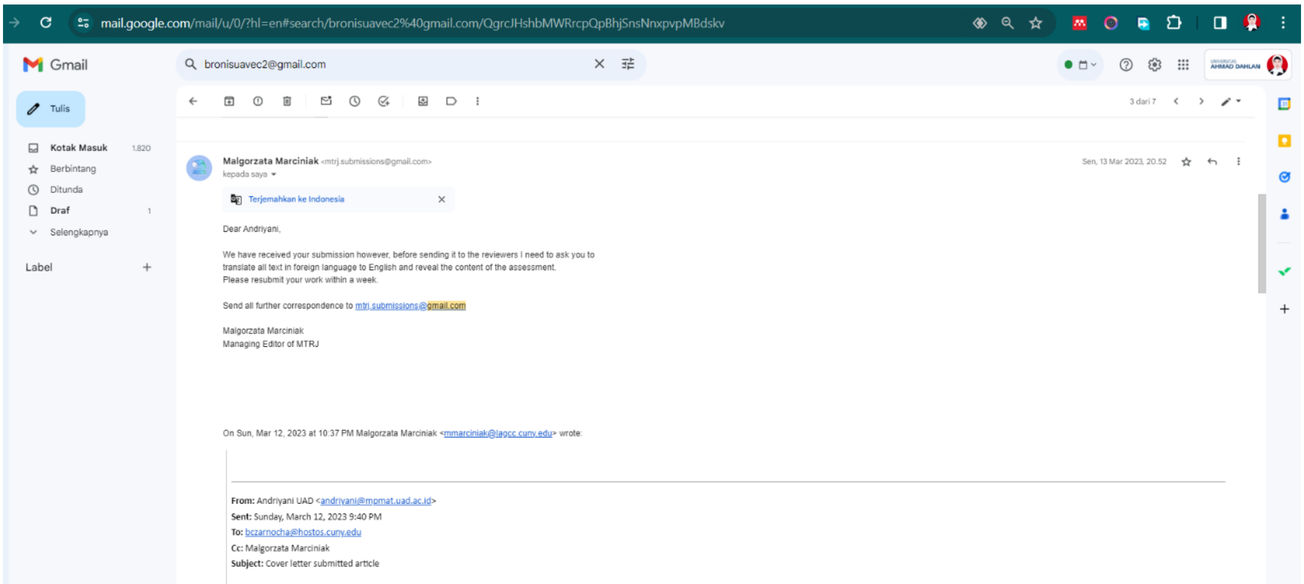
MTRJ_Artikel ke-...

Pada hari yang sama (13 Maret 2023), editor membalas dan mengkonfirmasi bahwa editor telah menerima kiriman artikel penulis, namun sebelum editor mengirimkan artikel ke reviewer, penulis diminta menerjemahkan semua teks dalam bahasa asing ke bahasa Inggris dan melampirkan isi penilaian.



Malgorzata Marciniak <mtrj.submissions@gmail.com>
kepada saya
Sen, 13 Mar 2023, 20.52

Dear Andriyani,

We have received your submission however, before sending it to the reviewers I need to ask you to translate all text in foreign language to English and reveal the content of the assessment.
Please resubmit your work within a week.

Send all further correspondence to mtrj.submissions@gmail.com

Malgorzata Marciniak
Managing Editor of MTRJ

On Sun, Mar 12, 2023 at 10:37 PM Malgorzata Marciniak <mmarciniak@lagcc.cuny.edu> wrote:

From: Andriyani UAD <andriyani@mpmat.uad.ac.id>
Sent: Sunday, March 12, 2023 9:40 PM
To: bczarnocha@hostos.cuny.edu
Cc: Malgorzata Marciniak
Subject: Cover letter submitted article

Artikel awal yang dikirimkan pada editor pada tanggal 13 Maret 2023 adalah sebagai berikut.

Stimulation of Cognitive and Psychomotor Capability by Game-Based Learning with Computational Thinking Core

Andriyani

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Abstract: *Cognitive and psychomotor capabilities are two critical interrelated abilities in improving student learning outcomes. Both abilities play a role in understanding the process of new information and developing fine motor skills related to students' cognitive processes and physical activity. Because of this, schools train these two abilities to be equipped in solving mathematical problems such as basic arithmetic. This phenomenon has increased researcher' interest in choosing learning strategies oriented toward both achievements. However, few previous studies haven't much discussed the design of learning strategies oriented toward successfully integrating these two capabilities due to the lack of interest in learning post-pandemic. Moreover, these studies only focus on calculations in arithmetic operations, not the conceptual understanding of operations. Therefore, this study aims to describe the development of learning media designs that accommodate student activities through game-based learning to stimulate cognitive and psychomotor capability in conceptual arithmetic operations, especially multiplication. The learning framework uses core computational thinking integrated with interactive game-based learning. The research method used is ADDIE which contains five stages of development with data collection techniques through validation questionnaires, student responses, and tests. In the learning process, students apply their cognitive ability to understand the concept of operations effectively and encourage efficient problem-solving skills. The study results show that game-based learning media is valid according to experts and practical according to student responses. From the students' responses, it is known that the development of game-based learning can stimulate cognitive and psychomotor capability in solving contextual problems that were previously an obstacle for students through 'learning by gaming.'*

Keywords: *Cognitive, Computational-Thinking, Game-Based Learning, Psychomotor*

INTRODUCTION

Cognitive and psychomotor capabilities are essential components in student learning and development which are a challenge for educators and experts in education. According to Begam

& Tholappan (2018), a person's cognitive ability refers to his thinking/mental process continuity. This cognitive process involves acquisition, processing, and applying knowledge, including attention, memory, reasoning, understanding, and problem-solving. On the other hand, according to Simpson (1972), psychomotor capability refers to students' physical movement skills, including coordination, agility, and fine motor skills, that require practice with measurements based on aspects of speed, accuracy, procedures, and implementation techniques. With this psychomotor capability, students explore phenomena, conceptualize the ideas involved, and apply concepts to new situations (Karplus & Butts, 1977). In the context of learning with abstract objects such as mathematics, the processes contained in this psychomotor ability are interpreted by gaining direct experience and providing opportunities for students to manipulate objects and tools. More clearly, Piaget (1029) said that students' physical experience in learning mathematics could be obtained by giving students opportunities to explore mathematical concepts through the concrete physical experience before moving on to more abstract representations. These experts generally show that cognitive and psychomotor capabilities play a significant role in learning mathematics, especially in active exploration and reflection activities.

In the midst of this significant role, educators have the main challenge of identifying and overcoming differences in cognitive and psychomotor capability that each student has. Given the unique differences in the nature and characteristics of these two abilities, educators need to provide personalized instruction and support to meet the learning needs of each student. In addition, educators also need to find strategies to help students develop their cognitive and psychomotor capabilities on an ongoing basis. This is what requires the teacher's focus on creating interesting and challenging learning experiences for students to follow. Teachers need to design lessons that can stimulate these two capabilities, especially in solving real-world problems. Stimulus in problem-solving needs to be accompanied by providing opportunities to train students' physical skills in direct practical activities. Moreover, the Corona Virus Pandemic that hit the world last year had an impact on reducing the level of active involvement of students in learning and their study results (Haryani & Hamidah, 2022; Onyema et al., 2020; Orlov et al., 2021).

A decrease in student involvement in learning can also be caused by a lack of their intrinsic or extrinsic motivation (Fatimah & Saptandari, 2022) because there is a reasonably close relationship between motivation and student learning involvement (Saeed & Zyngier, 2012). This involvement affects students' academic outcomes (Finn & Zimmer, 2012). Hence an effective learning strategy is needed to increase student learning motivation, such as digital game-based learning, which also functions to encourage students' willingness to learn and self-awareness in both formal and informal learning contexts (Owston, 2009; Yang & Chen, 2010; Yien et al., 2011). The implication of digital educational games is as a learning tool that significantly influences motivating users in a fun learning atmosphere (Kirriemuir & McFarlane, 2004). These educational games tend to arouse curiosity and challenge users to actively explore games until they feel happy when they can finish the game well so that students are motivated and enjoy learning through the game (Chen et al., 2007; Hong et al., 2009; Moon & Baek, 2009). This positive implication raises a lot of attention given to the relationship between digital games and the education field (Chiang et al., 2011).

The variety of games implemented in learning makes developing game application models more adaptive and flexible to be designed as learning media based on the material presented (Hays, 2005; Papoutsi & Drigas, 2016). Games are designed with various systematic, visual, and kinetic activity loads to stimulate students' skills and awareness of specific knowledge (Besgen et al., 2015; Shuqin, 2012). Various student skills are oriented towards achievement through integrating games into learning, including learning basic mathematics such as basic arithmetic, especially multiplication. Through games, students are trained to make decisions by controlling objects in the game for a specific purpose designed in a system or program (Jason in Aprilianti et al., 2013). Several studies on multiplication-themed educational games have been carried out, including research on Android-based arithmetic games by Amrizal & Kurniati (2016), research on mobile educational games for multiplication calculations based on the horizontal method with Html 5 and PhoneGap by Ricky (2013), and research on designing learning game application for 3rd-grade math calculation operations using unity by Kristina & Talitha (2021). This research is related to developing educational games that contain multiplication calculations through fast multiplication counting activities.

In this study, a game-based multiplication concept learning will be designed with the help of digital game applications whose accessibility is carried out on student androids. So students aren't only trained to count fast but understand the concept of multiplication, whose construction is formed from repeated addition. In learning arithmetic, students need adaptive skills, which are functional academic skills in the basic operations of addition, subtraction, division, and multiplication (Polspoel et al., 2019). These adaptive skills are needed for everyday life because they involve communication, life and social, work, and functional academic skills such as reading, writing, and arithmetic (Ainsworth & Baker, 2004; Hodapp, 2002). Thus, learning arithmetic requires both psychomotor and cognitive abilities, especially if arithmetic problems are in the context of students' everyday problems.

Cognitive and psychomotor capabilities have an important role in the formation of adaptive skills, which are the main elements of the elementary school mathematics curriculum (National Math Panel, 2008) and play a fundamental role in solving more complex mathematical problems (Juliana & Hao, 2018; Prendergast et al., 2017). Therefore, teachers need to train these abilities to students for mastery of arithmetic concepts. Knowledge of students' ideas of a basic arithmetic operation can be achieved if students understand the concept of operations and the links between operations (Rahman et al., 2017). But in fact, there are still many students who are afraid of learning mathematics because it is considered difficult and complex (Laurens et al., 2018).

The results of an initial study conducted by researcher in November 2022 in three elementary schools from the Municipality of Yogyakarta and Bantul Regency show that grade III students still do not understand the concept of multiplication operations and often have difficulty solving contextual problems, especially multiplication abstraction which correlates with modeling problems and the procedure for solving it. Meanwhile, the teacher still uses the rote method to teach multiplication. Students' lack of understanding of multiplication often causes boredom, laziness, and a lack of interest for students in learning multiplication. This is similar to Thai & Yasin's (2016) research on multiplication teaching methods. Therefore, we need alternatives in thinking processes and developing problem-solving strategies, including computational thinking (Wing, 2006).

Along with technological advances in recent years, computational thinking has become an important topic in various fields of life (Lindberg et al., 2019). Various countries have attempted to promote computational thinking education in schools, universities, industry, and government (Lin et al., 2020). A large number of researchers attempt to identify students' computational thinking abilities. For example, research by Yadav et al. (2017) and Denning (2017), who researched the development of computational thinking-based teaching guidelines for students; research by Shute et al. (2017) regarding the design of a model for assessing student computing learning outcomes; as well as research by Sullivan & Bers (2018)S and P´erez-Marín et al., (2020) on computational thinking-based learning performance. These studies are clear evidence that computational thinking has become a basic skill needed in learning in this digital era.

Based on the problems experienced by students in learning the concept of multiplication operations above, the researcher considers it necessary and important to design game-based learning with the help of interactive learning media that can stimulate students' cognitive and psychomotor capabilities. The developed interactive learning media is a digital game filled with computational thinking core to help students understand the concept of arithmetic operations, especially multiplication. By integrating computational thinking cores, students learn to understand the concept of multiplication operations by solving contextual problems presented in the digital game.

METHOD

This study aims to describe the development of instructional media designs that accommodate student activities through game-based learning to stimulate cognitive and psychomotor capability in conceptual arithmetic operations. The procedure for this research study consists of an analysis stage, a design stage, a development stage, an implementation stage, and an evaluation stage (Branch, 2009; Sugiyono, 2019). The researcher chose this model to develop media learning in digital games because it facilitates constructing students' knowledge and skills in instructional guided learning plans. In addition, the ADDIE model is also devoted to solving problems related to gaps due to students' lack of knowledge and skills. Furthermore, the ADDIE model contains generative processes (stages) by applying concepts and theories to a particular context.

In the analysis stage, the researcher identified the probable causes of incongruity/differences between learning outcomes and theories, concepts, or other learning problems in the multiplication concept material. Identification is based on experiences, preferences (tendencies), abilities, experiences, and student motivation during learning. In addition, the researcher also identified the resources needed during the development process, including the curriculum used, the concept of multiplication, the learning models or methods used, teaching materials, facilities, learning environment, technology, and the characteristics of the students involved during the development process. To determine the extent to which the characteristics of the students at the research site, the researcher conducted written tests at three Elementary Schools to measure students' understanding of multiplication concepts presented through contextual problems.

At the design stage, the researcher designs a product that will be developed based on the analysis results from the previous stage and begin with selecting media which is digital games with core computational thinking to stimulate cognitive and psychomotor capability. Next, the researcher prepares the initial design of the media by making a picture or representation of the interactions between the system and its environment or making a model of the behavior of the information system in the form of a diagram until it produces a product blueprint. At this stage, the researcher also formulates specific, measurable, applicable, and realistic learning objectives based on appropriate learning strategies.

In the development stage, the researcher developed an initial prototype according to the blueprint designed in the previous stage, including developing test instruments, validation questionnaires, and student responses to be validated by validators who are evaluation experts. Likewise, the initial prototype of the media was also validated by the validator, an expert in the field of learning media, and an expert in mathematics learning materials. Furthermore, the researcher revised all the development results according to the suggestions of the validators, each consisting of three validators, so the digital game was declared valid and ready to be implemented in small and large classes.

At the implementation stage, the researcher makes concrete steps to implement the learning system that was developed. Here the researcher tested game products in small trial classes of 10 third-grade students at an Elementary School in the District of Yogyakarta. The tryout was carried out for three meetings, and then the researcher gave a response questionnaire to students as a product user. The researcher will use the results of the student responses to revise the product. The researcher again tested the product on third-grade students from four classes at three elementary schools. Of the three elementary schools, two are located in Bantul Regency, and one is from Yogyakarta Municipality, which has two study group classes. To find out the responses of the large trial classes, the researcher distributed response questionnaires whose results were used as a basis for determining the practicality of the game products that had been developed.

At the evaluation stage, the researcher continuously evaluates, beginning from the initial development stage, for the requirement of revision, until final product development. Evaluation is carried out through qualitative and quantitative data analysis. Based on the needs analysis results in the first development stage, the researcher analyzed the quantitative data, which was the result of the test to find out the characteristics of the students regarding their understanding of the concept of multiplication in contextual problems. The validation results at the development stage and field trials at the implementation stage were also analyzed for product revision materials. Qualitative data from input, suggestions, and expert criticism will be interpreted as a basis for gradual revisions for better media development. While the quantitative analysis of the results of validation questionnaires and student response questionnaires was carried out to assess the quality of the eligibility of the media in terms of validity and practicality. All stages of this evaluation are aimed at the feasibility of the final product in terms of content, design, and user-friendliness.

The subjects used in this study were ten third-grade students from an Elementary School in the District of Yogyakarta as small class trial subjects, 123 third-grade students from three Elementary Schools, two of which were located in Bantul Regency and one school from the District of Yogyakarta. This one school where the large class trial was held had two study group classes, so there were four trial classes. Data collection techniques consist of test and non-test techniques in questionnaires to validate products and student response questionnaires. The data analysis technique used in this study was in the form of qualitative and quantitative data analysis. Quantitative data analysis was carried out by calculating the mean score of students' conceptual understanding test results in solving contextual problems. In addition, the researcher also calculated the mean validation score and the mean student response score, which was then followed by converting the mean score into the product validity and practicality category, which refers to the validity and practicality criteria guidelines on five Linkert scales successively - respectively consisting of criteria: 'not good' for a score of 1; 'Less Good' for a score of 2; 'Good Enough' for a score of 3; 'Good' for a score of 4; and 'Very Good' for a score of 5 (Widoyoko, 2018). The product is said to reach validity and practicality standards if it reaches the minimum "Good" criteria.

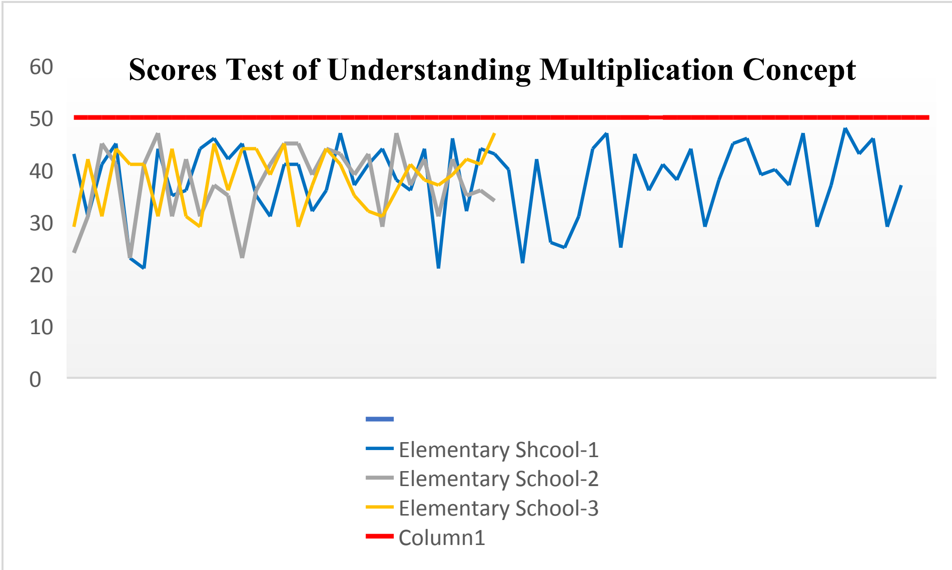
RESULTS AND DISCUSSION

1. Analysis Stage

At this stage, the researcher identifies the curriculum that will be used as a guideline for developing digital games concerning the curriculum guidelines used by the school. Next, the researcher assessed the material related to the concept of multiplication. In this case, the researcher interviewed mathematics teachers about the application of the curriculum used by schools to teach multiplication material in class. Based on the results of interviews with the mathematics teacher, it is known that the teacher delivers multiplication material limited to calculating two or more integers with an allocation of time per week is 4×45 minutes or two meetings with an allocation each session of 2×45 minutes. To check student understanding, the teacher added one meeting in the form of a written test. The time allocation, which was only 2-3 sessions, turned out to cause problems for students, where students memorized multiplication more and were oriented towards counting skills only.

The interviews continued exploring the teacher's teaching methods in the expository form. The teacher conveys the multiplication of two or more numbers directly, whereas the teacher teaches the meaning of multiplication as a number multiplied according to the multiplier number. Students who find it difficult to accept the abstraction of the multiplication meaning will eventually choose to memorize the multiplication of integer numbers in the range 1-10. All of this was caused by the difficulties he experienced in interpreting the teacher's explanations which tended to lead only to calculating numbers. So that students look less enthusiastic about participating in learning and are unable to solve contextual problems given by the teacher.

In addition to the learning methods used by the teacher, the researcher also conducted interviews about the teacher's teaching materials. The results of the interviews showed that the teacher's teaching materials were books that tended to be textual. This certainly does deficient attract students' interest in learning, which during the Coronavirus pandemic, often carried out online learning and accessed digital learning resources. Therefore, we need an interactive digital learning media that can accommodate their learning needs through new post-pandemic habits. In the initial research, the researcher measured students' understanding by giving contextual problems about multiplication concepts. The results of an analysis of third-grade students from four different classes in three Elementary Schools in Yogyakarta Province show that students' understanding of multiplication concepts is still low, with a mean score below 50 with a maximum score of 100 because they focus more on numeracy skills. The low level of students' understanding of multiplication can be seen in Figure 1 below.

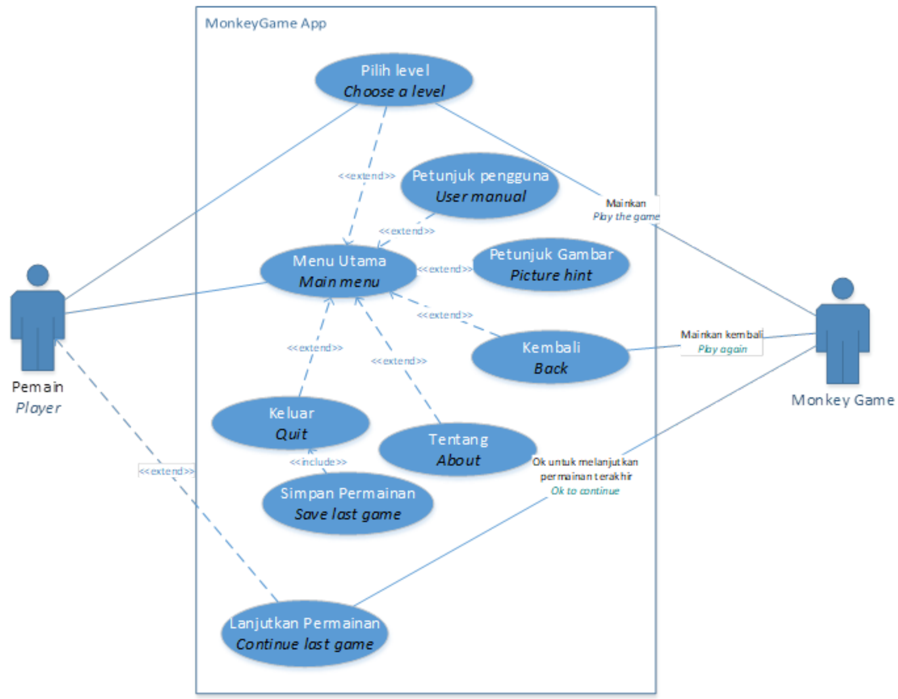


Picture 1. Level of Understanding of the Multiplication Concept

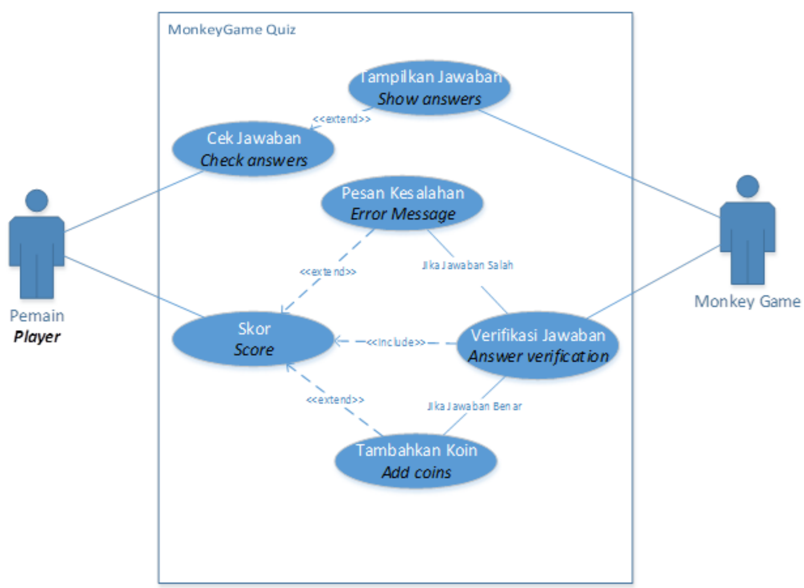
From Figure 1 above, we can conclude that students' cognitive and psychomotor capabilities are less than half the maximum score or less than 50. So on this basis, the researcher intends to develop a digital game with core computational thinking to support learning multiplication concepts. With this game, it is hoped that students can understand the abstraction of multiplication concepts by solving contextual problems that were previously difficult for students to solve.

2. Tahap Desain

At the design stage, the researcher designs a digital game that will be developed based on the requirement analysis results at the previous stage. From the results of this analysis, the researcher chose digital game media with core Computational Thinking to stimulate students' cognitive and psychomotor capabilities. Furthermore, at the game design stage, researchers began creating use case diagrams that describe or represent the interactions between the system and its environment, as shown in Figure 2 (a)-(b) below.



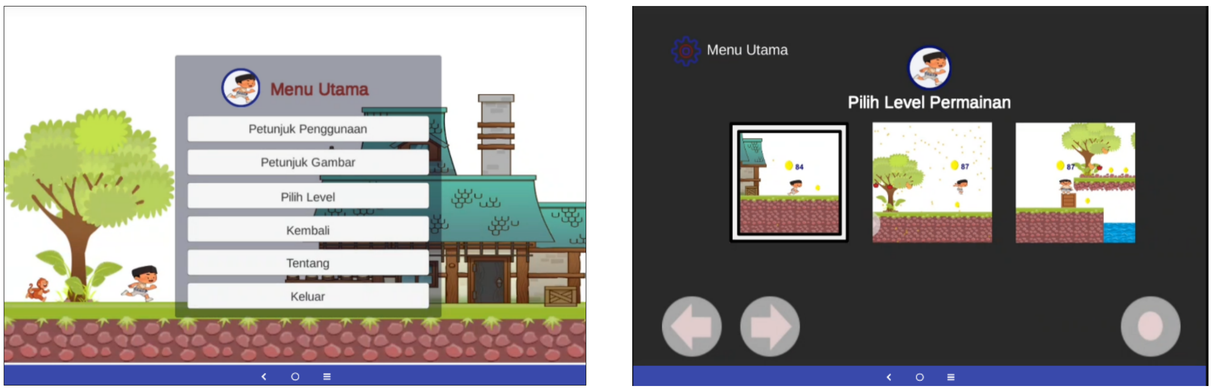
(a) Main Use Case Diagram



(b) Part Diagram of the Main Use Case Contains Checking Answers and Feedback

Figure 2. Digital Game Use Case Diagram

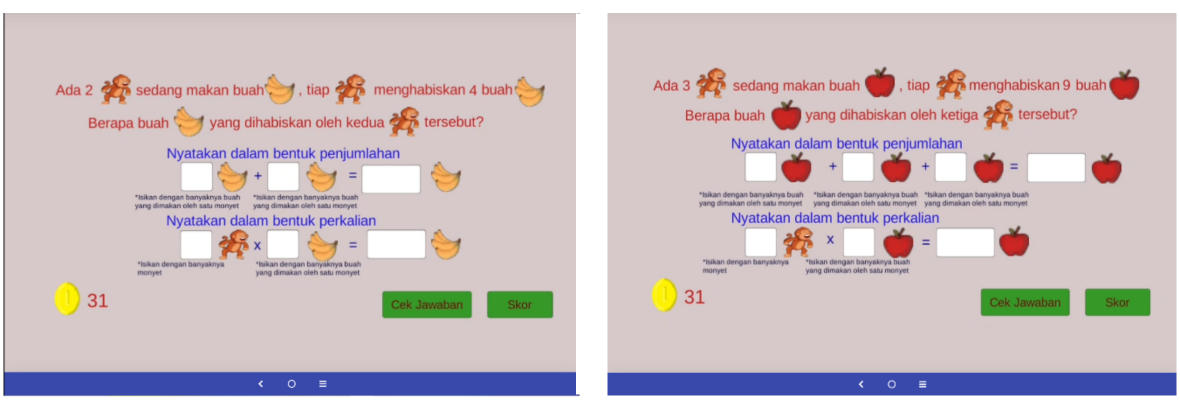
The researcher uses the Use Case diagram above to define functional modeling and system operational requirements by determining the scene method used to build the system from the results of previous application analysis. At this stage, the researcher determines a digital game title containing the concept of multiplication with the name Monkey Game Arithmetic-CT. Then the researcher formulated the digital game concept according to the achievement orientation of students' cognitive and psychomotor capability, which were leveled with levels 1 to 3 on the menu as presented in Figure 3 (a)-(b) below.



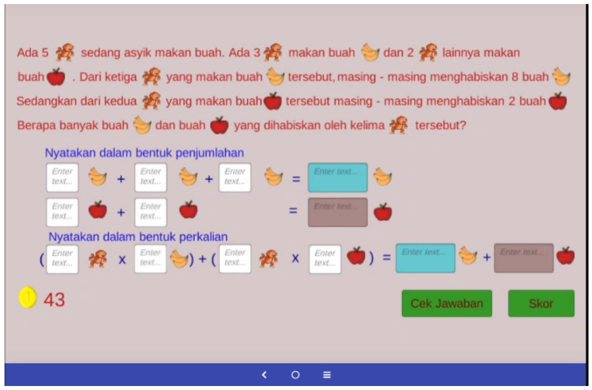
(a) Game Main Menu (b) First Level to Third Level Game

Figure 3. Game Leveling on the Main Menu

The basis of game leveling refers to the complexity of the contextual problems presented at each level so that each level of the game has contextual problems with different levels of difficulty solving, as shown in Figure 4 (a)-(c) below.



(a) First Level (b) Second Level



(c) Third Level

Figure 4. Examples of Contextual Problems at First Level to Third Level

Computational thinking core loaded, namely abstraction, algorithm design, pattern recognition, decomposition, and debugging in digital games, is represented in problem-solving activities as presented in Figure 5 below.

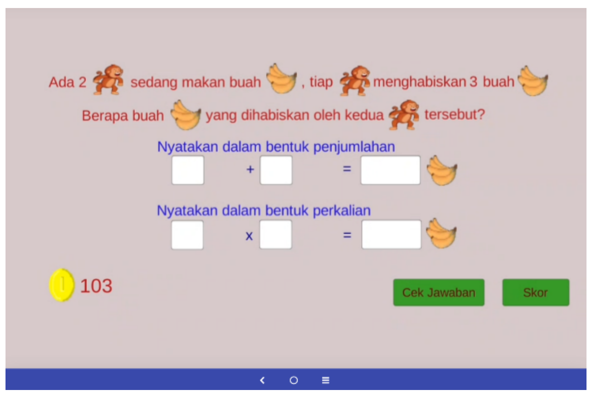


Figure 5. The Abstraction Core of Computational Thinking

Figure 5 shows that students must generalize and identify common cores by filtering out specific details and any needed patterns and ignoring unrelated data to solve the problem. In this game, students must be able to sort out the amount of fruit each monkey ate and the number of monkeys that ate the fruit to fill in each answer box in the addition and multiplication statements. In the game's display, there aren't fruit picture hints or instructions containing information that must be entered in the answer box. So students have to filter the details of the data as their abstraction entity.

The core loaded of the algorithm design is presented in the problem-solving steps, as shown in Figure 6 below.

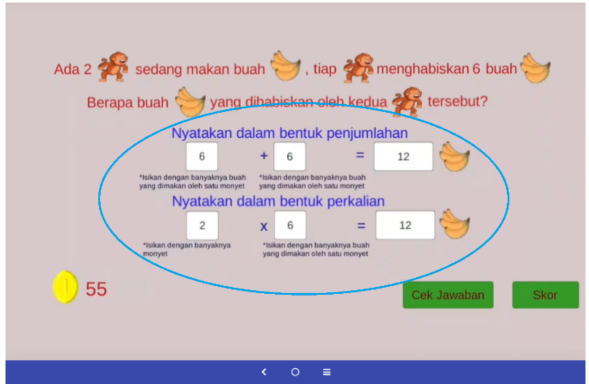
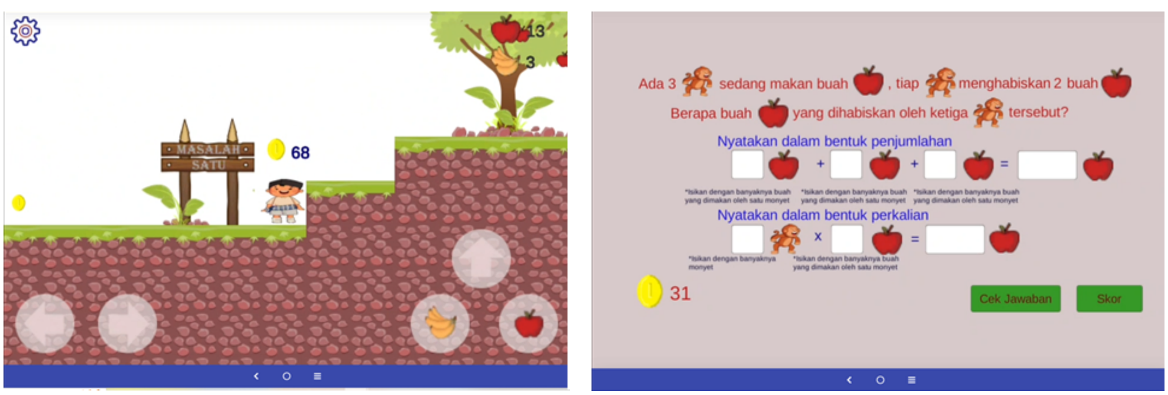


Figure 6. The Algorithm Design Core of Computational Thinking

Figure 6 shows that students must develop logical and systematic problem-solving instructions to solve problems so that other people can use the steps or information to solve the same problem. In this game, in the first step, students must fill in the number of fruits eaten by one monkey in each statement box of the addition model. In the second step, students must fill in the number of monkeys in the first statement box of the multiplication model. Furthermore, students must also fill in the number of fruits each monkey eats in the second statement box of the multiplication model. In the final step, students check their answers by pushing the 'check the answers' button, followed by pushing the 'score' button to check the achievement of the problem-solving score.
The core loaded of pattern recognition is presented in the problem-solving step, as shown in Figure 7 (a)-(b) below.



(a) First Problem and Its Content

(b) Second Problem and Its Content

Figure 7. The Pattern Recognition Core of Computational Thinking

Figure 7 (a)-(b) shows that students must be able to see similarities or differences in patterns and methods in the data that will be used in predicting and presenting data to classify problems and provide appropriate solutions. This pattern recognition uses previous experience and prior knowledge as the basis for logical thinking. Then, from this logic, students get new experience and knowledge to solve various identic problems according to patterns they already know. In this game, students must be able to see the data pattern and the regularity of solving the first problem presented, as shown in Figure 6 (a) above. The first problem presents a data pattern about three monkeys eating apples, and each monkey eats two apples. Students were asked to determine how many apples the three monkeys ate.

The second problem is presented using an identic multiplication problem. The second problem shows the existence of three monkeys who are eating apples, and each monkey eats seven apples. Students were asked to determine how many apples the three monkeys ate. To solve the first problem, students design a solving algorithm that begins with applying the concept of repeated addition. Then, they continue with the solution step by applying the multiplication concept related to the previous repeated addition concept. Using the patterns and regularities of the data in the first problem, students design solutions to the second problem by predicting the same steps for solving the two multiplication problems.

The core loaded of decomposition is presented in the problem-solving step, as shown in Figure 8 below.

Figure 8. The Decomposition Core of Computational Thinking

Figure 8 shows that students must be able to break down complex data, problems, or processes into smaller problem that is simple parts. So, if there is a complex problem, it can be more easily solved by breaking down the complex problem into these small parts. In this case, students must be able to break down the problem of the number of bananas and the number of apples eaten by the monkey into two smaller problems, namely the problem of the number of bananas eaten by the monkey and the problem of the number of apples eaten by the monkey separately.

The core loaded of debugging is presented in the problem-solving step, as shown in Figure 9 below.

(a) Problem-solving (b) Result of Recheck

(c) Result of Error Correction from Rechecking Process

Figure 9. The Debugging Core of Computational Thinking

In Figure 9, it is shown that students must carry out an inspection or process of rechecking each step of problem-solving to ensure the process is carried out correctly. In this game, students must check every step of solving the problem they have done, as shown in Figure 9 (a), to determine whether the process is correct. If students make mistakes while solving the problem, the system will provide feedback in the form of notifications that the student's answers are still incorrect, as shown in Figure 9 (b). The picture states that the student's multiplication form is still wrong, where students fill in the boxes which switch for the number of monkeys that should be filled in with the amount of fruit eaten by the monkeys. Furthermore, students are given a chance to improve their problem-solving and recheck their answers. If the student's answer is correct, the system will provide feedback in the notification that the student gets ten gold coins as a prize for their accuracy in solving problems in the game.

3. Development Stage

This stage begins with an instrument feasibility assessment in the form of a product validation questionnaire in terms of media and material, also a student response questionnaire. Testing the validity of the contents of these three instruments was carried out using expert judgment or reviewing the grid, especially the suitability instruments with the research objectives and the questions. Based on the results of expert judgment, the three instruments are declared valid. Furthermore, the researcher validated the product regarding material substance and media design, carried out by three validators using assessment instruments declared valid by experts. The results of the material substance validation by the three validators are presented in Figure 10 and Table 1 below.

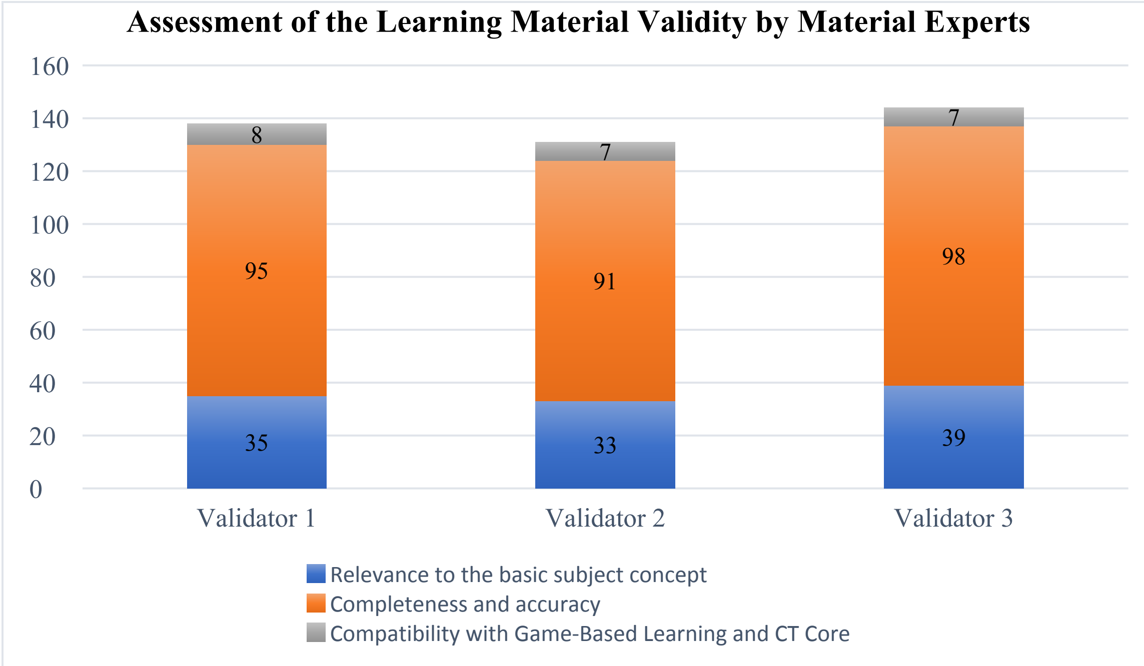


Figure 10. Description of the Assessment Results by Material Experts

Component	Validator-1	Validator-2	Validator-3
Mean	**138**	**135**	**144**
Mean total		**139**	

Table 1: Average Assessment of the Validity of Learning Materials by Material Experts

Based on the analysis of the results of the material expert validation, it is known that the mean score of material validator-1 is 138 in the "Very Good" criteria, the mean score of material validator-2 is 135 in the "Good" criteria, while the mean score of the material validator-3 is 144 in the "Very Good" criteria. The mean total of the three material validators is 139, with the "Very Good" criteria. Thus it can be concluded that the developed learning media has reached the category of validity of a product in terms of material. Assessment of the validity of learning media by media validators is presented in Figure 11 and Table 2 below.

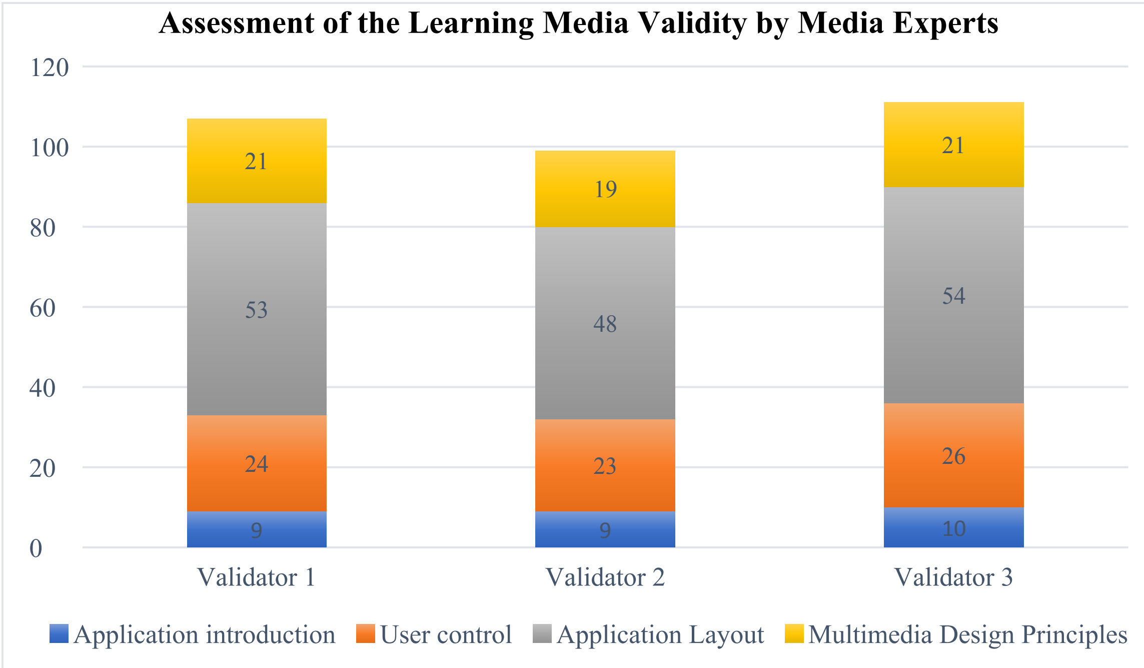


Figure 11. Description of the Assessment Results by Media Experts

Component	Validator-1	Validator-2	Validator-3
Mean	**107**	**99**	**111**
Mean total		**105,67**	

Table 2: Average Assessment of the Validity of Learning Media by Media Experts

Judging from the mean score of media validator-1 is 107 in the "Very Good" criteria, the mean score of media validator-2 is 99 in the "Good" criteria, while the mean score of media validator-3 is 111 in the "Very Good" criteria. The overall mean score of the three media validators is 105.67, with the “Very Good” criteria. Thus it can be concluded that the developed learning media has reached the category of validity of a product in terms of media. Regarding material and media, it can be supposed that the interactive digital games based on computational thinking developed in this study have reached the validity criteria of a development product.

4. Implementation Stage

At the implementation stage, the researcher conducted a small class trial and based on the trial results, it was found that the product being developed reached the "Very Good" criteria. Next, the researcher conducted a large class trial of four classes of students from three Elementary Schools. The results of student responses in large classes were 81.9 in the "Very Good" criteria. Therefore, we can conclude that students' assessments of the digital games developed in this study reach the practicality category of learning media. Of 98 out of 123 students gave a very good impression regarding using these digital games.

5. Evaluation Stage

At the evaluation stage, the researcher conducted a continuous evaluation which began with evaluating the test results of students' understanding of the multiplication concept in contextual problems. The test results showed that the mean score of students' multiplication concept understanding of contextual problems was represented in students' cognitive and psychomotor capability achievements that are still less than half of the maximum score, precisely less than 50. The evaluation was also carried out on the validation results at the development stage. The researcher made several revisions to the game, especially in the illustration of contextual problems and the appearance of characters in games from a media perspective. Regarding the material perspective, the researcher also revised the legibility of contextual problems. According to students' assessment of the use of games, researchers do not need to make revisions because more than 90% of students very appreciate and enthusiastically welcome the implementation of games that are considered user-friendly.

The use of digital games that are integrated into learning mathematics has a positive impact on student responses as users. In this game-based learning of multiplication material, the teacher uses digital games specially designed to assist students' understanding of multiplication concepts by presenting contextual problems. The digital game used as a supporting device in game-based learning here is an educational game called Arithmetic-CT Monkey Game. This educational game gives students a fun and attractive learning experience with structured game content. Monkey Game Arithmetic-CT trains students' adaptation skills to solve various problems with varying difficulty levels. Even to win the game, students must use their creativity in passing challenges or contextual problems that must be faced. While using this game, students get feedback from the system when they access the answer-checking feature. In this case, students can improve their answers because games are designed with specific tasks to guide students ‘learning by gaming’. Various features that support the game are also designed to attract students' attention to this game which has a storyline of everyday life. So emotionally, students also feel meaningful experiences accompanied by feelings of having experienced ongoing events.

Game-based learning supported by the Arithmetic-CT Monkey Game application on the Android platform contains twelve characteristics of digital learning, as stated by Prensky (2003). This learning also refers to two things: education and gameplay, as well as achieving learning goals and entertainment (Lin et al., 2020). Furthermore, Lin et al. (2020) stated that the use of digital games in learning is designed by integrating the system into the experience of playing games.

Because of this, a content design model and game features are often adapted to the behavior habits of its users, such as rules, targets, imagination, mystery, sensory stimulation, and control abilities (Garris et al., 2002). This underlies the conduct of several studies on computer use by children under seven years of age, which is considered to reduce children's important developmental tasks in terms of social and intellectual as well as other types of learning (Healy, 2000).

On the other hand, this game-based learning also loads core computational thinking. In the game, there are three levels with different levels of difficulty, namely level one for simple contextual problems that contain one particular variable and involve integers 1-5 as the numbers to be operated on; the second level is for simple contextual problems that contain one particular variable and involve integers less than ten; and level three for complex contextual problems that contain more than one variable. These problems are used to assess students' cognitive abilities in sorting concepts into several components (the concept of addition and the concept of multiplication), then linking them together to understand the concept as a whole (the concept of multiplication is constructed from a repeated addition). In this case, core computational thinking abstraction is significant in determining students' success in solving contextual problems in games through analytical activities. Likewise, with the development of logical and systematic problem-solving instructions and the process of rechecking the correctness of each problem-solving step, such as algorithm design and debugging in the core of computational thinking, those two thought processes are indicators of a student's cognitive capability that can achieve during learning. The student's cognitive achievement is an implication of the ease of operation, and the continuous interaction between students and games during learning will build students' thinking habits while playing.

The contextual problems of multiplication that students must solve at each level are also used to assess students' psychomotor capability, which can be seen from the attitude/way of students in solving problems or manipulating problem-solving in their way. Students must link various skills or work based on patterns (similarities or differences in patterns) to predict or produce appropriate solutions such as core computational thinking pattern recognition. How to break down complex data or problems into simple problems so that students can more easily solve them, such as decomposition in the core of computational thinking, is also an indicator of the psychomotor abilities students can achieve. Thus, the experience of 'learning by doing' is obtained by students when playing games, affecting their behavior and psychomotor capability when solving problems. Because with learning game-based mathematics, students transfer the abstractness of mental objects in their cognition into external representations/student behavior that can be observed so that their computational thinking skills increase. This is in line with the research results of Andriyani & Maulana (2019), which show that a good learning experience is needed to acquire mathematical knowledge which has abstract and hierarchical objects. With digital games in learning, students look enthusiastic about using interactive technology because this technology reduces the abstractness of learning concepts, so the students easier to understand a learning situation (Buliali et al., 2022; Dikovic, 2009; Panthi et al., 2021).

CONCLUSION

Digital game interactive media as a support device for game-based learning can be said to reach the validity category based on the results of the product feasibility test as indicated by the fulfillment of the "Very Good" criteria in the aspect of material and media. The practicality of learning media is also indicated by the fulfillment of the "Very Good" criteria regarding student responses. Therefore, digital games are proven to solve contextual multiplication problems that were previously difficult for students due to their lack of understanding of the multiplication concept. The researcher hasn't measured the effectiveness of digital games in game-based learning, so this possibility opened up as material for further research. Digital games can be an alternative to support students' cognitive achievements by facilitating the translation of abstract images of multiplication concepts and training students' psychomotor capability in solving multiplication contextual problems at each level of the game. With core computational thinking content, digital games are proven to help with cognitive development tasks and psychomotor enhancement, represented by increasing each level. So that students are conditioned in the mode of 'learning by gaming.' The students' responses have also proven that the core of computational thinking increases their interest in learning multiplication. With this core loaded, students feel assisted in determining the optimal solution strategy through problem formulation activities and appropriate information processing.

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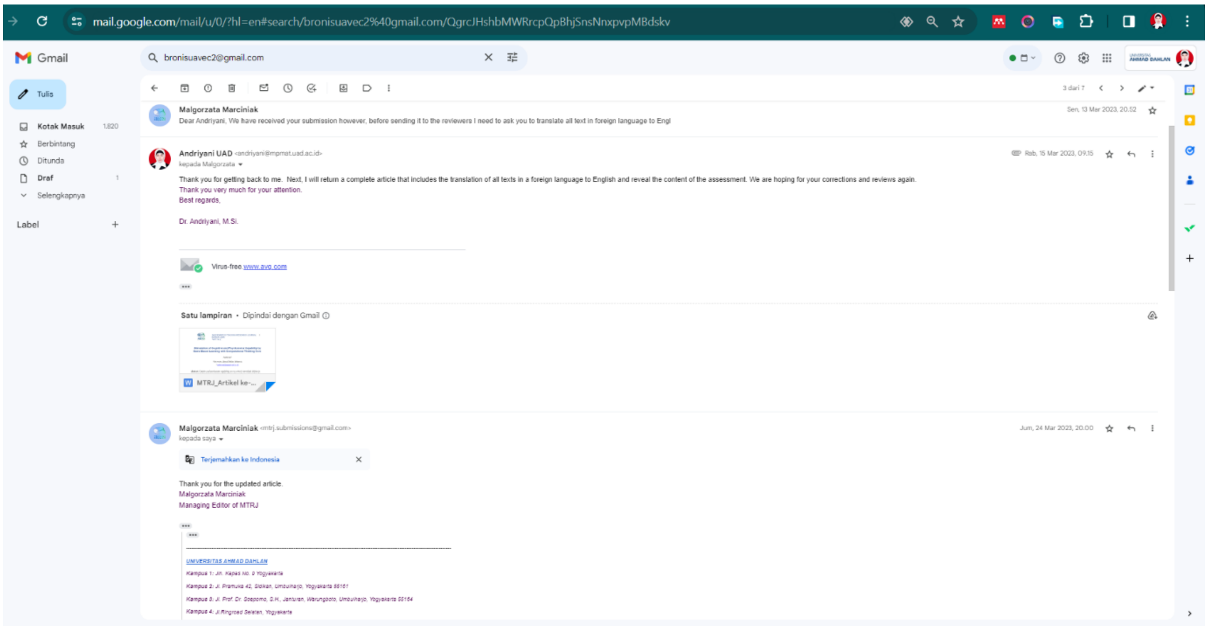
Selanjutnya, penulis mengirimkan hasil revisi sesuai saran editor agar artikel dapat segera mendapat review dari reviewer pada tanggal 15 Maret 2023 dan pada tanggal 24 Maret 2023 editor memberikan konfirmasi penerimaan update artikel dari penulis.



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Stimulation of Cognitive and Psychomotor Capability by Game-Based Learning with Computational Thinking Core

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Abstract: *Cognitive and psychomotor capabilities are two critical interrelated abilities in improving student learning outcomes. Both abilities play a role in understanding the process of new information and developing fine motor skills related to students' cognitive processes and physical activity. Because of this, schools train these two abilities to be equipped in solving mathematical problems such as basic arithmetic. This phenomenon has increased researcher' interest in choosing learning strategies oriented toward both achievements. However, few previous studies haven't much discussed the design of learning strategies oriented toward successfully integrating these two capabilities due to the lack of interest in learning post-pandemic. Moreover, these studies only focus on calculations in arithmetic operations, not the conceptual understanding of operations. Therefore, this study aims to describe the development of learning media designs that accommodate student activities through game-based learning to stimulate cognitive and psychomotor capability in conceptual arithmetic operations, especially multiplication. The learning framework uses core computational thinking integrated with interactive game-based learning. The research method used is ADDIE which contains five stages of development with data collection techniques through validation questionnaires, student responses, and tests. In the learning process, students apply their cognitive ability to understand the concept of operations effectively and encourage efficient problem-solving skills. The study results show that game-based learning media is valid according to experts and practical according to student responses. From the students' responses, it is known that the development of game-based learning can stimulate cognitive and psychomotor capability in solving contextual problems that were previously an obstacle for students through 'learning by gaming.'*

Keywords: *Cognitive, Computational-Thinking, Game-Based Learning, Psychomotor*

INTRODUCTION

Cognitive and psychomotor capabilities are essential components in student learning and development which are a challenge for educators and experts in education. According to Begam

& Tholappan (2018), a person's cognitive ability refers to his thinking/mental process continuity. This cognitive process involves acquisition, processing, and applying knowledge, including attention, memory, reasoning, understanding, and problem-solving. On the other hand, according to Simpson (1972), psychomotor capability refers to students' physical movement skills, including coordination, agility, and fine motor skills, that require practice with measurements based on aspects of speed, accuracy, procedures, and implementation techniques. With this psychomotor capability, students explore phenomena, conceptualize the ideas involved, and apply concepts to new situations (Karplus & Butts, 1977). In the context of learning with abstract objects such as mathematics, the processes contained in this psychomotor ability are interpreted by gaining direct experience and providing opportunities for students to manipulate objects and tools. More clearly, Piaget (1029) said that students' physical experience in learning mathematics could be obtained by giving students opportunities to explore mathematical concepts through the concrete physical experience before moving on to more abstract representations. These experts generally show that cognitive and psychomotor capabilities play a significant role in learning mathematics, especially in active exploration and reflection activities.

In the midst of this significant role, educators have the main challenge of identifying and overcoming differences in cognitive and psychomotor capability that each student has. Given the unique differences in the nature and characteristics of these two abilities, educators need to provide personalized instruction and support to meet the learning needs of each student. In addition, educators also need to find strategies to help students develop their cognitive and psychomotor capabilities on an ongoing basis. This is what requires the teacher's focus on creating interesting and challenging learning experiences for students to follow. Teachers need to design lessons that can stimulate these two capabilities, especially in solving real-world problems. Stimulus in problem-solving needs to be accompanied by providing opportunities to train students' physical skills in direct practical activities. Moreover, the Corona Virus Pandemic that hit the world last year had an impact on reducing the level of active involvement of students in learning and their study results (Haryani & Hamidah, 2022; Onyema et al., 2020; Orlov et al., 2021).

A decrease in student involvement in learning can also be caused by a lack of their intrinsic or extrinsic motivation (Fatimah & Saptandari, 2022) because there is a reasonably close relationship between motivation and student learning involvement (Saeed & Zyngier, 2012). This involvement affects students' academic outcomes (Finn & Zimmer, 2012). Hence an effective learning strategy is needed to increase student learning motivation, such as digital game-based learning, which also functions to encourage students' willingness to learn and self-awareness in both formal and informal learning contexts (Owston, 2009; Yang & Chen, 2010; Yien et al., 2011). The implication of digital educational games is as a learning tool that significantly influences motivating users in a fun learning atmosphere (Kirriemuir & McFarlane, 2004). These educational games tend to arouse curiosity and challenge users to actively explore games until they feel happy when they can finish the game well so that students are motivated and enjoy learning through the game (Chen et al., 2007; Hong et al., 2009; Moon & Baek, 2009). This positive implication raises a lot of attention given to the relationship between digital games and the education field (Chiang et al., 2011).

The variety of games implemented in learning makes developing game application models more adaptive and flexible to be designed as learning media based on the material presented (Hays, 2005; Papoutsi & Drigas, 2016). Games are designed with various systematic, visual, and kinetic activity loads to stimulate students' skills and awareness of specific knowledge (Besgen et al., 2015; Shuqin, 2012). Various student skills are oriented towards achievement through integrating games into learning, including learning basic mathematics such as basic arithmetic, especially multiplication. Through games, students are trained to make decisions by controlling objects in the game for a specific purpose designed in a system or program (Jason in Aprilianti et al., 2013). Several studies on multiplication-themed educational games have been carried out, including research on Android-based arithmetic games by Amrizal & Kurniati (2016), research on mobile educational games for multiplication calculations based on the horizontal method with Html 5 and PhoneGap by Ricky (2013), and research on designing learning game application for 3rd-grade math calculation operations using unity by Kristina & Talitha (2021). This research is related to developing educational games that contain multiplication calculations through fast multiplication counting activities.

In this study, a game-based multiplication concept learning will be designed with the help of digital game applications whose accessibility is carried out on student androids. So students aren't only trained to count fast but understand the concept of multiplication, whose construction is formed from repeated addition. In learning arithmetic, students need adaptive skills, which are functional academic skills in the basic operations of addition, subtraction, division, and multiplication (Polspoel et al., 2019). These adaptive skills are needed for everyday life because they involve communication, life and social, work, and functional academic skills such as reading, writing, and arithmetic (Ainsworth & Baker, 2004; Hodapp, 2002). Thus, learning arithmetic requires both psychomotor and cognitive abilities, especially if arithmetic problems are in the context of students' everyday problems.

Cognitive and psychomotor capabilities have an important role in the formation of adaptive skills, which are the main elements of the elementary school mathematics curriculum (National Math Panel, 2008) and play a fundamental role in solving more complex mathematical problems (Juliana & Hao, 2018; Prendergast et al., 2017). Therefore, teachers need to train these abilities to students for mastery of arithmetic concepts. Knowledge of students' ideas of a basic arithmetic operation can be achieved if students understand the concept of operations and the links between operations (Rahman et al., 2017). But in fact, there are still many students who are afraid of learning mathematics because it is considered difficult and complex (Laurens et al., 2018).

The results of an initial study conducted by researcher in November 2022 in three elementary schools from the Municipality of Yogyakarta and Bantul Regency show that grade III students still do not understand the concept of multiplication operations and often have difficulty solving contextual problems, especially multiplication abstraction which correlates with modeling problems and the procedure for solving it. Meanwhile, the teacher still uses the rote method to teach multiplication. Students' lack of understanding of multiplication often causes boredom, laziness, and a lack of interest for students in learning multiplication. This is similar to Thai & Yasin's (2016) research on multiplication teaching methods. Therefore, we need alternatives in thinking processes and developing problem-solving strategies, including computational thinking (Wing, 2006).

Along with technological advances in recent years, computational thinking has become an important topic in various fields of life (Lindberg et al., 2019). Various countries have attempted to promote computational thinking education in schools, universities, industry, and government (Lin et al., 2020). A large number of researchers attempt to identify students' computational thinking abilities. For example, research by Yadav et al. (2017) and Denning (2017), who researched the development of computational thinking-based teaching guidelines for students; research by Shute et al. (2017) regarding the design of a model for assessing student computing learning outcomes; as well as research by Sullivan & Bers (2018)S and P´erez-Marín et al., (2020) on computational thinking-based learning performance. These studies are clear evidence that computational thinking has become a basic skill needed in learning in this digital era.

Based on the problems experienced by students in learning the concept of multiplication operations above, the researcher considers it necessary and important to design game-based learning with the help of interactive learning media that can stimulate students' cognitive and psychomotor capabilities. The developed interactive learning media is a digital game filled with computational thinking core to help students understand the concept of arithmetic operations, especially multiplication. By integrating computational thinking cores, students learn to understand the concept of multiplication operations by solving contextual problems presented in the digital game.

METHOD

This study aims to describe the development of instructional media designs that accommodate student activities through game-based learning to stimulate cognitive and psychomotor capability in conceptual arithmetic operations. The procedure for this research study consists of an analysis stage, a design stage, a development stage, an implementation stage, and an evaluation stage (Branch, 2009; Sugiyono, 2019). The researcher chose this model to develop media learning in digital games because it facilitates constructing students' knowledge and skills in instructional guided learning plans. In addition, the ADDIE model is also devoted to solving problems related to gaps due to students' lack of knowledge and skills. Furthermore, the ADDIE model contains generative processes (stages) by applying concepts and theories to a particular context.

In the analysis stage, the researcher identified the probable causes of incongruity/differences between learning outcomes and theories, concepts, or other learning problems in the multiplication concept material. Identification is based on experiences, preferences (tendencies), abilities, experiences, and student motivation during learning. In addition, the researcher also identified the resources needed during the development process, including the curriculum used, the concept of multiplication, the learning models or methods used, teaching materials, facilities, learning environment, technology, and the characteristics of the students involved during the development process. To determine the extent to which the characteristics of the students at the research site, the researcher conducted written tests at three Elementary Schools to measure students' understanding of multiplication concepts presented through contextual problems.

At the design stage, the researcher designs a product that will be developed based on the analysis results from the previous stage and begin with selecting media which is digital games with core computational thinking to stimulate cognitive and psychomotor capability. Next, the researcher prepares the initial design of the media by making a picture or representation of the interactions between the system and its environment or making a model of the behavior of the information system in the form of a diagram until it produces a product blueprint. At this stage, the researcher also formulates specific, measurable, applicable, and realistic learning objectives based on appropriate learning strategies.

In the development stage, the researcher developed an initial prototype according to the blueprint designed in the previous stage, including developing test instruments, validation questionnaires, and student responses to be validated by validators who are evaluation experts. Likewise, the initial prototype of the media was also validated by the validator, an expert in the field of learning media, and an expert in mathematics learning materials. Furthermore, the researcher revised all the development results according to the suggestions of the validators, each consisting of three validators, so the digital game was declared valid and ready to be implemented in small and large classes.

At the implementation stage, the researcher makes concrete steps to implement the learning system that was developed. Here the researcher tested game products in small trial classes of 10 third-grade students at an Elementary School in the District of Yogyakarta. The tryout was carried out for three meetings, and then the researcher gave a response questionnaire to students as a product user. The researcher will use the results of the student responses to revise the product. The researcher again tested the product on third-grade students from four classes at three elementary schools. Of the three elementary schools, two are located in Bantul Regency, and one is from Yogyakarta Municipality, which has two study group classes. To find out the responses of the large trial classes, the researcher distributed response questionnaires whose results were used as a basis for determining the practicality of the game products that had been developed.

At the evaluation stage, the researcher continuously evaluates, beginning from the initial development stage, for the requirement of revision, until final product development. Evaluation is carried out through qualitative and quantitative data analysis. Based on the needs analysis results in the first development stage, the researcher analyzed the quantitative data, which was the result of the test to find out the characteristics of the students regarding their understanding of the concept of multiplication in contextual problems. The validation results at the development stage and field trials at the implementation stage were also analyzed for product revision materials. Qualitative data from input, suggestions, and expert criticism will be interpreted as a basis for gradual revisions for better media development. While the quantitative analysis of the results of validation questionnaires and student response questionnaires was carried out to assess the quality of the eligibility of the media in terms of validity and practicality. All stages of this evaluation are aimed at the feasibility of the final product in terms of content, design, and user-friendliness.

The subjects used in this study were ten third-grade students from an Elementary School in the District of Yogyakarta as small class trial subjects, 123 third-grade students from three Elementary Schools, two of which were located in Bantul Regency and one school from the District of Yogyakarta. This one school where the large class trial was held had two study group classes, so there were four trial classes. Data collection techniques consist of test and non-test techniques in questionnaires to validate products and student response questionnaires. The data analysis technique used in this study was in the form of qualitative and quantitative data analysis. Quantitative data analysis was carried out by calculating the mean score of students' conceptual understanding test results in solving contextual problems. In addition, the researcher also calculated the mean validation score and the mean student response score, which was then followed by converting the mean score into the product validity and practicality category, which refers to the validity and practicality criteria guidelines on five Linkert scales successively - respectively consisting of criteria: 'Not Good' for a score of 1; 'Less Good' for a score of 2; 'Good Enough' for a score of 3; 'Good' for a score of 4; and 'Very Good' for a score of 5 (Widoyoko, 2018). The product is said to reach validity and practicality standards if it reaches the minimum "Good" criteria.

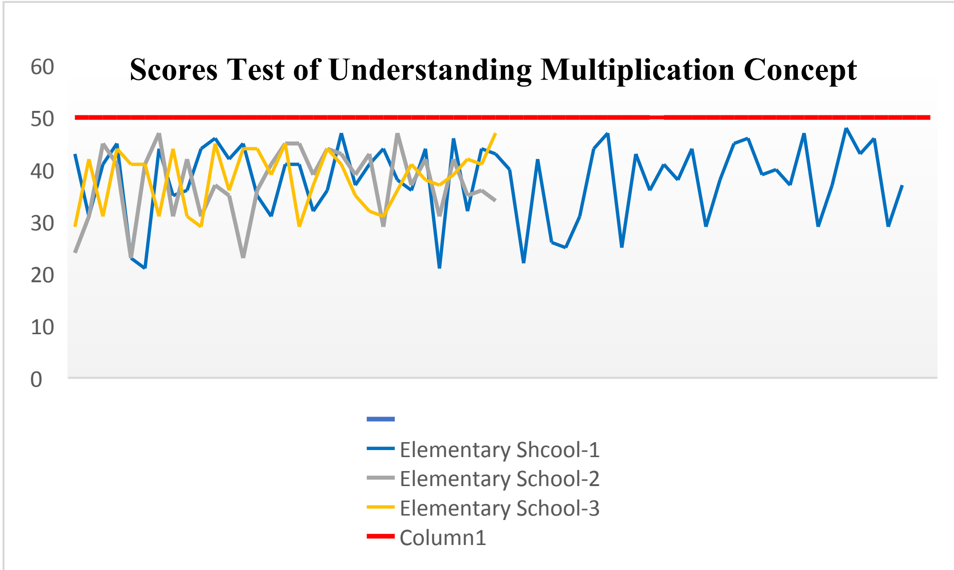
RESULTS AND DISCUSSION

1. Analysis Stage

At this stage, the researcher identifies the curriculum that will be used as a guideline for developing digital games concerning the curriculum guidelines used by the school. Next, the researcher assessed the material related to the concept of multiplication. In this case, the researcher interviewed mathematics teachers about the application of the curriculum used by schools to teach multiplication material in class. Based on the results of interviews with the mathematics teacher, it is known that the teacher delivers multiplication material limited to calculating two or more integers with an allocation of time per week is 4 × 45 minutes or two meetings with an allocation each session of 2 × 45 minutes. To check student understanding, the teacher added one meeting in the form of a written test. The time allocation, which was only 2-3 sessions, turned out to cause problems for students, where students memorized multiplication more and were oriented towards counting skills only.

The interviews continued exploring the teacher's teaching methods in the expository form. The teacher conveys the multiplication of two or more numbers directly, whereas the teacher teaches the meaning of multiplication as a number multiplied according to the multiplier number. Students who find it difficult to accept the abstraction of the multiplication meaning will eventually choose to memorize the multiplication of integer numbers in the range 1-10. All of this was caused by the difficulties he experienced in interpreting the teacher's explanations which tended to lead only to calculating numbers. So that students look less enthusiastic about participating in learning and are unable to solve contextual problems given by the teacher.

In addition to the learning methods used by the teacher, the researcher also conducted interviews about the teacher's teaching materials. The results of the interviews showed that the teacher's teaching materials were books that tended to be textual. This certainly does deficient attract students' interest in learning, which during the Coronavirus pandemic, often carried out online learning and accessed digital learning resources. Therefore, we need an interactive digital learning media that can accommodate their learning needs through new post-pandemic habits. In the initial research, the researcher measured students' understanding by giving contextual problems about multiplication concepts. The results of an analysis of third-grade students from four different classes in three Elementary Schools in Yogyakarta Province show that students' understanding of multiplication concepts is still low, with a mean score below 50 with a maximum score of 100 because they focus more on numeracy skills. The low level of students' understanding of multiplication can be seen in Figure 1 below.

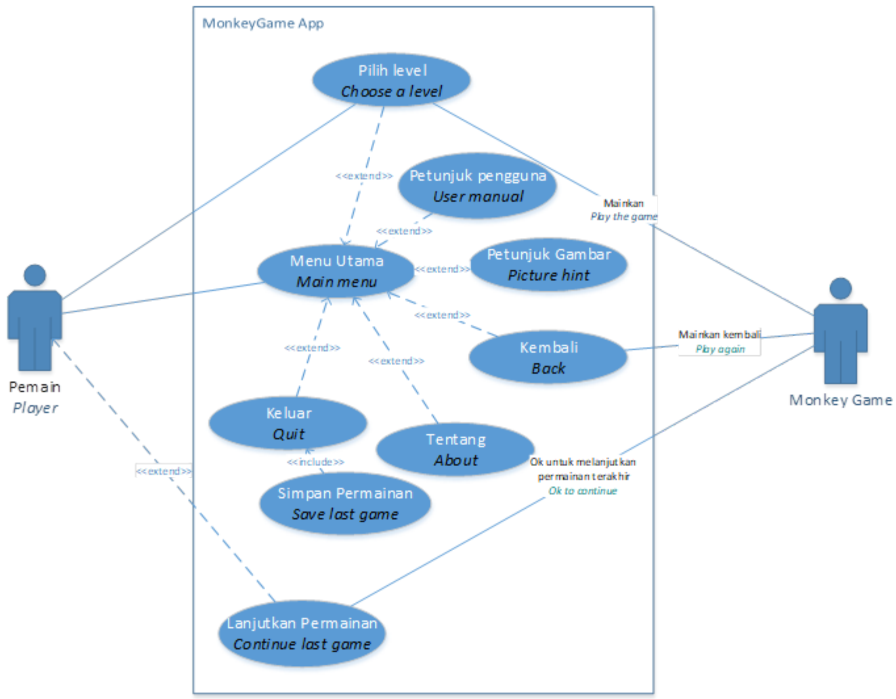


Picture 1. Level of Understanding of the Multiplication Concept

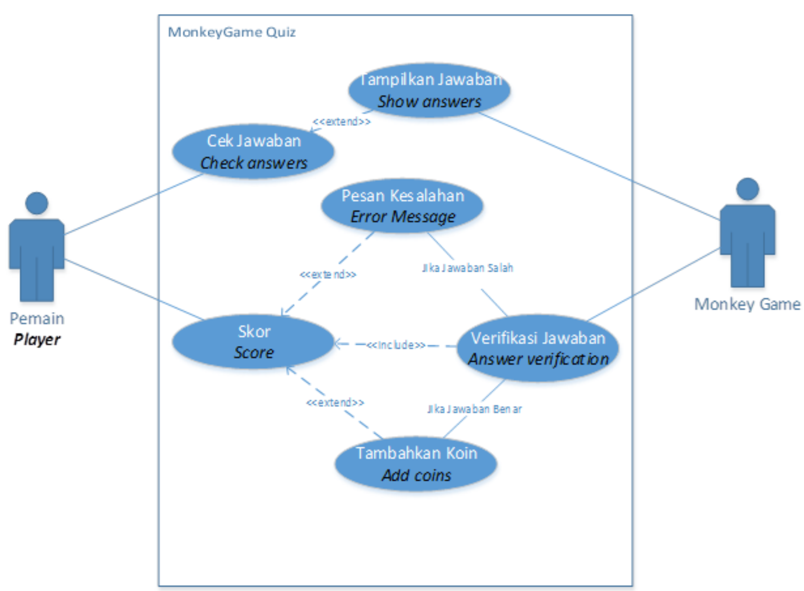
From Figure 1 above, we can conclude that students' cognitive and psychomotor capabilities are less than half the maximum score or less than 50. So on this basis, the researcher intends to develop a digital game with core computational thinking to support learning multiplication concepts. With this game, it is hoped that students can understand the abstraction of multiplication concepts by solving contextual problems that were previously difficult for students to solve.

2. Tahap Desain

At the design stage, the researcher designs a digital game that will be developed based on the requirement analysis results at the previous stage. From the results of this analysis, the researcher chose digital game media with core Computational Thinking to stimulate students' cognitive and psychomotor capabilities. Furthermore, at the game design stage, researchers began creating use case diagrams that describe or represent the interactions between the system and its environment, as shown in Figure 2 (a)-(b) below.



(a) Main Use Case Diagram

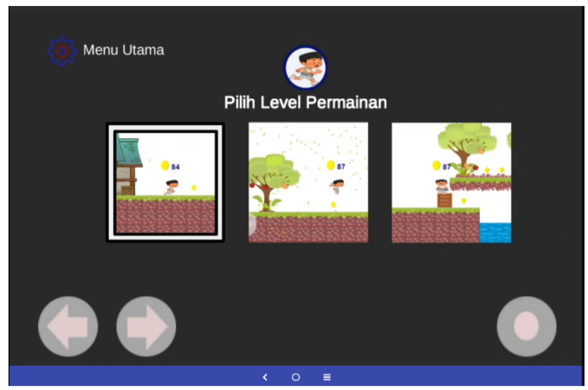


(b) Part Diagram of the Main Use Case Contains Checking Answers and Feedback

Figure 2. Digital Game Use Case Diagram

The researcher uses the Use Case diagram above to define functional modeling and system operational requirements by determining the scene method used to build the system from the results of previous application analysis. At this stage, the researcher determines a digital game title containing the concept of multiplication with the name Monkey Game Arithmetic-CT. Then the researcher formulated the digital game concept according to the achievement orientation of students' cognitive and psychomotor capability, which were leveled with levels 1 to 3 on the menu as presented in Figure 3 (a)-(b) below.

(a) Game Main Menu



(b) First Level to Third Level Game

First column translation:

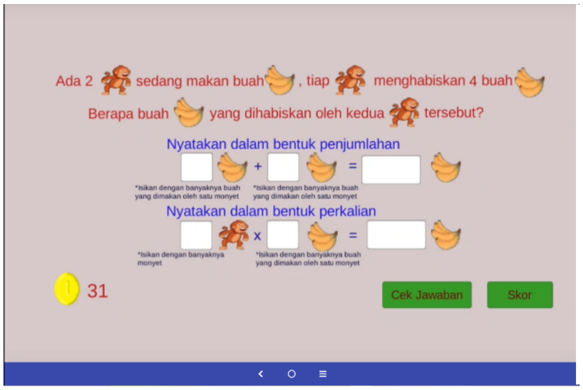
Main Menu
User Manual
Picture Hint
Choose a Level
Back
About
Quit

Second column translation:

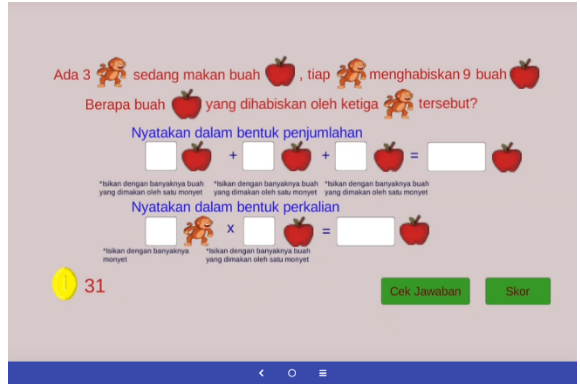
Choose a Game Level

Figure 3. Game Leveling on the Main Menu

The basis of game leveling refers to the complexity of the contextual problems presented at each level so that each level of the game has contextual problems with different levels of difficulty solving, as shown in Figure 4 (a)-(c) below.



(a) First Level



(b) Second Level

Column Translation:

There are two eating , and each eats four . How many did the two eat?

Express in the addition statement

□ + □ = □

Fill with the number of fruits eaten by one monkey — *Fill with the number of fruits eaten by one monkey*

Express in the multiplication statements

□ × □ = □

Fill in the number of monkeys — *Fill with the number of fruits eaten by one monkey*

Check answers *Score*

There are three eating , and each eats nine . How many did the three eat?

Express in the addition statement

□ + □ + □ = □

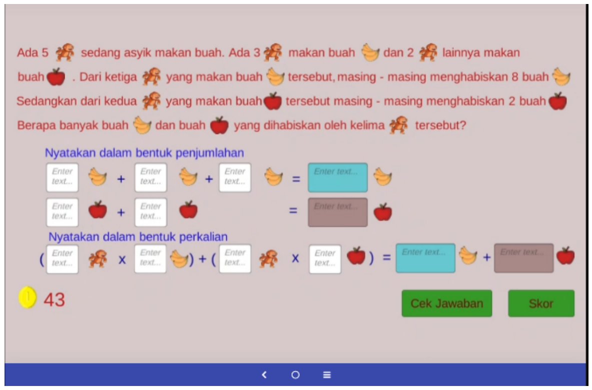
Fill with the number of fruits eaten by one monkey — *Fill with the number of fruits eaten by one monkey* — *Fill with the number of fruits eaten by one monkey*

Express in the multiplication statements

□ × □ = □

Fill in the number of monkeys — *Fill with the number of fruits eaten by one monkey*

Check answers *Score*



(c) Third Level

Column Translation:

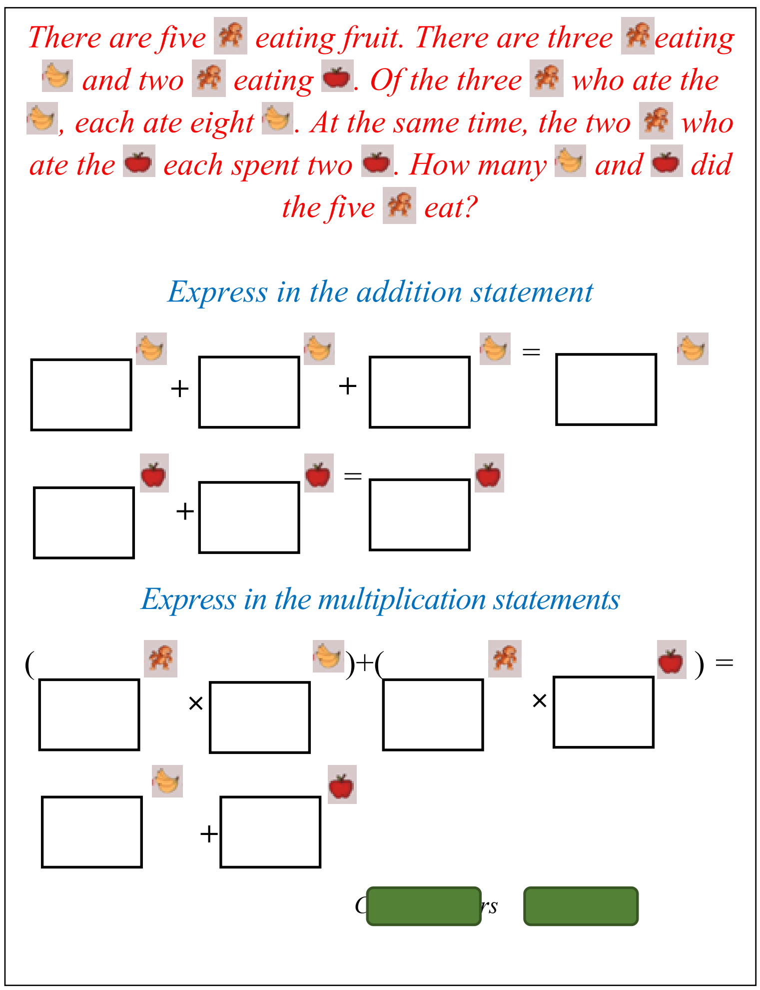


Figure 4. Examples of Contextual Problems at First Level to Third Level

Computational thinking core loaded, namely abstraction, algorithm design, pattern recognition, decomposition, and debugging in digital games, is represented in problem-solving activities as presented in Figure 5 below.

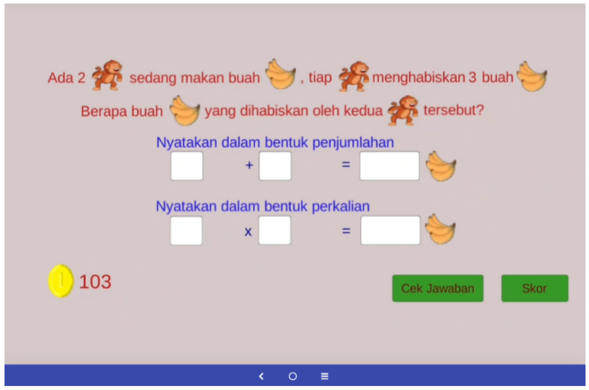


Figure 5. The Abstraction Core of Computational Thinking

Column Translation:

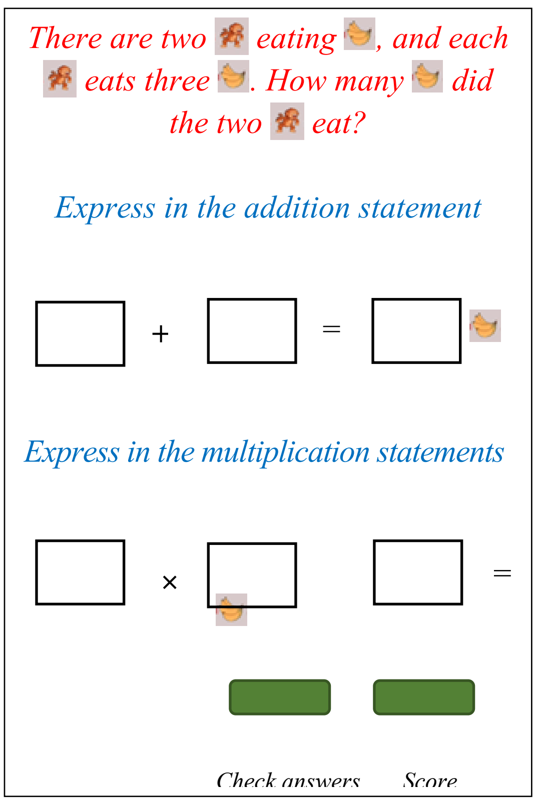


Figure 5 shows that students must generalize and identify common cores by filtering out specific details and any needed patterns and ignoring unrelated data to solve the problem. In this game, students must be able to sort out the amount of fruit each monkey ate and the number of monkeys that ate the fruit to fill in each answer box in the addition and multiplication statements. In the game's display, there aren't fruit picture hints or instructions containing information that must be entered in the answer box. So students have to filter the details of the data as their abstraction entity. The core loaded of the algorithm design is presented in the problem-solving steps, as shown in Figure 6 below.

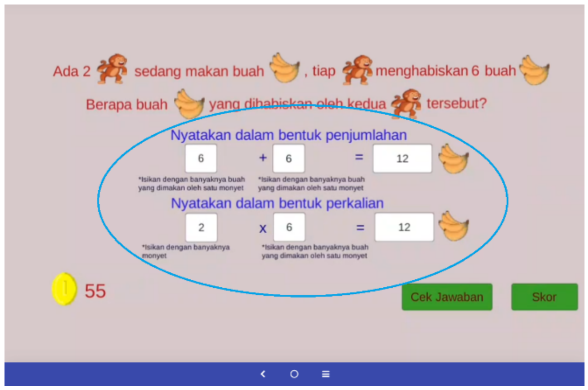


Figure 6. The Algorithm Design Core of Computational Thinking

Column Translation:

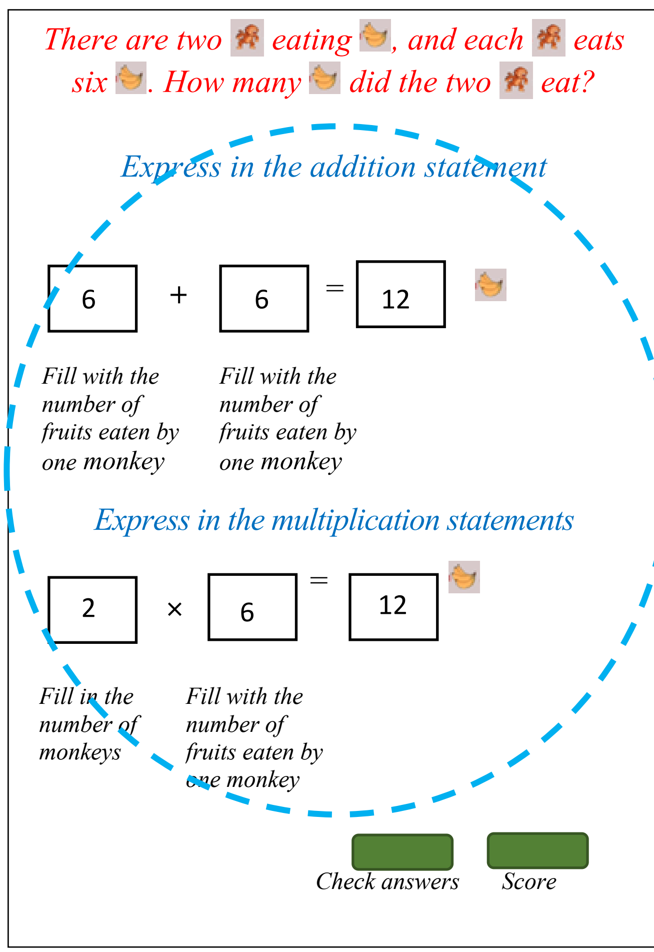
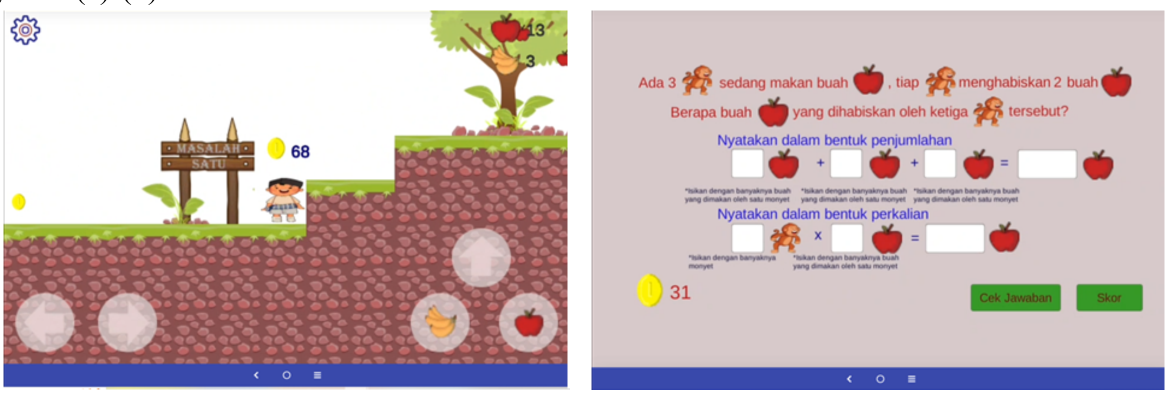
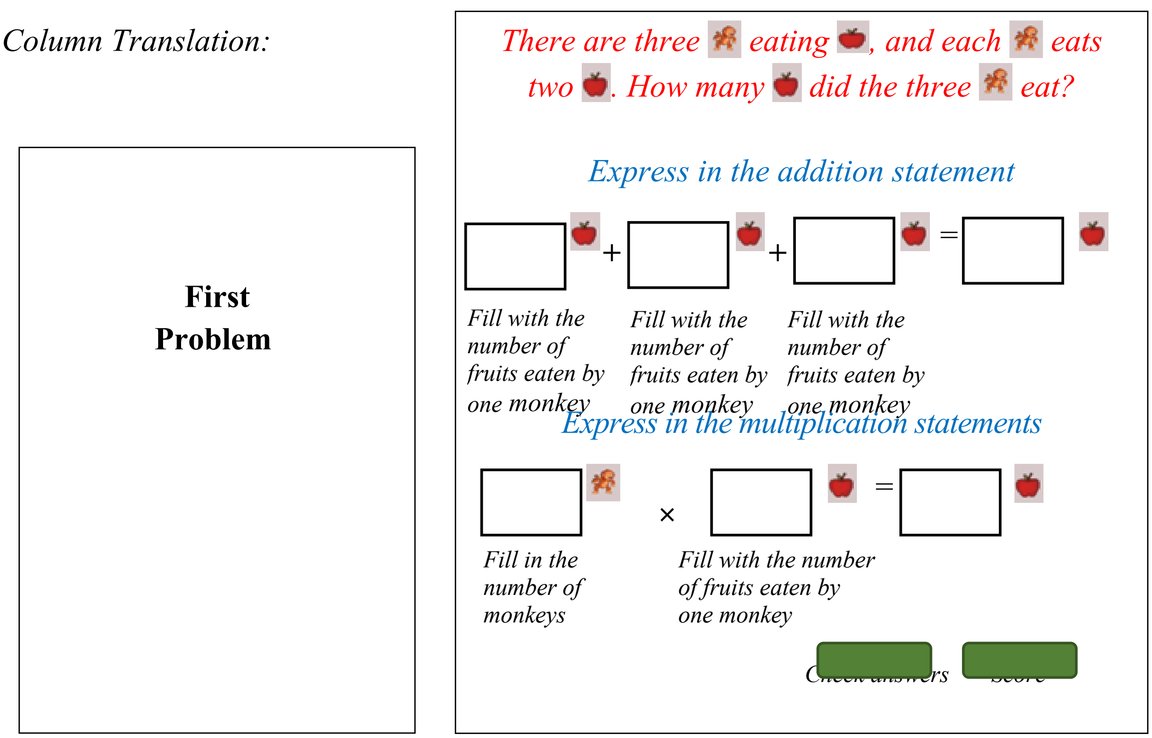


Figure 6 shows that students must develop logical and systematic problem-solving instructions to solve problems so that other people can use the steps or information to solve the same problem. In this game, in the first step, students must fill in the number of fruits eaten by one monkey in each statement box of the addition model. In the second step, students must fill in the number of monkeys in the first statement box of the multiplication model. Furthermore, students must also fill in the number of fruits each monkey eats in the second statement box of the multiplication model. In the final step, students check their answers by pushing the 'check the answers' button, followed by pushing the 'score' button to check the achievement of the problem-solving score. The core loaded of pattern recognition is presented in the problem-solving step, as shown in Figure 7 (a)-(b) below.



(a) First Problem and Its Content

Column Translation:



(b) Second Problem and Its Content

Column Translation:

Second Problem

There are three eating , and each eats seven . How many did the three eat?

Express in the addition statement

[ ] + [ ] + [ ] = [ ]

Fill with the number of fruits eaten by one monkey | *Fill with the number of fruits eaten by one monkey* | *Fill with the number of fruits eaten by one monkey*

Express in the multiplication statements

[ ] × [ ] = [ ]

Fill in the number of monkeys | *Fill with the number of fruits eaten by one monkey*

Check answers *Score*

Figure 7. The Pattern Recognition Core of Computational Thinking

Figure 7 (a)-(b) shows that students must be able to see similarities or differences in patterns and methods in the data that will be used in predicting and presenting data to classify problems and provide appropriate solutions. This pattern recognition uses previous experience and prior knowledge as the basis for logical thinking. Then, from this logic, students get new experience and knowledge to solve various identic problems according to patterns they already know. In this game, students must be able to see the data pattern and the regularity of solving the first problem presented, as shown in

Figure 6 (a) above. The first problem presents a data pattern about three monkeys eating apples, and each monkey eats two apples. Students were asked to determine how many apples the three monkeys ate.

The second problem is presented using an identic multiplication problem. The second problem shows the existence of three monkeys who are eating apples, and each monkey eats seven apples. Students were asked to determine how many apples the three monkeys ate. To solve the first problem, students design a solving algorithm that begins with applying the concept of repeated addition. Then, they continue with the solution step by applying the multiplication concept related to the previous repeated addition concept. Using the patterns and regularities of the data in the first problem, students design solutions to the second problem by predicting the same steps for solving the two multiplication problems. The core loaded of decomposition is presented in the problem-solving step, as shown in Figure 8 below.

Figure 8. The Decomposition Core of Computational Thinking

Column Translation:

There are five eating fruit. There are three eating and two eating . Of the three who ate the , each ate eight . At the same time, the two who ate the each spent two . How many and did the five eat?

Express in the addition statement

8 + 8 + 8 = 24

2 + 2 = 4

Express in the multiplication statements

(3 × 8)+(2 × 2) = 24 + 4

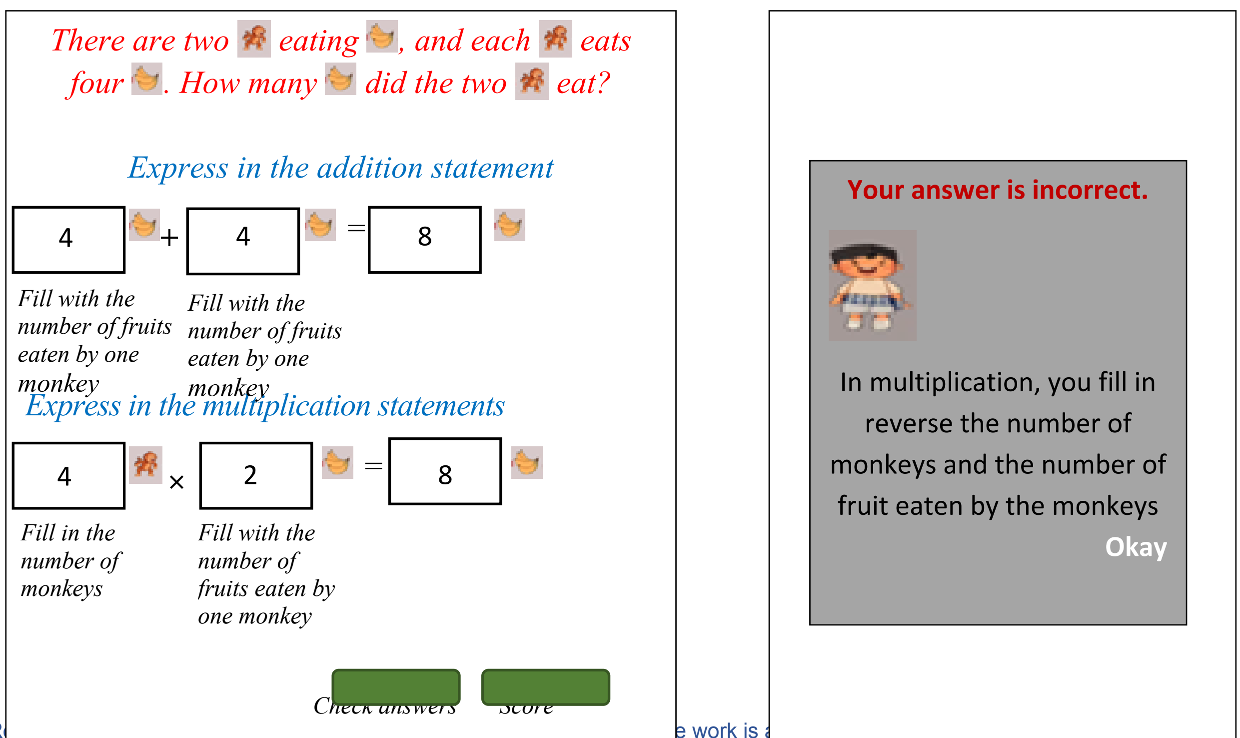
ers

Figure 8 shows that students must be able to break down complex data, problems, or processes into smaller problem that is simple parts. So, if there is a complex problem, it can be more easily solved by breaking down the complex problem into these small parts. In this case, students must be able to break down the problem of the number of bananas and the number of apples eaten by the monkey into two smaller problems, namely the problem of the number of bananas eaten by the monkey and the problem of the number of apples eaten by the monkey separately.

The core loaded of debugging is presented in the problem-solving step, as shown in Figure 9 below.

(a) Problem-solving (b) Result of Recheck

Column Translation:



(c) Result of Error Correction from Rechecking Process

Column Translation:

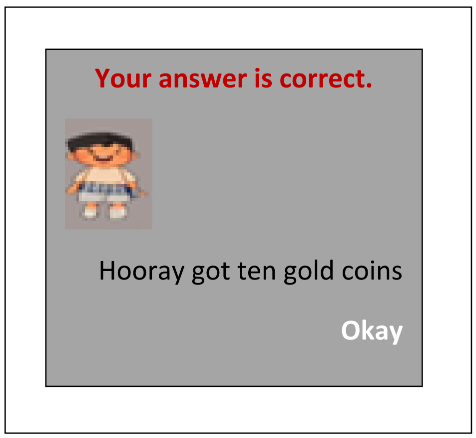


Figure 9. The Debugging Core of Computational Thinking

In Figure 9, it is shown that students must carry out an inspection or process of rechecking each step of problem-solving to ensure the process is carried out correctly. In this game, students must check every step of solving the problem they have done, as shown in Figure 9 (a), to determine whether the process is correct. If students make mistakes while solving the problem, the system will provide feedback in the form of notifications that the student's answers are still incorrect, as shown in Figure 9 (b). The picture states that the student's multiplication form is still wrong, where students fill in the boxes which switch for the number of monkeys that should be filled in with the amount of fruit eaten by the monkeys. Furthermore, students are given a chance to improve their problem-solving and recheck their answers. If the student's answer is correct, the system will provide feedback in the notification that the student gets ten gold coins as a prize for their accuracy in solving problems in the game.

3. Development Stage

This stage begins with an instrument feasibility assessment in the form of a product validation questionnaire in terms of media and material, also a student response questionnaire. Testing the validity of the contents of these three instruments was carried out using expert judgment or reviewing the grid, especially the suitability instruments with the research objectives and the questions. Based on the results of expert judgment, the three instruments are declared valid. Furthermore, the researcher validated the product regarding material substance and media design, carried out by three validators using assessment instruments declared valid by experts. The results of the material substance validation by the three validators are presented in Figure 10 and Table 1 below.

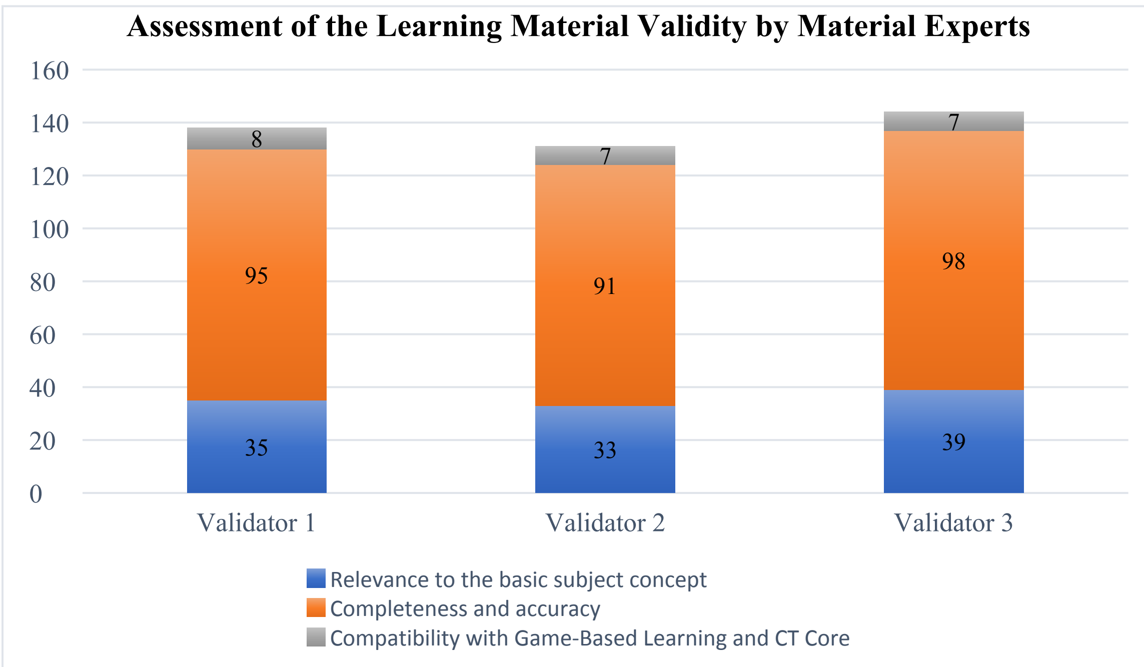


Figure 10. Description of the Assessment Results by Material Experts

Component	Validator-1	Validator-2	Validator-3
Mean	**138**	**131**	**144**
Mean total		**137,67**	

Table 1: Average Assessment of the Validity of Learning Materials by Material Experts

Based on the analysis of the results of the material expert validation, it is known that the mean score of material validator-1 is 138 in the "Very Good" criteria, the mean score of material validator-2 is 135 in the "Good" criteria, while the mean score of the material validator-3 is 144 in the "Very Good" criteria. The mean total of the three material validators is 137,67, with the "Very Good" criteria. Thus it can be concluded that the developed learning media has reached the category of validity of a product in terms of material. Assessment of the validity of learning media by media validators is presented in Figure 11 and Table 2 below.

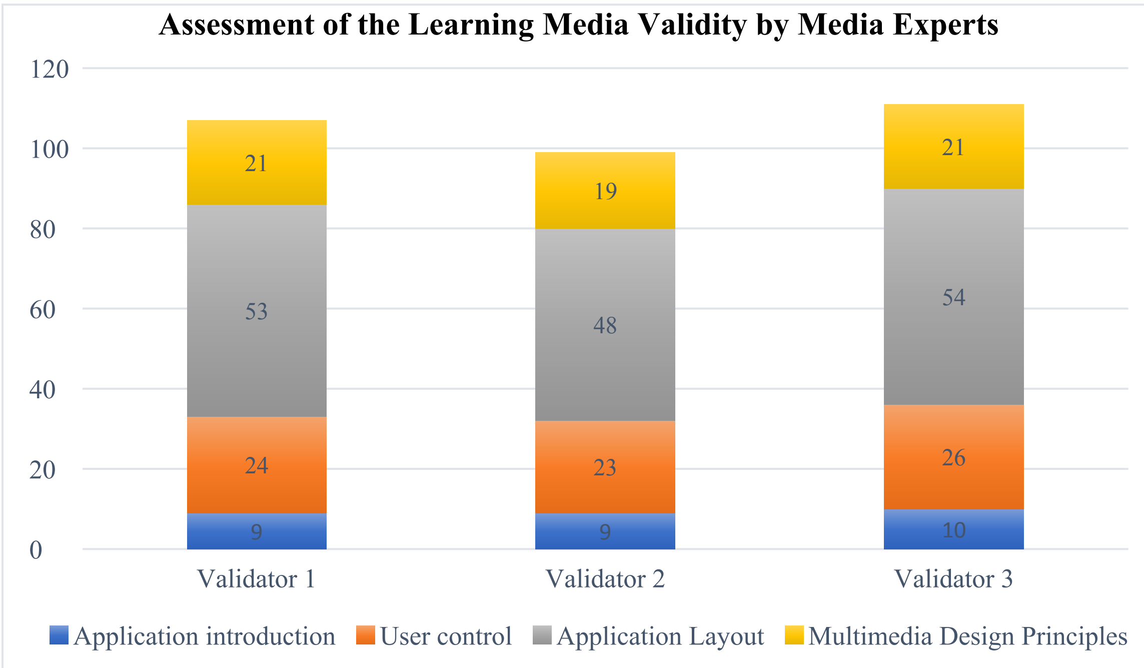


Figure 11. Description of the Assessment Results by Media Experts

Component	Validator-1	Validator-2	Validator-3
Mean	**107**	**99**	**111**
Mean total		**105,67**	

Table 2: Average Assessment of the Validity of Learning Media by Media Experts

Judging from the mean score of media validator-1 is 107 in the "Very Good" criteria, the mean score of media validator-2 is 99 in the "Good" criteria, while the mean score of media validator-3 is 111 in the "Very Good" criteria. The overall mean score of the three media validators is 105.67, with the “Very Good” criteria. Thus it can be concluded that the developed learning media has reached the category of validity of a product in terms of media. Regarding material and media, it can be supposed that the interactive digital games based on computational thinking developed in this study have reached the validity criteria of a development product.

4. Implementation Stage

At the implementation stage, the researcher conducted a small class trial and based on the trial results, it was found that the product being developed reached the "Very Good" criteria. Next, the researcher conducted a large class trial of four classes of students from three Elementary

Schools. The results of student responses in large classes were 81.9 in the "Very Good" criteria. Therefore, we can conclude that students' assessments of the digital games developed in this study reach the practicality category of learning media. Of 98 out of 123 students gave a very good impression regarding using these digital games.

5. Evaluation Stage

At the evaluation stage, the researcher conducted a continuous evaluation which began with evaluating the test results of students' understanding of the multiplication concept in contextual problems. The test results showed that the mean score of students' multiplication concept understanding of contextual problems was represented in students' cognitive and psychomotor capability achievements that are still less than half of the maximum score, precisely less than 50. The evaluation was also carried out on the validation results at the development stage. The researcher made several revisions to the game, especially in the illustration of contextual problems and the appearance of characters in games from a media perspective. Regarding the material perspective, the researcher also revised the legibility of contextual problems. According to students' assessment of the use of games, researchers do not need to make revisions because more than 90% of students very appreciate and enthusiastically welcome the implementation of games that are considered user-friendly.

The use of digital games that are integrated into learning mathematics has a positive impact on student responses as users. In this game-based learning of multiplication material, the teacher uses digital games specially designed to assist students' understanding of multiplication concepts by presenting contextual problems. The digital game used as a supporting device in game-based learning here is an educational game called Arithmetic-CT Monkey Game. This educational game gives students a fun and attractive learning experience with structured game content. Monkey Game Arithmetic-CT trains students' adaptation skills to solve various problems with varying difficulty levels. Even to win the game, students must use their creativity in passing challenges or contextual problems that must be faced. While using this game, students get feedback from the system when they access the answer-checking feature. In this case, students can improve their answers because games are designed with specific tasks to guide students ‘learning by gaming’. Various features that support the game are also designed to attract students' attention to this game which has a storyline of everyday life. So emotionally, students also feel meaningful experiences accompanied by feelings of having experienced ongoing events.

Game-based learning supported by the Arithmetic-CT Monkey Game application on the Android platform contains twelve characteristics of digital learning, as stated by Prensky (2003). This learning also refers to two things: education and gameplay, as well as achieving learning goals and entertainment (Lin et al., 2020). Furthermore, Lin et al. (2020) stated that the use of digital games in learning is designed by integrating the system into the experience of playing games. Because of this, a content design model and game features are often adapted to the behavior habits of its users, such as rules, targets, imagination, mystery, sensory stimulation, and control abilities (Garris et al., 2002). This underlies the conduct of several studies on computer use by children under seven years of age, which is considered to reduce children's important developmental tasks in terms of social and intellectual as well as other types of learning (Healy, 2000).

On the other hand, this game-based learning also loads core computational thinking. In the game, there are three levels with different levels of difficulty, namely level one for simple contextual problems that contain one particular variable and involve integers 1-5 as the numbers to be operated on; the second level is for simple contextual problems that contain one particular variable and involve integers less than ten; and level three for complex contextual problems that contain more than one variable. These problems are used to assess students' cognitive abilities in sorting concepts into several components (the concept of addition and the concept of multiplication), then linking them together to understand the concept as a whole (the concept of multiplication is constructed from a repeated addition). In this case, core computational thinking abstraction is significant in determining students' success in solving contextual problems in games through analytical activities. Likewise, with the development of logical and systematic problem-solving instructions and the process of rechecking the correctness of each problem-solving step, such as algorithm design and debugging in the core of computational thinking, those two thought processes are indicators of a student's cognitive capability that can achieve during learning. The student's cognitive achievement is an implication of the ease of operation, and the continuous interaction between students and games during learning will build students' thinking habits while playing.

The contextual problems of multiplication that students must solve at each level are also used to assess students' psychomotor capability, which can be seen from the attitude/way of students in solving problems or manipulating problem-solving in their way. Students must link various skills or work based on patterns (similarities or differences in patterns) to predict or produce appropriate solutions such as core computational thinking pattern recognition. How to break down complex data or problems into simple problems so that students can more easily solve them, such as decomposition in the core of computational thinking, is also an indicator of the psychomotor abilities students can achieve. Thus, the experience of 'learning by doing' is obtained by students when playing games, affecting their behavior and psychomotor capability when solving problems. Because with learning game-based mathematics, students transfer the abstractness of mental objects in their cognition into external representations/student behavior that can be observed so that their computational thinking skills increase. This is in line with the research results of Andriyani & Maulana (2019), which show that a good learning experience is needed to acquire mathematical knowledge which has abstract and hierarchical objects. With digital games in learning, students look enthusiastic about using interactive technology because this technology reduces the abstractness of learning concepts, so the students easier to understand a learning situation (Buliali et al., 2022; Dikovic, 2009; Panthi et al., 2021).

CONCLUSION

Digital game interactive media as a support device for game-based learning can be said to reach the validity category based on the results of the product feasibility test as indicated by the fulfillment of the "Very Good" criteria in the aspect of material and media. The practicality of learning media is also indicated by the fulfillment of the "Very Good" criteria regarding student responses. Therefore, digital games are proven to solve contextual multiplication problems that were previously difficult for students due to their lack of understanding of the multiplication concept. The researcher hasn't measured the effectiveness of digital games in game-based learning, so this possibility opened up as material for further research. Digital games can be an alternative to support students' cognitive achievements by facilitating the translation of abstract images of multiplication concepts and training students' psychomotor capability in solving multiplication contextual problems at each level of the game. With core computational thinking content, digital games are proven to help with cognitive development tasks and psychomotor enhancement, represented by increasing each level. So that students are conditioned in the mode of 'learning by gaming.' The students' responses have also proven that the core of computational thinking increases their interest in learning multiplication. With this core loaded, students feel assisted in determining the optimal solution strategy through problem formulation activities and appropriate information processing.

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APPENDIX 1.

ASSESSMENT SHEET OF THE LEARNING MATERIAL VALIDITY BY MATERIAL EXPERTS

A. PURPOSE

To assess the validity of the Arithmetic-CT Monkey Game of interactive learning media for application compatibility with Game-Based Learning and CT core quality, completeness, accuracy, and relevance to the basic subject concept by material experts.

B. INSTRUCTIONS

1. To Mr./Miss, please assess by giving a tick (√) in the column that has been provided that is appropriate with the following assessment criteria:
   1: Not Good
   2: Less Good
   3: Good Enough
   4: Good
   5: Very Good
2. To Mr./Miss, please advise on improvement by writing in the comment line suggestions that have been provided.

No	Assessment Criteria	Score				
		1	2	3	4	5
Compatibility with Game-Based Learning and CT Core						
1	The game content present problems whose solutions contain the abstraction core of computational thinking					
2	The game content present problems whose solutions contain the algorithm design of computational thinking					
3	The game content present problems whose solutions contain the pattern recognition of computational thinking					
4	The game content present problems whose solutions contain the decomposition of computational thinking					
5	The game content present problems whose solutions contain the debugging of computational thinking					
6	Games contain special learning that helpzs to solve problems related to the concept of multiplication.					
Completeness and accuracy						

7	Coherent in the preparation of material from simple concepts to more complex concepts					
8	Diversity in giving examples related to the concept of multiplication					
9	The accuracy of the problem given with the concept of multiplication					
10	Correctness of the problem-solving feedback					
11	Readability and clarity of information contained in-game issues					
Relevance to the basic subject concept						
12	Suitability of the material with the core competencies and basic competencies in the referenced curriculum					
13	The usefulness of games as learning media needed by students and facilitates the achievement of learning objectives					
14	Conformity of material with the truth of its substance					
15	Examples of clarity in illustrating the abstract concept of multiplication					
16	Coverage (breadth/depth) of the material					
17	Factual material and material actualization					
18	Appropriateness of the language used with the level of the cognitive and intellectual development of students					
19	Interactivity between students and games that attract student learning motivation					
20	Instruction traction					

Comment and Suggestion:
…………………………………………………………………………………………………
..……………………………………………………………………………………………..
…..…………………………………………………………………………………………..

C. CONCLUSION

In terms of material aspects, the Arithmetic-CT Monkey Game of interactive learning media states:

1. Worth
2. Worth using after revision
3. Not worth

Please give a circle sign of the choice of numbers provided as the assessment result.

..........., ……………… 2022
Validator,

……………………………….....

APPENDIX 2.

ASSESSMENT SHEET OF THE LEARNING MEDIA VALIDITY BY MEDIA EXPERTS

D. PURPOSE

To assess the validity of the Arithmetic-CT Monkey Game of interactive learning media for the aspect of application introduction quality, user control, application view, and multimedia design principles by media experts.

E. INSTRUCTIONS

1. To Mr./Miss, please assess by giving a tick (√) in the column that has been provided that is appropriate with the following assessment criteria:
   1: Not Good
   2: Less Good
   3: Good Enough
   4: Good
   5: Very Good
2. To Mr./Miss, please advise on improvement by writing in the comment line suggestions that have been provided.

No	Assessment Criteria	Score				
		1	2	3	4	5
Introduction of Application						
1	Ease of game title in providing an overview of the game					
2	Clarity of game operating guidance and the displayed menu					
3	How attracting the view of the education game					
User control						
4	Control sequence accuracy					
5	Consistency of the navigation button layout of the game					
6	Smooth use without hang, crash, or lag					
7	Use of games on the Android platform flexibility of time and place of usage					
8	Interactive education game					
Application View						
9	Accuracy of the game background selection					

10	Consistency of the game color use					
11	Consistency of selection of the game's text types and fonts presented					
12	Consistency of the game's text size selection					
13	The icons and navigation buttons of the game are easy to understand					
14	Consistency of the game's use of icons as navigation buttons					
15	Suitability of the animation used in the game					
16	Accuracy of presentation of the game's audio replacement writing					
17	Suitability of game use with material					
18	Accuracy of the game background selection					
19	Consistency of the game color use					
Multimedia Design Principles						
20	Presentation of game content using more than one medium					
21	Presentation of game content using images, words, and animations simultaneously					
22	Presentation of game content non-excessive					

Comment and Suggestion:
…………………………………………………………………………………………………
..…………………………………………………………………………………………………..

F. CONCLUSION

In terms of media aspects, the Arithmetic-CT Monkey Game of interactive learning media states:

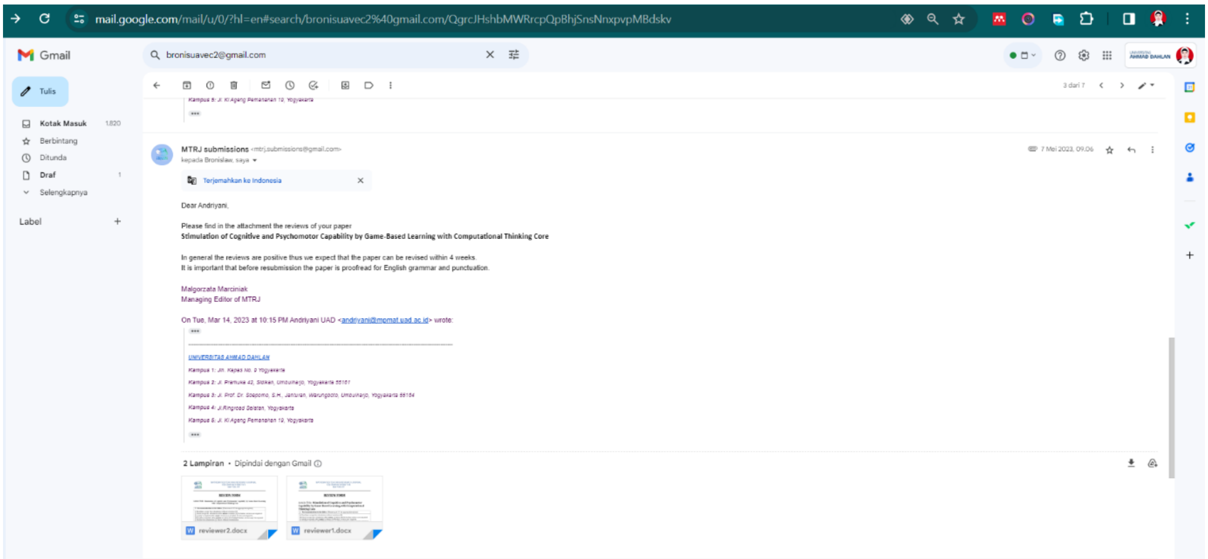
1. Worth
2. Worth using after revision
3. Not worth

Please give a circle sign of the choice of numbers provided as the assessment result.

............, ……………… 2022
Validator,

………………………………......

Pada tanggal 7 Mei 2023, editor mengirimkan perlunya revisi artikel sesuai saran dua reviewer pada tahap 1. Secara umum hasil review positif sehingga editor berharap artikel dapat direvisi dalam waktu 4 minggu. Dan editor menyampaikan agar penulis perlu mengoreksi kembali tata bahasa dan tanda baca bahasa Inggris.



Hasil review kedua reviewer adalah sebagai berikut.

MATHEMATICS TEACHING RESEARCH JOURNAL
City University of New York
New York, NY

REVIEW FORM

Article Title: Stimulation of Cognitive and Psychomotor Capability by Game-Based Learning with Computational Thinking Core

❖ **Recommendation to the Editor** (Please mark "X" for appropriate option)
( ) Excellent, accept the submission without revisions (5) ( ) Good, accept the submission after **minor** revisions (4) No further reviews are required (X) Likely acceptable after **major** revisions (3) Further reviews are required. () Possibly acceptable after **serious** revisions (2) Multiple further reviews may be required ( ) Decline the submission (1) Reject without resubmission

The editor will forward the section below to the author/s

❖ **Evaluation** (Please evaluate various aspects of the manuscript by grades 1-5)	
5=excellent, 4=good and needs minor improvements, 3=average and needs major improvements, 2=below average and needs serious improvements, 1=unacceptable	
Items	**Grade brief description**
Contribution to existing knowledge What is the paper about? Does it propose a new idea, a new approach? How does it fit in the MTRJ mission in terms of classroom involvement and research involvement? Who is the possible audience?	The author developed a game for understanding connection between multiplication and addition. This is a practical assignment that fits in MTRJ mission. Educators who wish to develop similar games may be interested in reading the paper, in particular, learning how to validate such a game.
Readability and language Does the paper need proofreading and help with English?	Some typos are present in the paper, for example, in the introduction "*researcher' interest*" probably should be "*researchers' interest*". The paper needs proofreading for grammar and spelling.
Motivation or justification Why is the didactic proposal made? The research problem or other studies of similar characteristics are presented.	The game is developed to address students needs for learning that resembles playing.
Adequacy of literature review Motivation for the investigations and placing the work in the existing knowledge	The literature review is exhausting.
Soundness of methodology How does the proposal improve students'	Methodology appears reasonable. The procedures are clearly described.

learning experience? Is the methodology, the procedures, the source of the data collection, and analysis clearly stated (sample size, characteristics, qualitative or quantitative or mixed, etc.)? Evidence of the development of the proposal in the classroom together with all materials and practical guidelines necessary for repeating the experiment by other researchers. Are students' answers and teachers' comments included in the submission?	The questionnaire is attached. Students' answers are digital thus not included. The paper contains the screenshots with feedback for incorrect and correct answers.
Results and Conclusions Clear connection among the goals, the literature review and the conclusions. Analysis of an overall perspective of the development of the activity. Difficulties during the implementation and possible remedies.	Included

❖ **Strengths**

The topic is very timely since playing and gaming is probably the future of education, especially for young children.

❖ **Weaknesses**

The paper needs proofreading for spelling, grammar and wordy sentences.

❖ **Suggestions to the Author/s**

The paper should be placed in the new journal template (can be found on the journal webpage).

In Picture 1 (which should be properly labeled as Figure 1) the meaning of the horizontal axis is unclear.

What is the reasoning for using monkeys, apples, and bananas?

Please return the form to the journal editor

MATHEMATICS TEACHING RESEARCH JOURNAL
City University of New York
New York, NY

REVIEW FORM

Article Title: **Stimulation of Cognitive and Psychomotor Capability by Game-Based Learning with Computational Thinking Core**

Recommendation to the Editor (Please mark "X" for appropriate option)
( ) Excellent, accept the submission without revisions (5) (X) Good, accept the submission after **minor** revisions (4) No further reviews are required ( ) Likely acceptable after **major** revisions (3) Further reviews are required. ( ) Possibly acceptable after **serious** revisions (2) Multiple further reviews may be required ( ) Decline the submission (1) Reject without resubmission

The editor will forward the section below to the author/s

Evaluation (Please evaluate various aspects of the manuscript by grades 1-5)	
5=excellent, 4=good and needs minor improvements, 3=average and needs major improvements, 2=below average and needs serious improvements, 1=unacceptable	
Items	**Grade brief description**
<u>Contribution to existing knowledge</u> What is the paper about? Does it propose a new idea, a new approach? How does it fit in the MTRJ mission in terms of classroom involvement and research involvement? Who is the possible audience?	This paper focuses on the utilization of digital game interactive media as a supportive tool for game-based learning. It aligns perfectly with the mission of MTRJ, as the author employs a digital game to aid students in developing a conceptual understanding of multiplication as repeated addition.
<u>Readability and language</u> Does the paper need proofreading and help with English?	The article contains minimal typographical errors.
<u>Motivation or justification</u> Why is the didactic proposal made? The research problem or other studies of similar characteristics are presented.	The didactic proposal is formulated in response to the prevalent issue of students lacking a comprehensive understanding of multiplication as repeated addition, often resorting to mere memorization of the multiplication table.
<u>Adequacy of literature review</u> Motivation for the investigations and placing the work in the existing knowledge	The paper frequently cites references that are relevant to its content and are seamlessly integrated into its body.
<u>Soundness of methodology</u>	The author has provided practical guidelines that are crucial for other researchers to

How does the proposal improve students' learning experience? Is the methodology, the procedures, the source of the data collection, and analysis clearly stated (sample size, characteristics, qualitative or quantitative or mixed, etc.)? Evidence of the development of the proposal in the classroom together with all materials and practical guidelines necessary for repeating the experiment by other researchers. Are students' answers and teachers' comments included in the submission?	replicate this study. The digital game was accompanied by screenshots with English translations, making it accessible to a broader audience. Additionally, the study involved basic data analysis of the students' responses, which helped to further understand the impact of the digital game on their learning.
Results and Conclusions Clear connection among the goals, the literature review and the conclusions. Analysis of an overall perspective of the development of the activity. Difficulties during the implementation and possible remedies.	Based on data analysis of the students' responses to the digital game developed by the author, the conclusion drawn is clear and supported by the study's findings. However suggestions to improve the conclusions are provided.

Strengths

In this research evaluations were carried out through qualitative and quantitative data analysis.

This study recognizes Computational Thinking as a vital tool for teaching mathematics.

The author employs visualization as a crucial tool for teaching mathematics through the digital game presented.

Weaknesses

The article has minimal typographical errors.

Suggestions to the Author/s

On page 8 explain the meaning of "Tahap Desain".

Figure 2. Digital Game Use Case Diagram needs to be translated into English completely.

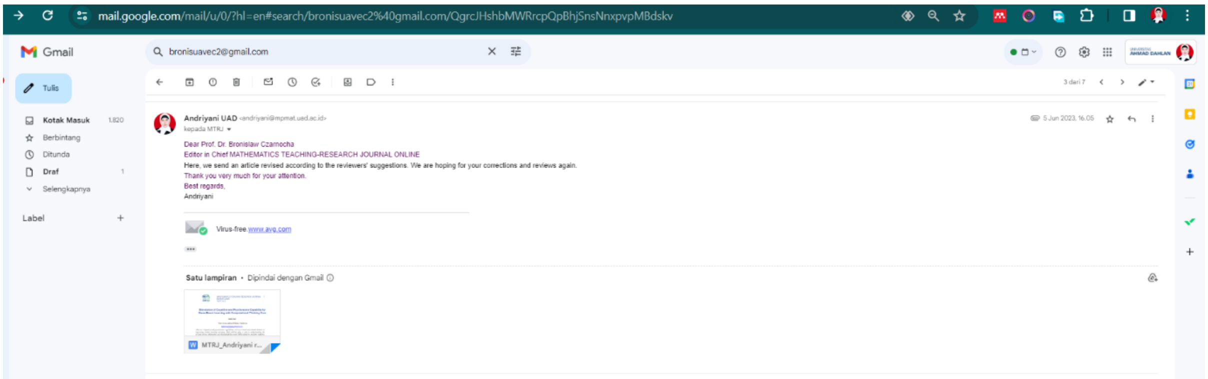
On page 24 fix "so the students easier to understand a learning situation", "easier" is not a verb. It is actually the comparative form of the adjective "easy." The verb form of "easy" is "ease." For example, you can say, "He eased the burden" or "She eased into the new routine."

In the conclusion the word "proven" is too "strong", Change "Therefore, digital games are proven to solve contextual multiplication problems that were previously difficult for students due to their lack of understanding of the multiplication concept." For something like this: "Hence, digital games have been shown to effectively address contextual multiplication problems that previously posed challenges to students due to their limited grasp of the

multiplication concept." Change "With core computational thinking content, digital games are proven to help with cognitive development tasks and psychomotor enhancement, represented by increasing each level. So that students are conditioned in the mode of 'learning by gaming.' The students' responses have also proven that the core of computational thinking increases their interest in learning multiplication." For something like this: By incorporating essential computational thinking content, digital games have been demonstrated to facilitate cognitive development tasks and enhance psychomotor skills, exemplified by progressive level advancements. As a result, students become accustomed to a "learning by gaming" approach. Furthermore, the students' feedback has provided evidence that the core of computational thinking heightens their enthusiasm for learning multiplication. In general, in the conclusion avoid using the word "proven".

Please return the form to the journal editor

Pada 5 Juni 2023 penulis kembali mengirimkan hasil revisi artikel sesuai saran kedua reviewer sebagai berikut.



Artikel yang direvisi dan dikirimkan pada editor pada tanggal 5 Juni 2023 adalah sebagai berikut.

Stimulation of Cognitive and Psychomotor Capability by Game-Based Learning with Computational Thinking Core

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Abstract: Cognitive and psychomotor capabilities are two critical interrelated abilities in improving student learning outcomes. Both abilities play a role in understanding the process of new information and developing fine motor skills related to students' cognitive processes and physical activity. Because of this, schools train these two abilities to be equipped in solving mathematical problems such as basic arithmetic. This phenomenon has increased researcher' interest in choosing learning strategies oriented toward both achievements. However, few previous studies haven't much discussed the design of learning strategies oriented toward successfully integrating these two capabilities due to the lack of interest in learning post-pandemic. Moreover, these studies only focus on calculations in arithmetic operations, not the conceptual understanding of operations. Therefore, this study aims to describe the development of learning media designs that accommodate student activities through game-based learning to stimulate cognitive and psychomotor capability in conceptual arithmetic operations, especially multiplication. The learning framework uses core computational thinking integrated with interactive game-based learning. The research method used is ADDIE which contains five stages of development with data collection techniques through validation questionnaires, student responses, and tests. In the learning process, students apply their cognitive ability to understand the concept of operations effectively and encourage efficient problem-solving skills. The study results show that game-based learning media is valid according to experts and practical according to student responses. From the students' responses, it is known that the development of game-based learning can stimulate cognitive and psychomotor capability in solving contextual problems that were previously an obstacle for students through 'learning by gaming'.

Keywords: *Cognitive, Computational-Thinking, Game-Based Learning, Psychomotor*

INTRODUCTION

Cognitive and psychomotor capabilities are essential components in student learning and development which are a challenge for educators and experts in education. According to Begam & Tholappan (2018), a person's cognitive ability refers to his thinking/mental process continuity.

This cognitive process involves acquisition, processing, and applying knowledge, including attention, memory, reasoning, understanding, and problem-solving. On the other hand, according to (Simpson, 1972), psychomotor capability refers to students' physical movement skills, including coordination, agility, and fine motor skills, that require practice with measurements based on aspects of speed, accuracy, procedures, and implementation techniques. With this psychomotor capability, students explore phenomena, conceptualize the ideas involved, and apply concepts to new situations (Karplus & Butts, 1977). In the context of learning with abstract objects such as mathematics, the processes contained in this psychomotor ability are interpreted by gaining direct experience and providing opportunities for students to manipulate objects and tools. More clearly, (Piaget, 1029) said that students' physical experience in learning mathematics could be obtained by giving students opportunities to explore mathematical concepts through the concrete physical experience before moving on to more abstract representations. These experts generally show that cognitive and psychomotor capabilities play a significant role in learning mathematics, especially in active exploration and reflection activities.

In the midst of this significant role, educators have the main challenge of identifying and overcoming differences in cognitive and psychomotor capability that each student has. Given the unique differences in the nature and characteristics of these two abilities, educators need to provide personalized instruction and support to meet the learning needs of each student. In addition, educators also need to find strategies to help students develop their cognitive and psychomotor capabilities on an ongoing basis. This is what requires the teacher's focus on creating interesting and challenging learning experiences for students to follow. Teachers need to design lessons that can stimulate these two capabilities, especially in solving real-world problems. Stimulus in problem-solving needs to be accompanied by providing opportunities to train students' physical skills in direct practical activities. Moreover, the Corona Virus Pandemic that hit the world last year had an impact on reducing the level of active involvement of students in learning and their study results (Haryani & Hamidah, 2022; Onyema et al., 2020; Orlov et al., 2021).

A decrease in student involvement in learning can also be caused by a lack of their intrinsic or extrinsic motivation (Fatimah & Saptandari, 2022) because there is a reasonably close relationship between motivation and student learning involvement (Saeed & Zyngier, 2012). This involvement affects students' academic outcomes (Finn & Zimmer, 2012). Hence an effective learning strategy is needed to increase student learning motivation, such as digital game-based learning, which also functions to encourage students' willingness to learn and self-awareness in both formal and informal learning contexts (Owston, 2009; Yang & Chen, 2010; Yien et al., 2011). This positive implication raises a lot of attention given to the relationship between digital games and the education field (Chiang et al., 2011).

The variety of games implemented in learning makes developing game application models more adaptive and flexible to be designed as learning media based on the material presented (Hays, 2005; Papoutsi & Drigas, 2016). Several studies on multiplication-themed educational games have been carried out, including research on Android-based arithmetic games by Amrizal & Kurniati, 2016, research on mobile educational games for multiplication calculations based on the horizontal method with Html 5 and Phone Gap by Ricky (2013), and research on designing learning game application for 3rd-grade math calculation operations using unity by Kristina & Talitha (2021). This research is related to developing educational games that contain multiplication calculations through fast multiplication counting activities.

In this study, a game-based multiplication concept learning will be designed with the help of digital game applications whose accessibility is carried out on student androids. So students aren't only trained to count fast but understand the concept of multiplication, whose construction is formed from repeated addition. In learning arithmetic, students need adaptive skills, which are functional academic skills in the basic operations of addition, subtraction, division, and multiplication (Polspoel et al., 2019). These adaptive skills are needed for everyday life because they involve communication, life and social, work, and functional academic skills such as reading, writing, and arithmetic (Ainsworth & Baker, 2004; Hodapp, 2002). Thus, learning arithmetic requires both psychomotor and cognitive abilities, especially if arithmetic problems are in the context of students' everyday problems. But in fact, there are still many students who are afraid of learning mathematics because it is considered difficult and complex (Laurens et al., 2018).

The results of an initial study conducted by researcher in November 2022 in three elementary schools from the Municipality of Yogyakarta and Bantul Regency show that grade III students still do not understand the concept of multiplication operations and often have difficulty solving contextual problems, especially multiplication abstraction which correlates with modeling problems and the procedure for solving it. Meanwhile, the teacher still uses the rote method to teach multiplication. Students' lack of understanding of multiplication often causes boredom, laziness, and a lack of interest for students in learning multiplication. This is similar to Thai & Yasin (2016) research on multiplication teaching methods. Therefore, we need alternatives in thinking processes and developing problem-solving strategies, including computational thinking (Wing, 2006).

Along with technological advances in recent years, computational thinking has become an important topic in various fields of life (Lindberg et al., 2019). Various countries have attempted to promote computational thinking education in schools, universities, industry, and government (Lin et al., 2020). A large number of researchers attempt to identify students' computationalthinking abilities. For example, research by Yadav et al. (2017) and Denning (2017) who researched the development of computational thinking-based teaching guidelines for students; research by Shute et al. (2017) regarding the design of a model for assessing student computing learning outcomes; as well as research by Sullivan & Bers (2018) and P´erez-Marín et al. (2020) on computational thinking-based learning performance. These studies are clear evidence that computational thinking has become a basic skill needed in learning in this digital era.

Based on the problems experienced by students in learning the concept of multiplication operations above, the researcher considers it necessary and important to design game-based learning with the help of interactive learning media that can stimulate students' cognitive and psychomotor capabilities. The developed interactive learning media is a digital game filled with computational thinking core to help students understand the concept of arithmetic operations, especially multiplication. By integrating computational thinking cores, students learn to understand the concept of multiplication operations by solving contextual problems presented in the digital gamerole, position, or function at your institution.

LITERATURE REVIEW

Cognitive and psychomotor capabilities have an important role in the formation of adaptive skills, which are the main elements of the elementary school mathematics curriculum (National Math Panel, 2008) and play a fundamental role in solving more complex mathematical problems (Juliana & Hao, 2018; Prendergast et al., 2017). Therefore, teachers need to train these abilities to students for mastery of mathematical concept, including the arithmetic concepts. Knowledge of students' ideas of a basic arithmetic operation can be achieved if students understand the concept of operations and the links between operations (Rahman et al., 2017).

Cognitive cability is an ability related to a person's thinking activity in receiving, processing, and transmitting the information obtained (Basri, 2018; Darouich et al., 2017). Cognitive cability is often associated with acquiring information for the short term (Darouich et al., 2017), and the long term is seen as an adaptive function of humans to the cultural, social, and emotional environment (Anderson, 1994). In its development, this cognitive ability is significantly influenced by students' thinking activities (Basri, 2018). In mathematics learning, the completion of mathematical tasks is a basis for starting and practicing various students' mathematical thinking activities, including thinking about solving mathematical problems and understanding mathematical content so that the thinking operations that occur become part of students' conceptual understanding and procedural understanding (Swanson & Williams, 2014). Developing a person's cognitive abilities directly relates to developing other psychomotor, social, affective, and adaptive skills.

Psychomotor cability is the ability to perform motor-physical movements related to learning outcomes in cognitive activity (Murrihy et al., 2017). Yet the link between motor coordination and learning outcomes is largely neglected in the psycho-educational domain. The results of research related to this have been widely published, with the results of a statistically significant relationship between motor difficulties and academic achievements such as language, reading, spelling, and arithmetic (Archibald, L., & Alloway, 2008; Lopes et al., 2013). This shows that cognitive and psychomotor abilities are closely related to achieving meaningful mathematics learning goals. According to Vallori (2014), meaningful learning has important principles that must be met, namely:

(a) Open work enables all learners to learn;
(b) Motivation helps improve the classroom environment, making learners interested in their tasks;
(c) Means must be related to the environment of learners;
(d) Creativity strengthens imagination and intelligence;
(e) Concept mapping helps learners to link and connect concepts;
(f) Educational curricula must be adapted considering learners with special needs.

These six important principles show the need for teachers to choose fun learning strategies that can accommodate various characteristics of the student's environment so that students can receive complete information by associating new information with relevant concepts contained in students' previous cognitive structures. One effective learning strategy to accommodate these needs so that students' learning motivation with fun learning is digital game-based learning (Owston, 2009; Yang & Chen, 2010; Yien et al., 2011). The implication of digital educational games is as a learning tool that significantly influences motivating users in a fun learning atmosphere (Kirriemuir & McFarlane, 2004). These educational games tend to arouse curiosity and challenge users to actively explore games until they feel happy when they can finish the game well so that students are motivated and enjoy learning through the game (Chen et al., 2007; Hong et al., 2009; Moon & Baek, 2009).

Games are designed with various systematic, visual, and kinetic activity loads to stimulate students' skills and awareness of specific knowledge (Besgen et al., 2015; Shuqin, 2012). Various student skills are oriented towards achievement through integrating games into learning, including learning basic mathematics such as basic arithmetic, especially multiplication. Through games, students are trained to make decisions by controlling objects in the game for a specific purpose designed in a system or program (Jason in Aprilianti et al., 2013).

Regarding selecting learning strategies that can increase student learning motivation and develop the skills needed, the education system has integrated Information and Communication Technologies (ICT) in implementing quality improvement and the quality of student learning in schools (Malik et al., 2017). By utilizing ICT in learning, students can become active learners through dynamic and collaborative learning so that the interactivity and communication of learning increase. In learning that integrates ICT, students are stimulated to use their ability to think logically, systematically, and skillfully when making the right decisions facing two different possibilities (Munir, 2014).

An alternative learning strategy that follows the achievement of this stimulus and has a wide area of application to solve problems is a computational thinking approach (Malik et al., 2017). Furthermore, Malik et al. (2017) explains that in a computational thinking approach, students do not have to think like computers but think about computing which includes the ability to: (1) formulate problems in the form of computational problems; and (2) develop a good computational solution (in the form of an algorithm) or explain why no suitable solution has been found. According to Ioannidou (2011), the computational thinking approach contains the cores of (1) decomposition, which is the ability to break down complex tasks (problems) into smaller, more detailed tasks; (2) pattern recognition, which is the ability to recognize general similarities or differences which will later help in making predictions; (3) generalization of patterns and abstractions, which is the ability to filter out information that is not needed and draw generalizations from the information needed so that one can use that information to solve problems. Similar problem; (4) algorithm, which is the ability to arrange steps to solve a problem; and (5) debugging, which is checking or re-checking every step of problem-solving to ensure the process is correct. If it is incorrect, then exploring why the appropriate solution was not found is necessary.

METHOD

This study aims to describe the development of instructional media designs that accommodate student activities through game-based learning to stimulate cognitive and psychomotor capability in conceptual arithmetic operations. The procedure for this research study consists of an analysis stage, a design stage, a development stage, an implementation stage, and an evaluation stage (Branch, 2009; Sugiyono, 2019). The researcher chose this model to develop media learning in digital games because it facilitates constructing students' knowledge and skills in instructional guided learning plans. In addition, the ADDIE model is also devoted to solving problems related to gaps due to students' lack of knowledge and skills. Furthermore, the ADDIE model contains generative processes (stages) by applying concepts and theories to a particular context.

In the analysis stage, the researcher identified the probable causes of incongruity/differences between learning outcomes and theories, concepts, or other learning problems in the multiplication concept material. Identification is based on experiences, preferences (tendencies), abilities, experiences, and student motivation during learning. In addition, the researcher also identified the resources needed during the development process, including the curriculum used, the concept of multiplication, the learning models or methods used, teaching materials, facilities, learning environment, technology, and the characteristics of the students involved during the development process. To determine the extent to which the characteristics of the students at the research site, the researcher conducted written tests at three Elementary Schools to measure students' understanding of multiplication concepts presented through contextual problems.

At the design stage, the researcher designs a product that will be developed based on the analysis results from the previous stage and begin with selecting media which is digital games with core computational thinking to stimulate cognitive and psychomotor capability. Next, the researcher prepares the initial design of the media by making a picture or representation of the interactions between the system and its environment or making a model of the behavior of the information system in the form of a diagram until it produces a product blueprint. At this stage, the researcher also formulates specific, measurable, applicable, and realistic learning objectives based on appropriate learning strategies.

In the development stage, the researcher developed an initial prototype according to the blueprint designed in the previous stage, including developing test instruments, validation questionnaires, and student responses to be validated by validators who are evaluation experts. Likewise, the initial prototype of the media was also validated by the validator, an expert in the field of learning media, and an expert in mathematics learning materials. Furthermore, the researcher revised all the development results according to the suggestions of the validators, each consisting of three validators, so the digital game was declared valid and ready to be implemented in small and large classes.

At the implementation stage, the researcher makes concrete steps to implement the learning system that was developed. Here the researcher tested game products in small trial classes of 10 third-grade students at an Elementary School in the District of Yogyakarta. The tryout was carried out for three meetings, and then the researcher gave a response questionnaire to students as a product user. The researcher will use the results of the student responses to revise the product. The researcher again tested the product on third-grade students from four classes at three elementary schools. Of the three elementary schools, two are located in Bantul Regency, and one is from Yogyakarta Municipality, which has two study group classes. To find out the responses of the large trial classes, the researcher distributed response questionnaires whose results were used as a basis for determining the practicality of the game products that had been developed.

At the evaluation stage, the researcher continuously evaluates, beginning from the initial development stage, for the requirement of revision, until final product development. Evaluation is carried out through qualitative and quantitative data analysis. Based on the needs analysis results in the first development stage, the researcher analyzed the quantitative data, which was the result of the test to find out the characteristics of the students regarding their understanding of the concept of multiplication in contextual problems. The validation results at the development stage and field trials at the implementation stage were also analyzed for product revision materials. Qualitative data from input, suggestions, and expert criticism will be interpreted as a basis for gradual revisions for better media development. While the quantitative analysis of the results of validation questionnaires and student response questionnaires was carried out to assess the quality of the eligibility of the media in terms of validity and practicality. All stages of this evaluation are aimed at the feasibility of the final product in terms of content, design, and user-friendliness.

The subjects used in this study were ten third-grade students from an Elementary School in the District of Yogyakarta as small class trial subjects, 123 third-grade students from three Elementary Schools, two of which were located in Bantul Regency and one school from the

District of Yogyakarta. This one school where the large class trial was held had two study group classes, so there were four trial classes. Data collection techniques consist of test and non-test techniques in questionnaires to validate products and student response questionnaires. The data analysis technique used in this study was in the form of qualitative and quantitative data analysis. Quantitative data analysis was carried out by calculating the mean score of students' conceptual understanding test results in solving contextual problems. In addition, the researcher also calculated the mean validation score and the mean student response score, which was then followed by converting the mean score into the product validity and practicality category, which refers to the validity and practicality criteria guidelines on five Linkert scales successively - respectively consisting of criteria: 'not good' for a score of 1; 'Less Good' for a score of 2; 'Good Enough' for a score of 3; 'Good' for a score of 4; and 'Very Good' for a score of 5 (Widoyoko, 2018). The product is said to reach validity and practicality standards if it reaches the minimum "Good" criteria.

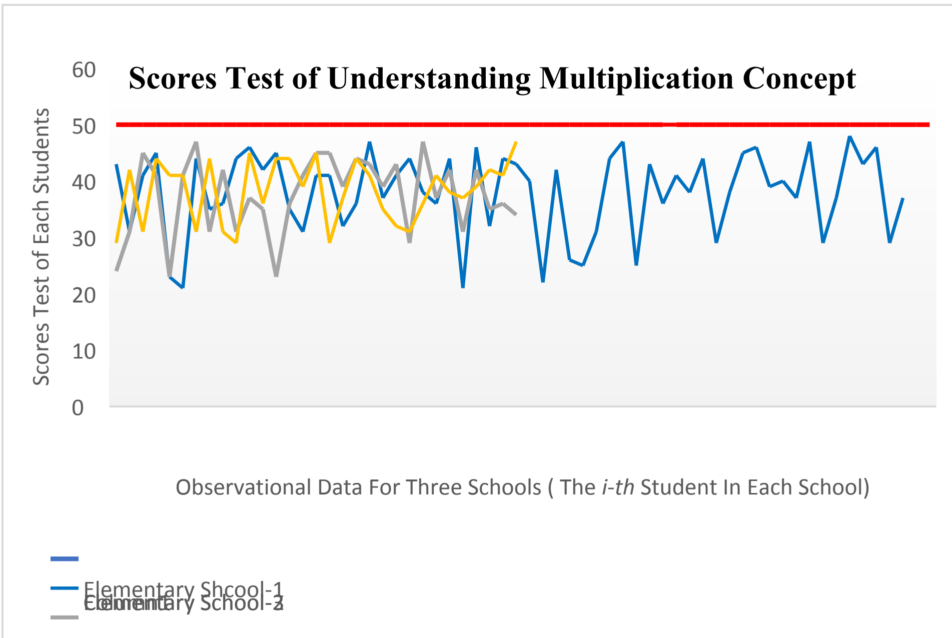
RESULTS

1. Analysis Stage

At this stage, the researcher identifies the curriculum that will be used as a guideline for developing digital games concerning the curriculum guidelines used by the school. Next, the researcher assessed the material related to the concept of multiplication. In this case, the researcher interviewed mathematics teachers about the application of the curriculum used by schools to teach multiplication material in class. Based on the results of interviews with the mathematics teacher, it is known that the teacher delivers multiplication material limited to calculating two or more integers with an allocation of time per week is 4×45 minutes or two meetings with an allocation each session of 2×45 minutes. To check student understanding, the teacher added one meeting in the form of a written test. The time allocation, which was only 2-3 sessions, turned out to cause problems for students, where students memorized multiplication more and were oriented towards counting skills only.

The interviews continued exploring the teacher's teaching methods in the expository form. The teacher conveys the multiplication of two or more numbers directly, whereas the teacher teaches the meaning of multiplication as a number multiplied according to the multiplier number. Students who find it difficult to accept the abstraction of the multiplication meaning will eventually choose to memorize the multiplication of integer numbers in the range 1-10. All of this was caused by the difficulties he experienced in interpreting the teacher's explanations which tended to lead only to calculating numbers. So that students look less enthusiastic about participating in learning and are unable to solve contextual problems given by the teacher.

In addition to the learning methods used by the teacher, the researcher also conducted interviews about the teacher's teaching materials. The results of the interviews showed that the teacher's teaching materials were books that tended to be textual. This certainly does deficient attract students' interest in learning, which during the Coronavirus pandemic, often carried out online learning and accessed digital learning resources. Therefore, we need an interactive digital learning media that can accommodate their learning needs through new post-pandemic habits. In the initial research, the researcher measured students' understanding by giving contextual problems about multiplication concepts. The results of an analysis of third-grade students from four different classes in three Elementary Schools in Yogyakarta Province show that students' understanding of multiplication concepts is still low, with a mean score below 50 with a maximum score of 100 because they focus more on numeracy skills. The low level of students' understanding of multiplication can be seen in Figure 1 below.



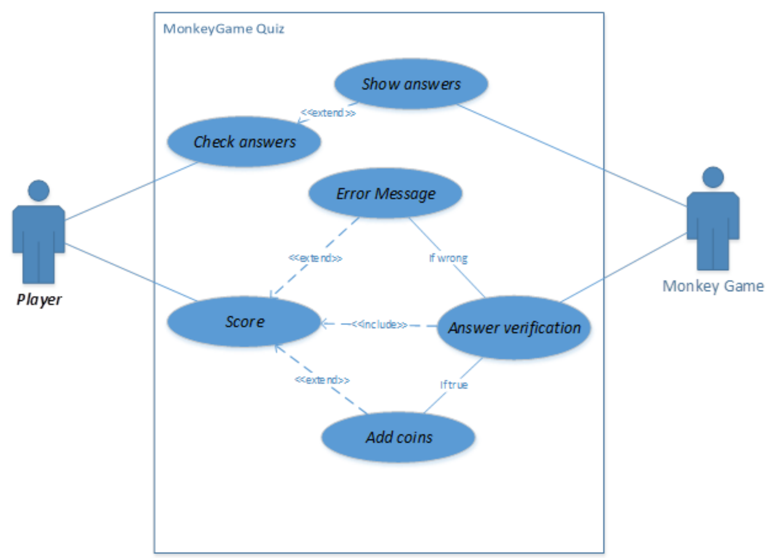
Picture 1. Level of Understanding of the Multiplication Concept

From Figure 1 above, we can conclude that students' cognitive and psychomotor capabilities are less than half the maximum score or less than 50. So on this basis, the researcher intends to develop a digital game with core computational thinking to support learning multiplication concepts. With this game, it is hoped that students can understand the abstraction of multiplication concepts by solving contextual problems that were previously difficult for students to solve.

2. Design Stage

At the design stage, the researcher designs a digital game that will be developed based on the requirement analysis results at the previous stage. From the results of this analysis, the researcher chose digital game media with core Computational Thinking to stimulate students' cognitive and psychomotor capabilities. Furthermore, at the game design stage, researchers began creating use case diagrams that describe or represent the interactions between the system and its environment, as shown in Figure 2 (a)-(b) below.

(a) Main Use Case Diagram

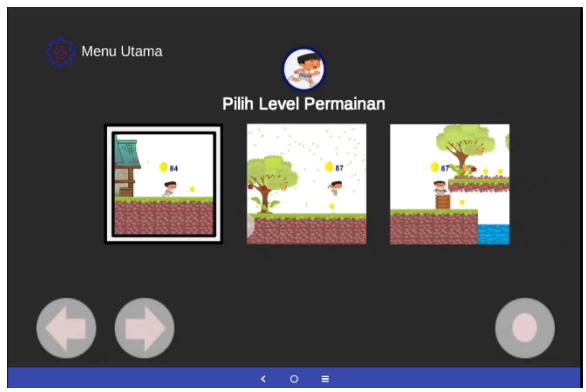


(b) Part Diagram of the Main Use Case Contains Checking Answers and Feedback

Figure 2. Digital Game Use Case Diagram

The researcher uses the Use Case diagram above to define the functional modeling and system operational requirements by determining the scene method used to build the system from the results of the previous application analysis. At this stage the researcher determines a digital game title that contains the concept of multiplication with the name Monkey Game Arithmetic-CT. In this digital game, there is a monkey character. The monkey is the main character of a fable that sticks in the memories of many children in Indonesia because parents often hear it during the golden age of children to stimulate reading and listening activities and improve children's imagination and vocabulary skills. The fable's monkey character represents an agile animal with a lot of sense and likes to eat fruits, especially bananas and apples, often found in the monkey's natural habitat. Then the researcher formulated the digital games concept according to the achievement orientation of students' cognitive and psychomotor capability, which were leveled with levels 1 to 3 on the menu as presented in Figure 3 (a)-(b) below.

(a) Game Main Menu



(b) First Level to Third Level Game

First column translation:

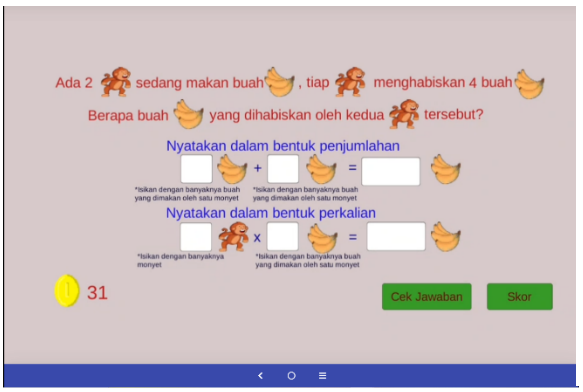
Main Menu
User Manual
Picture Hint
Choose a Level
Back
About
Quit

Second column translation:

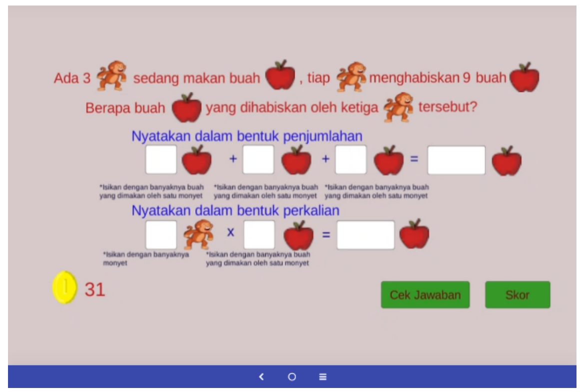
Choose a Game Level

Figure 3. Game Leveling on the Main Menu

The basis of game leveling refers to the complexity of the contextual problems presented at each level so that each level of the game has contextual problems with different levels of difficulty solving, as shown in Figure 4 (a)-(c) below.



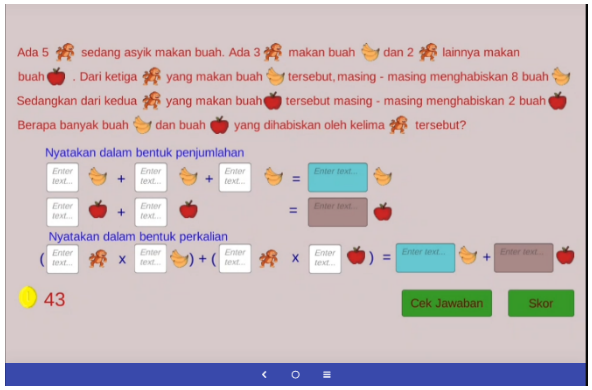
(a) First Level



(b) Second Level

Column Translation:

There are two eating , and each eats four . How many did the two eat? *Express in the addition statement* □ + □ = □ *Fill with the number of fruits eaten by one monkey* — *Fill with the number of fruits eaten by one monkey* *Express in the multiplication statements* □ × □ □ = *Fill in the number of monkeys* — *Fill with the number of fruits eaten by one monkey* *Check answers* *Score*	*There are three eating , and each eats nine . How many did the three eat?* *Express in the addition statement* □ + □ + □ = □ *Fill with the number of fruits eaten by one monkey* — *Fill with the number of fruits eaten by one monkey* — *Fill with the number of fruits eaten by one monkey* *Express in the multiplication statements* □ × □ = □ *Fill in the number of monkeys* — *Fill with the number of fruits eaten by one monkey* *Check answers* *Score*



(c) Third Level

Column Translation:

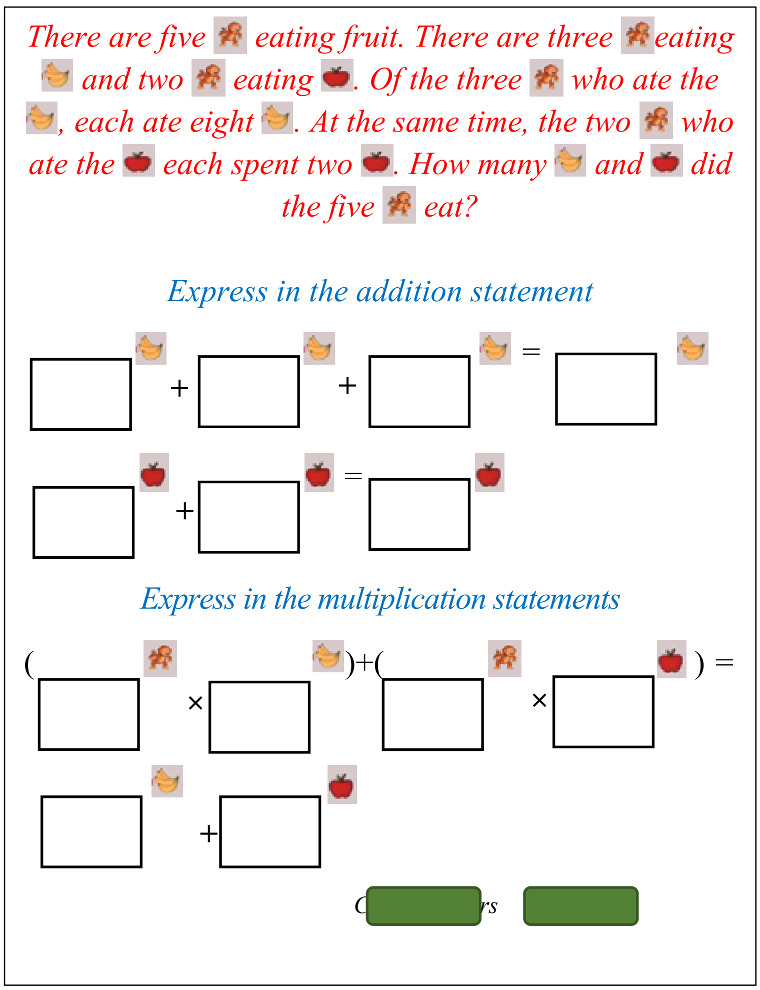
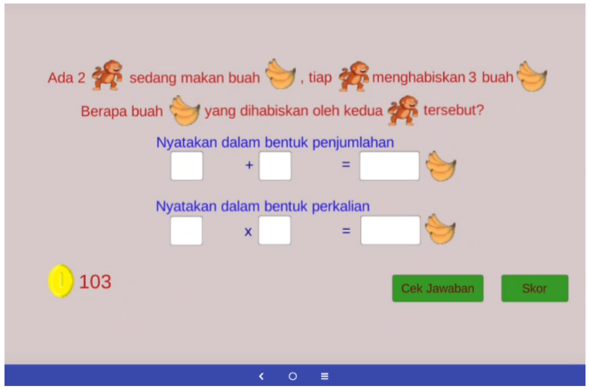


Figure 4. Examples of Contextual Problems at First Level to Third Level

Computational thinking core loaded, namely abstraction, algorithm design, pattern recognition, decomposition, and debugging in digital games, is represented in problem-solving activities as presented in Figure 5 below.



Column Translation:

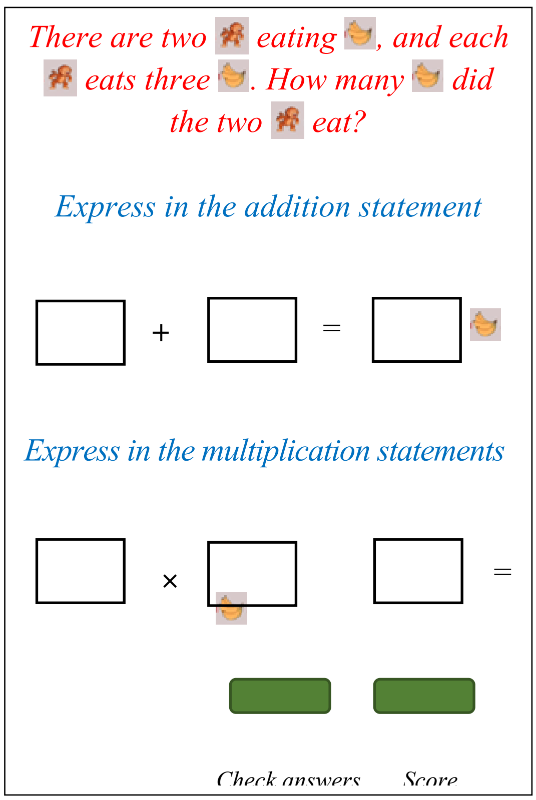


Figure 5. The Abstraction Core of Computational Thinking

Figure 5 shows that students must generalize and identify common cores by filtering out specific details and any needed patterns and ignoring unrelated data to solve the problem. In this game, students must be able to sort out the amount of fruit each monkey ate and the number of monkeys that ate the fruit to fill in each answer box in the addition and multiplication statements. In the game's display, there aren't fruit picture hints or instructions containing information that must be entered in the answer box. So students have to filter the details of the data as their abstraction entity. The core loaded of the algorithm design is presented in the problem-solving steps, as shown in Figure 6 below.

Column Translation:

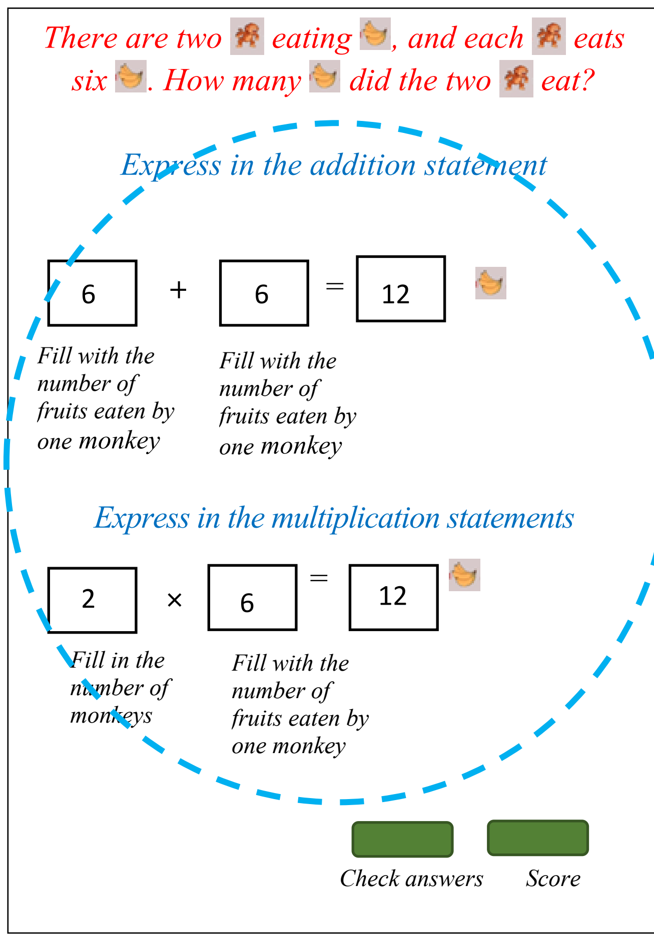
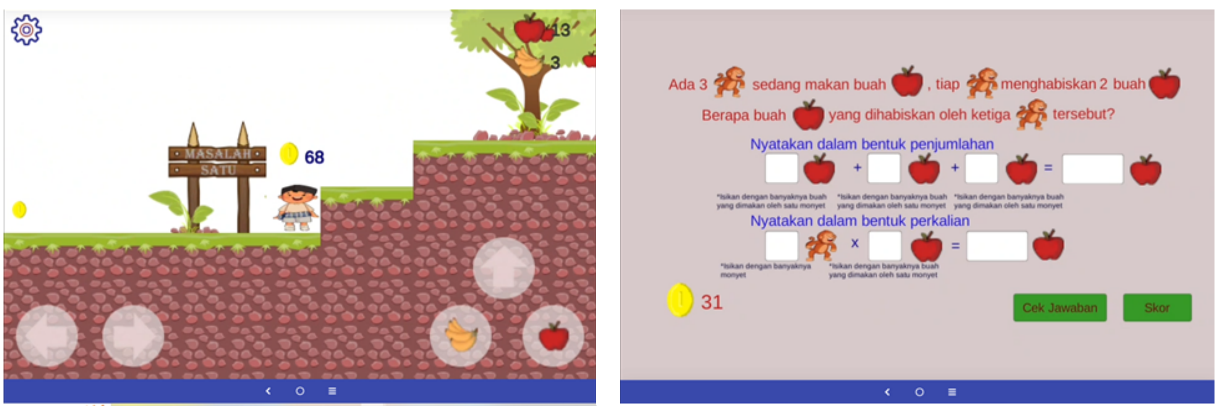


Figure 6. The Algorithm Design Core of Computational Thinking

Figure 6 shows that students must develop logical and systematic problem-solving instructions to solve problems so that other people can use the steps or information to solve the same problem. In this game, in the first step, students must fill in the number of fruits eaten by one monkey in each statement box of the addition model. In the second step, students must fill in the number of monkeys in the first statement box of the multiplication model. Furthermore, students must also fill in the number of fruits each monkey eats in the second statement box of the multiplication model. In the final step, students check their answers by pushing the 'check the answers' button, followed by pushing the 'score' button to check the achievement of the problem-solving score.

The core loaded of pattern recognition is presented in the problem-solving step, as shown in Figure 7 (a)-(b) below.



(a) First Problem and Its Content

Column Translation:

First Problem

There are three eating, and each eats two. How many did the three eat?

Express in the addition statement

☐ + ☐ + ☐ = ☐

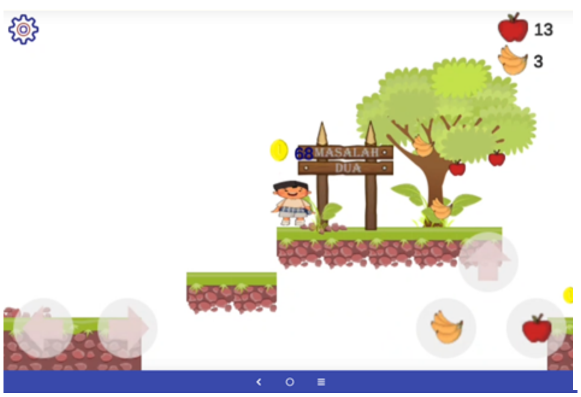
Fill with the number of fruits eaten by one monkey | *Fill with the number of fruits eaten by one monkey* | *Fill with the number of fruits eaten by one monkey*

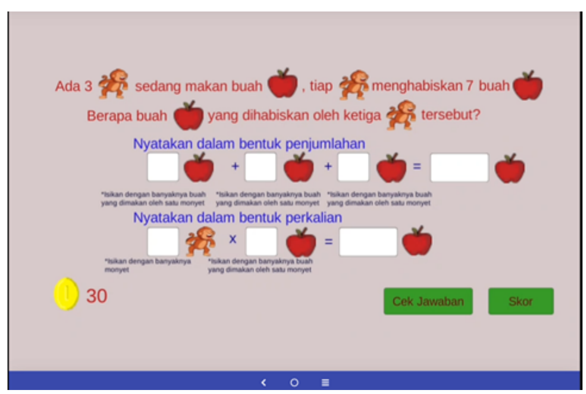
Express in the multiplication statements

☐ × ☐ = ☐

Fill in the number of monkeys | *Fill with the number of fruits eaten by one monkey*

Check answers *Score*





(b) Second Problem and Its Content

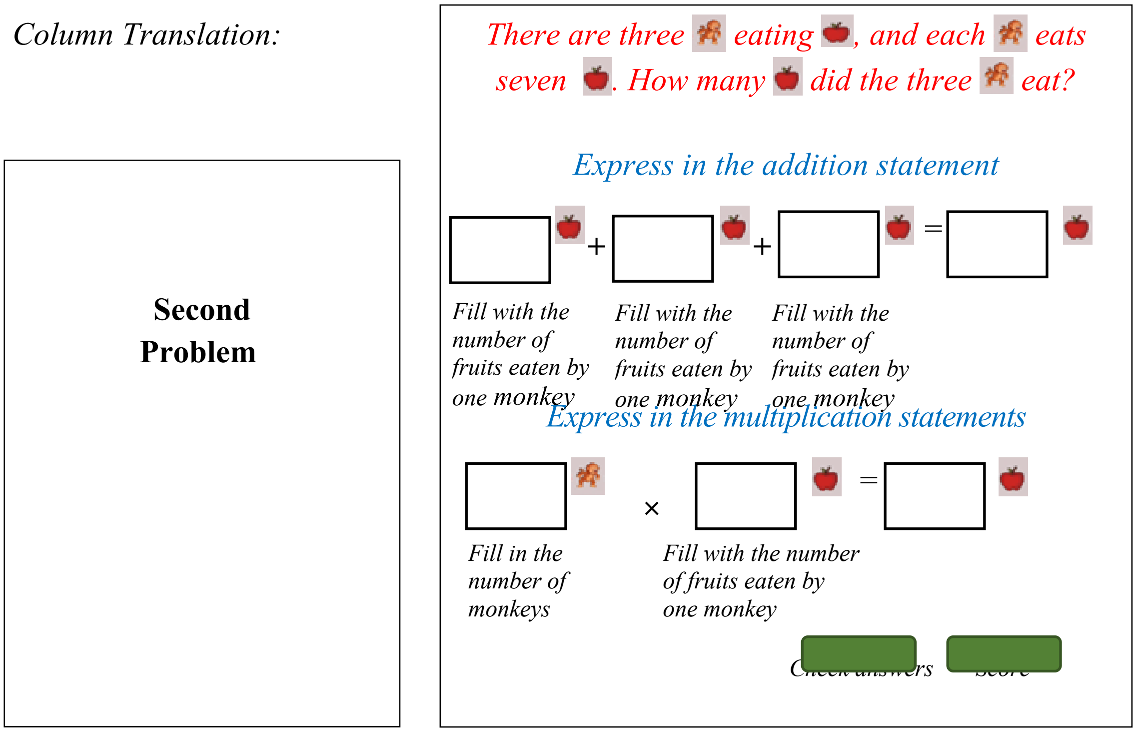


Figure 7. The Pattern Recognition Core of Computational Thinking

Figure 7 (a)-(b) shows that students must be able to see similarities or differences in patterns and methods in the data that will be used in predicting and presenting data to classify problems and provide appropriate solutions. This pattern recognition uses previous experience and prior knowledge as the basis for logical thinking. Then, from this logic, students get new experience and knowledge to solve various identic problems according to patterns they already know. In this game, students must be able to see the data pattern and the regularity of solving the first problem presented, as shown in Figure 6 (a) above. The first problem presents a data pattern about three monkeys eating apples, and each monkey eats two apples. Students were asked to determine how many apples the three monkeys ate.

The second problem is presented using an identic multiplication problem. The second problem shows the existence of three monkeys who are eating apples, and each monkey eats seven apples. Students were asked to determine how many apples the three monkeys ate. To solve the first problem, students design a solving algorithm that begins with applying the concept of repeated addition. Then, they continue with the solution step by applying the multiplication concept related to the previous repeated addition concept. Using the patterns and regularities of the data in the first problem, students design solutions to the second problem by predicting the same steps for solving the two multiplication problems.

The core loaded of decomposition is presented in the problem-solving step, as shown in Figure 8 below.

Figure 8. The Decomposition Core of Computational Thinking

Column Translation:

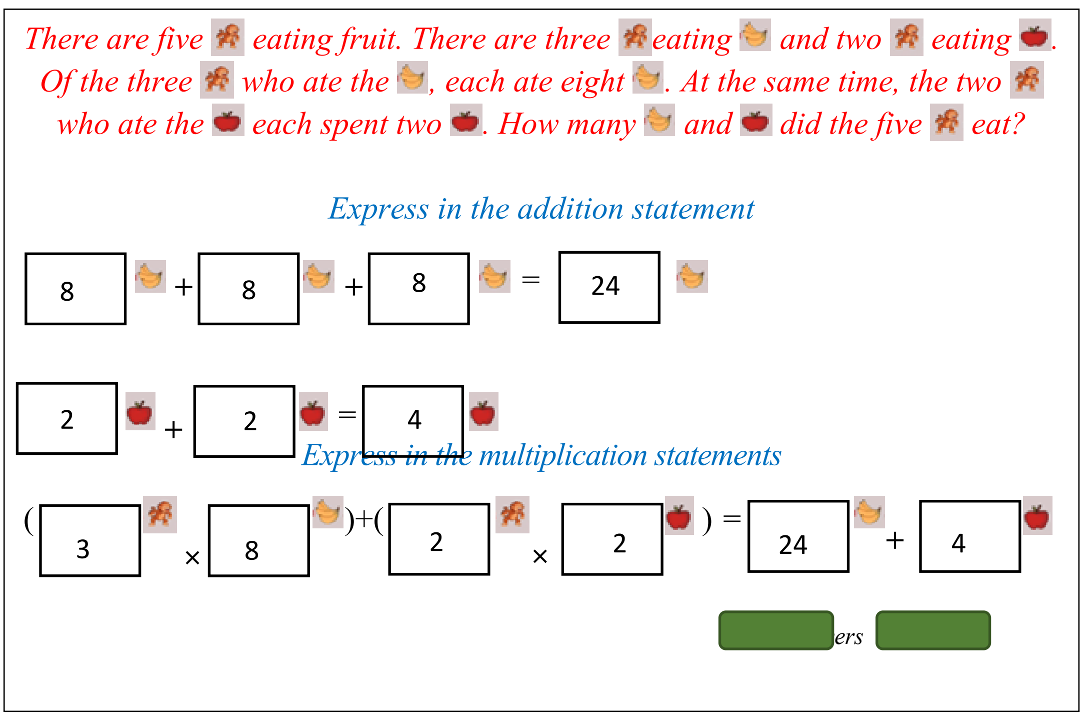
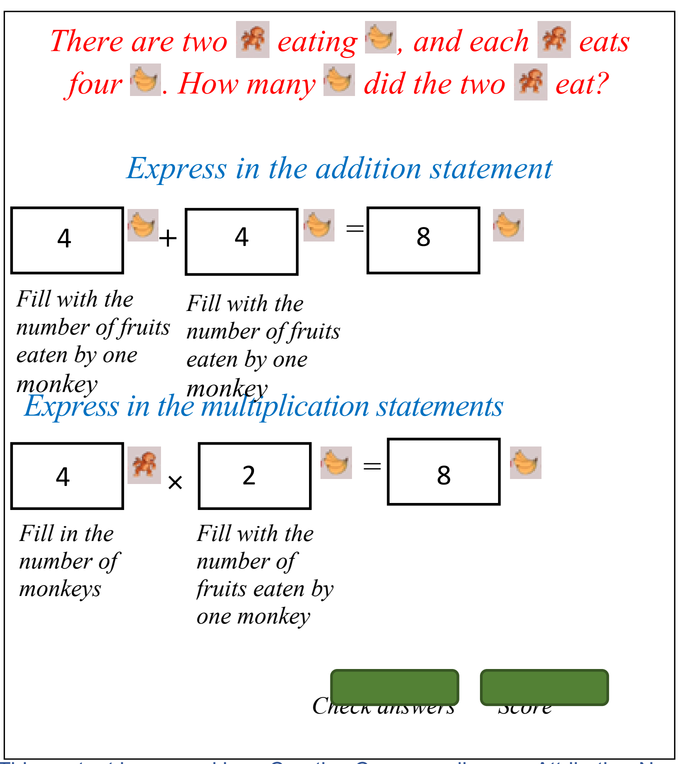
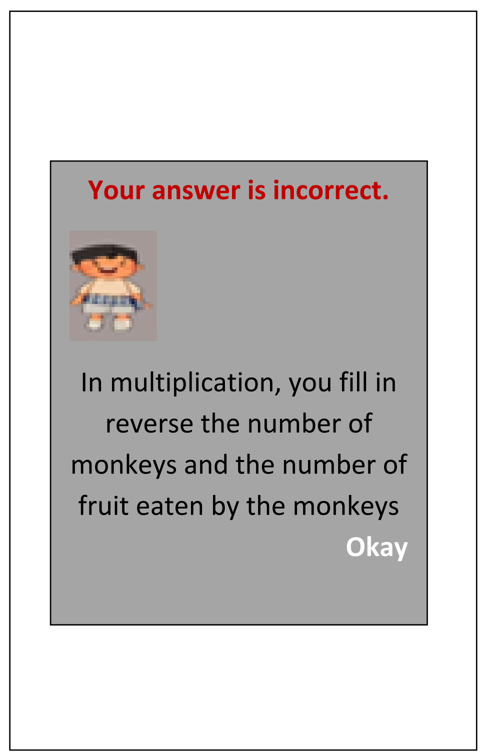


Figure 8 shows that students must be able to break down complex data, problems, or processes into smaller problem that is simple parts. So, if there is a complex problem, it can be more easily solved by breaking down the complex problem into these small parts. In this case, students must be able to break down the problem of the number of bananas and the number of apples eaten by the monkey into two smaller problems, namely the problem of the number of bananas eaten by the monkey and the problem of the number of apples eaten by the monkey separately.

The core loaded of debugging is presented in the problem-solving step, as shown in Figure 9 below.

(a) Problem-solving (b) Result of Recheck





(c) Result of Error Correction from Rechecking Process

Column Translation:

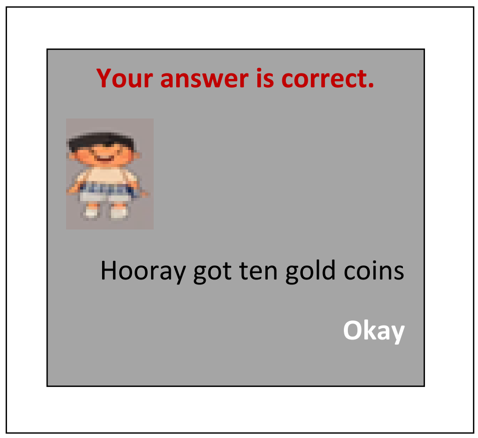


Figure 9. The Debugging Core of Computational Thinking

In Figure 9, it is shown that students must carry out an inspection or process of rechecking each step of problem-solving to ensure the process is carried out correctly. In this game, students must check every step of solving the problem they have done, as shown in Figure 9 (a), to determine whether the process is correct. If students make mistakes while solving the problem, the system will provide feedback in the form of notifications that the student's answers are still incorrect, as shown in Figure 9 (b). The picture states that the student's multiplication form is still wrong, where students fill in the boxes which switch for the number of monkeys that should be filled in with the amount of fruit eaten by the monkeys. Furthermore, students are given a chance to improve their problem-solving and recheck their answers. If the student's answer is correct, the system will provide feedback in the notification that the student gets ten gold coins as a prize for their accuracy in solving problems in the game.

3. Development Stage

This stage begins with an instrument feasibility assessment in the form of a product validation questionnaire in terms of media and material, also a student response questionnaire. Testing the validity of the contents of these three instruments was carried out using expert judgment or reviewing the grid, especially the suitability instruments with the research objectives and the questions. Based on the results of expert judgment, the three instruments are declared valid. Furthermore, the researcher validated the product regarding material substance and media design, carried out by three validators using assessment instruments declared valid by experts. The results of the material substance validation by the three validators are presented in Figure 10 and Table 1 below.

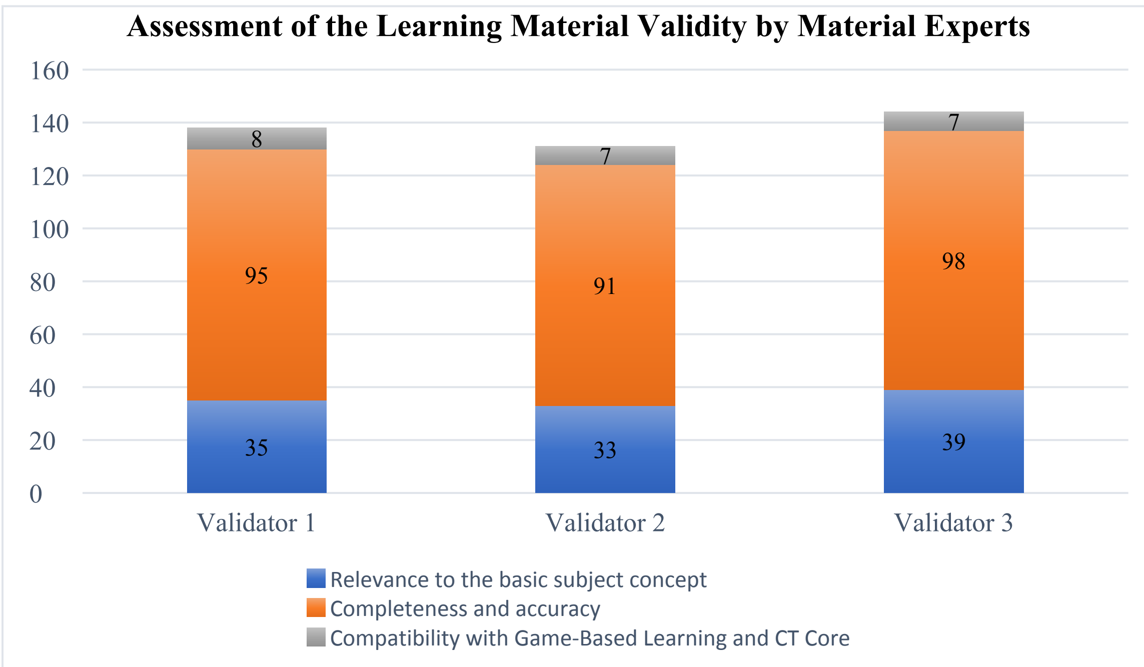


Figure 10. Description of the Assessment Results by Material Experts

Component	Validator-1	Validator-2	Validator-3
Mean	**138**	**135**	**144**
Mean total		**139**	

Table 1: Average Assessment of the Validity of Learning Materials by Material Experts

Based on the analysis of the results of the material expert validation, it is known that the mean score of material validator-1 is 138 in the "Very Good" criteria, the mean score of material validator-2 is 135 in the "Good" criteria, while the mean score of the material validator-3 is 144 in the "Very Good" criteria. The mean total of the three material validators is 139, with the "Very Good" criteria. Thus it can be concluded that the developed learning media has reached the category of validity of a product in terms of material. Assessment of the validity of learning media by media validators is presented in Figure 11 and Table 2 below.

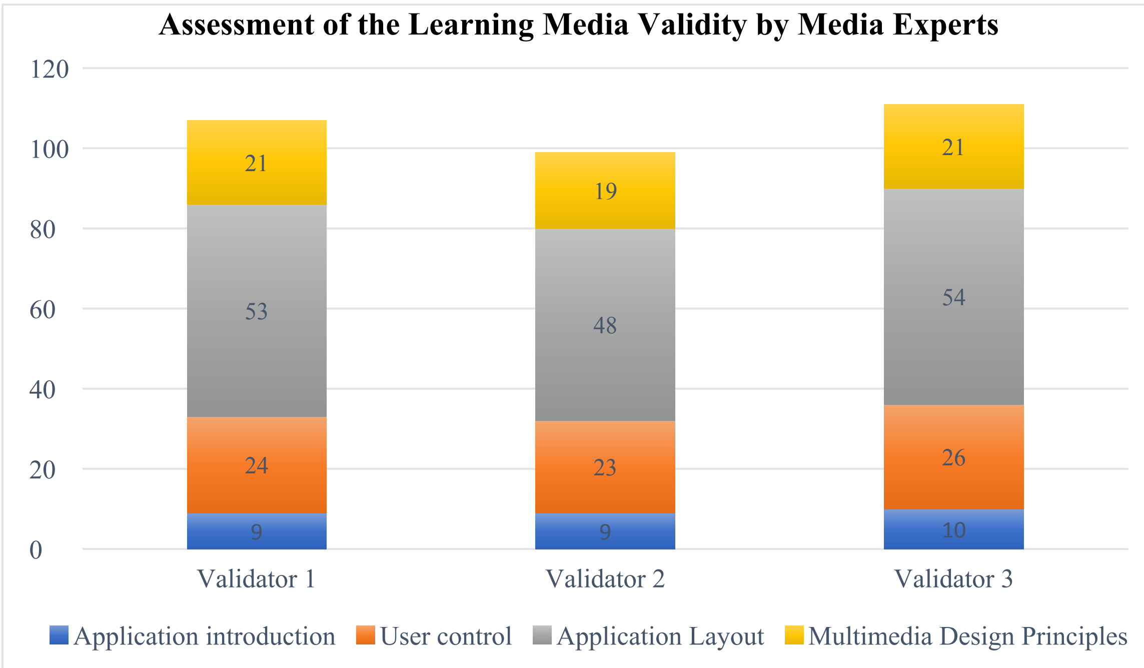


Figure 11. Description of the Assessment Results by Media Experts

Component	Validator-1	Validator-2	Validator-3
Mean	**107**	**99**	**111**
Mean total		**105,67**	

Table 2: Average Assessment of the Validity of Learning Media by Media Experts

Judging from the mean score of media validator-1 is 107 in the "Very Good" criteria, the mean score of media validator-2 is 99 in the "Good" criteria, while the mean score of media validator-3 is 111 in the "Very Good" criteria. The overall mean score of the three media validators is 105.67, with the “Very Good” criteria. Thus it can be concluded that the developed learning media has reached the category of validity of a product in terms of media. Regarding material and media, it can be supposed that the interactive digital games based on computational thinking developed in this study have reached the validity criteria of a development product.

4. Implementation Stage

At the implementation stage, the researcher conducted a small class trial and based on the trial results, it was found that the product being developed reached the "Very Good" criteria. Next, the researcher conducted a large class trial of four classes of students from three Elementary

Schools. The results of student responses in large classes were 81.9 in the "Very Good" criteria. Therefore, we can conclude that students' assessments of the digital games developed in this study reach the practicality category of learning media. Of 98 out of 123 students gave a very good impression regarding using these digital games.

5. Evaluation Stage

At the evaluation stage, the researcher conducted a continuous evaluation which began with evaluating the test results of students' understanding of the multiplication concept in contextual problems. The test results showed that the mean score of students' multiplication concept understanding of contextual problems was represented in students' cognitive and psychomotor capability achievements that are still less than half of the maximum score, precisely less than 50. The evaluation was also carried out on the validation results at the development stage. The researcher made several revisions to the game, especially in the illustration of contextual problems and the appearance of characters in games from a media perspective. Regarding the material perspective, the researcher also revised the legibility of contextual problems. According to students' assessment of the use of games, researchers do not need to make revisions because more than 90% of students very appreciate and enthusiastically welcome the implementation of games that are considered user-friendly.

DISCUSSION

The use of digital games that are integrated into learning mathematics has a positive impact on student responses as users. In this game-based learning of multiplication material, the teacher uses digital games specially designed to assist students' understanding of multiplication concepts by presenting contextual problems. The digital game used as a supporting device in game-based learning here is an educational game called Arithmetic-CT Monkey Game. This educational game gives students a fun and attractive learning experience with structured game content. Monkey Game Arithmetic-CT trains students' adaptation skills to solve various problems with varying difficulty levels. Even to win the game, students must use their creativity in passing challenges or contextual problems that must be faced. While using this game, students get feedback from the system when they access the answer-checking feature. In this case, students can improve their answers because games are designed with specific tasks to guide students ‘learning by gaming’. Various features that support the game are also designed to attract students' attention to this game which has a storyline of everyday life. So emotionally, students also feel meaningful experiences accompanied by feelings of having experienced ongoing events.

Game-based learning supported by the Arithmetic-CT Monkey Game application on the Android platform contains twelve characteristics of digital learning, as stated by Prensky (2003). This learning also refers to two things: education and gameplay, as well as achieving learning goals and entertainment (Lin et al., 2020). Furthermore, Lin et al. (2020) stated that the use of digital games in learning is designed by integrating the system into the experience of playing games. Because of this, a content design model and game features are often adapted to the behavior habits of its users, such as rules, targets, imagination, mystery, sensory stimulation, and control abilities (Garris et al., 2002). This underlies the conduct of several studies on computer use by children under seven years of age, which is considered to reduce children's important developmental tasks in terms of social and intellectual as well as other types of learning (Healy, 2000).

On the other hand, this game-based learning also loads core computational thinking. In the game, there are three levels with different levels of difficulty, namely level one for simple contextual problems that contain one particular variable and involve integers 1-5 as the numbers to be operated on; the second level is for simple contextual problems that contain one particular variable and involve integers less than ten; and level three for complex contextual problems that contain more than one variable. These problems are used to assess students' cognitive abilities in sorting concepts into several components (the concept of addition and the concept of multiplication), then linking them together to understand the concept as a whole (the concept of multiplication is constructed from a repeated addition). In this case, core computational thinking abstraction is significant in determining students' success in solving contextual problems in games through analytical activities. Likewise, with the development of logical and systematic problem-solving instructions and the process of rechecking the correctness of each problem-solving step, such as algorithm design and debugging in the core of computational thinking, those two thought processes are indicators of a student's cognitive capability that can achieve during learning. The student's cognitive achievement is an implication of the ease of operation, and the continuous interaction between students and games during learning will build students' thinking habits while playing.

The contextual problems of multiplication that students must solve at each level are also used to assess students' psychomotor capability, which can be seen from the attitude/way of students in solving problems or manipulating problem-solving in their way. Students must link various skills or work based on patterns (similarities or differences in patterns) to predict or produce appropriate solutions such as core computational thinking pattern recognition. How to break down complex data or problems into simple problems so that students can more easily solve them, such as decomposition in the core of computational thinking, is also an indicator of the psychomotor abilities students can achieve. Thus, the experience of 'learning by doing' is obtained by students when playing games, affecting their behavior and psychomotor capability when solving problems. Because with learning game-based mathematics, students transfer the abstractness of mental objects in their cognition into external representations/student behavior that can be observed so that their computational thinking skills increase. This is in line with the research results of Andriyani and Maulana (2019), which show that a good learning experience is needed to acquire mathematical knowledge which has abstract and hierarchical objects. With digital games in learning, students look enthusiastic about using interactive technology because this technology reduces the abstractness of learning concepts, so the students understand a learning situation more quickly (Buliali et al., 2022; Panthi et al., 2021).

CONCLUSION

Digital game interactive media as a support device for game-based learning can be said to reach the validity category based on the results of the product feasibility test as indicated by the fulfillment of the "Very Good" criteria in the aspect of material and media. The practicality of learning media is also indicated by the fulfillment of the "Very Good" criteria regarding student responses. Hence, digital games have been shown to effectively address contextual multiplication problems that previously posed challenges to students due to their limited grasp of the multiplication concept. The researcher hasn't measured the effectiveness of digital games in game-based learning, so this possibility opened up as material for further research. Digital games can be an alternative to support students' cognitive achievements by facilitating the translation of abstract images of multiplication concepts and training students' psychomotor capability in solving multiplication contextual problems at each level of the game. By incorporating core computational thinking content, digital games have been demonstrated to facilitate cognitive development tasks and enhance psychomotor skills, exemplified by progressive level advancements. As a result, students become accustomed to a "learning by gaming" approach. Furthermore, the students' feedback has provided evidence that the core of computational thinking heightens their enthusiasm for learning multiplication. With this core loaded, students feel assisted in determining the optimal solution strategy through problem formulation activities and appropriate information processing.

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APPENDIX

ASSESSMENT SHEET OF THE LEARNING MATERIAL VALIDITY BY MATERIAL EXPERTS

A. PURPOSE

To assess the validity of the Arithmetic-CT Monkey Game of interactive learning media for application compatibility with Game-Based Learning and CT core quality, completeness, accuracy, and relevance to the basic subject concept by material experts.

B. INSTRUCTIONS

1. To Mr./Miss, please assess by giving a tick (√) in the column that has been provided that is appropriate with the following assessment criteria:
   1: Not Good
   2: Less Good
   3: Good Enough
   4: Good
   5: Very Good
2. To Mr./Miss, please advise on improvement by writing in the comment line suggestions that have been provided.

No	Assessment Criteria	Score				
		1	2	3	4	5
Compatibility with Game-Based Learning and CT Core						
1	The game content present problems whose solutions contain the abstraction core of computational thinking					
2	The game content present problems whose solutions contain the algorithm design of computational thinking					
3	The game content present problems whose solutions contain the pattern recognition of computational thinking					
4	The game content present problems whose solutions contain the decomposition of computational thinking					
5	The game content present problems whose solutions contain the debugging of computational thinking					
6	Games contain special learning that helpzs to solve					

	problems related to the concept of multiplication.					
Completeness and accuracy						
7	Coherent in the preparation of material from simple concepts to more complex concepts					
8	Diversity in giving examples related to the concept of multiplication					
9	The accuracy of the problem given with the concept of multiplication					
10	Correctness of the problem-solving feedback					
11	Readability and clarity of information contained in-game issues					
Relevance to the basic subject concept						
12	Suitability of the material with the core competencies and basic competencies in the referenced curriculum					
13	The usefulness of games as learning media needed by students and facilitates the achievement of learning objectives					
14	Conformity of material with the truth of its substance					
15	Examples of clarity in illustrating the abstract concept of multiplication					
16	Coverage (breadth/depth) of the material					
17	Factual material and material actualization					
18	Appropriateness of the language used with the level of the cognitive and intellectual development of students					
19	Interactivity between students and games that attract student learning motivation					
20	Instruction traction					

Comment and Suggestion:
…………………………………………………………………………………………………
..……………………………………………………………………………………………..
…..…………………………………………………………………………………………..

C. CONCLUSION

In terms of material aspects, the Arithmetic-CT Monkey Game of interactive learning media states:

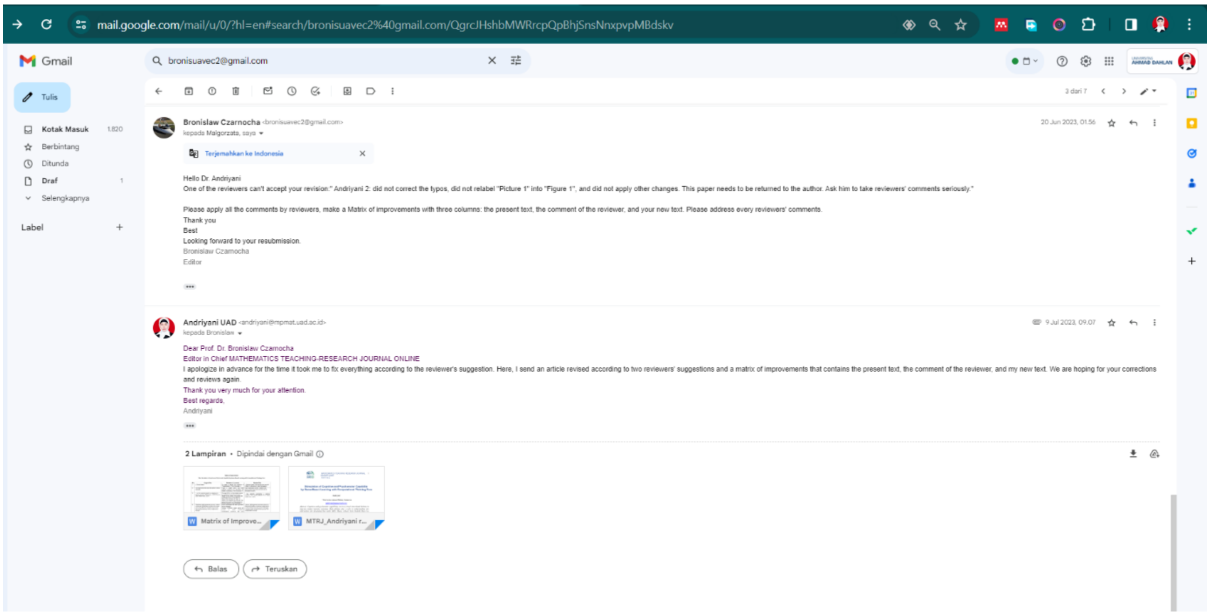
1. Worth
2. Worth using after revision
3. Not worth

Please give a circle sign of the choice of numbers provided as the assessment result.

..........., ……………… 2022
Validator,

……………………………….....

Pada tanggal 20 Juni 2023, Editor mengirimkan notifikasi di email terkait apa yang harus direvisi oleh penulis pada tahap-2. Menurut editor, salah satu reviewer tidak dapat menerima revisi penulis mulai dari perbaikan kesalahan ketik, pelabel ulang gambar dan beberapa revisi yang belum dilakukan penulis. Editor meminta penulis untuk menanggapi hasil review dari reviewer dengan membuat matriks perbaikan yang memuat tiga kolom yaitu: kolom teks saat ini, kolom komentar reviewer, dan kolom teks baru penulis. Pada tanggal 9 Juli 2023, penulis mengirimkan matriks perbaikan dan hasil revisi tahap-2.



Artikel yang direvisi dan matriks perbaikan dikirimkan pada editor pada tanggal 9 Juli 2023 adalah sebagai berikut.

Stimulation of Cognitive and Psychomotor Capability by Game-Based Learning with Computational Thinking Core

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Abstract: Cognitive and psychomotor capabilities are two critical interrelated abilities to improve student learning outcomes. Both abilities play a role in understanding new information and developing fine motor skills. Hence, schools train students these two abilities to equip them with basic skills in solving mathematical problems such as basic arithmetic. However, few previous studies have not much discussed the design of learning strategies which successfully integrate these two capabilities. Moreover, these studies only focus on calculations in arithmetic operations, not the conceptual understanding of operations. Therefore, this study aims to describe the development of learning media designs that accommodate student activities through game-based learning to stimulate cognitive and psychomotor capability in conceptual arithmetic operations, especially multiplication. Core computational thinking integrated with interactive game-based learning was used as the learning framework. The research method was called ADDIE comprising five stages of development with data collection techniques of questionnaires, student responses, and tests. Results show that according to experts and students, game-based learning media are valid and practical correspondingly. From the students' responses, it is known that the development of game-based learning can stimulate cognitive and psychomotor capability to solve contextual problems that were previously becoming obstacles for students.

Keywords: *Cognitive, Computational-Thinking, Game-Based Learning, Psychomotor*

INTRODUCTION

Cognitive and psychomotor capabilities are essential components in student learning and development which are also challenges for educators and experts in education. According to Begam and Tholappan (2018), a person's cognitive ability refers to his thinking/mental process continuity. This cognitive process involves acquiring, processing, and applying knowledge, including attention, memory, reasoning, understanding, and problem-solving. On the other hand, according to Simpson (1972), psychomotor capability refers to students' physical movement skills, including coordination, agility, and fine motor skills, that require practice with measurements based on aspects of speed, accuracy, procedures, and implementation techniques. With this psychomotor capability, students explore phenomena, conceptualize the ideas involved, and apply concepts to new situations (Karplus & Butts, 1977). In the context of learning with abstract objects such as mathematics, the processes contained in this psychomotor ability are interpreted by gaining direct experience and providing opportunities for students to manipulate objects and tools. More clearly, Piaget (1929) claims that students' physical experience in learning mathematics could be obtained by giving students opportunities to explore mathematical concepts through the concrete physical experience before moving on to more abstract representations. These experts generally show that cognitive and psychomotor capabilities play a significant role in learning mathematics, especially in active exploration and reflection activities.

In the midst of this significant role, educators have the main challenge of identifying and overcoming differences in individual cognitive and psychomotor capability. Given the unique differences in the nature and characteristics of these two abilities, educators need to provide personalized instruction and support to meet the learning needs of each student. In addition, educators also need to find strategies to help students develop their cognitive and psychomotor capabilities on an ongoing basis. This requires teachers' focus on creating interesting and challenging learning experiences for students to follow. Teachers need to design lessons that can stimulate these two capabilities, especially in solving real-world problems. Stimulus in problem-solving needs to be accompanied by providing opportunities to train students' physical skills in direct practical activities. Moreover, the corona virus pandemic that hit the world last year has an impact on reducing the level of students' active involvement in learning and their study results (Haryani & Hamidah, 2022; Onyema et al., 2020; Orlov et al., 2021).

A decrease in student learning involvement can also be caused by a lack of their intrinsic or extrinsic motivation (Fatimah & Saptandari, 2022) because there is a reasonably close relationship between the two (Saeed & Zyngier, 2012). This involvement affects students' academic outcomes (Finn & Zimmer, 2012). Hence, an effective learning strategy is needed to increase student learning motivation, such as digital game-based learning, which also functions to encourage students' willingness to learn and self-awareness in both formal and informal learning contexts (Owston, 2009; Yang & Chen, 2010; Yien et al., 2011). This positive implication raises a lot of attention given to the relationship between digital games and the education field (Chiang et al., 2011).

The variety of games implemented in learning makes the development of game application models more adaptive and flexible as learning media based on the material presented (Hays, 2005; Papoutsi & Drigas, 2016). Several studies on multiplication-themed educational games have been carried out, including research on Android-based arithmetic games by Amrizal and Kurniati (2016), mobile educational games for multiplication calculations based on the horizontal method with Html 5 and Phone Gap by Ricky (2013), and designing learning game application for 3rd-grade math calculation operations using unity by Kristina and Talitha (2021). Those studies are related to developing educational games that contain multiplication calculations through fast multiplication counting activities.

In this study, a game-based multiplication concept learning will be designed with the help of digital game applications of which are accessible on Androids. Students are not only trained to count fast but also understand the concept of multiplication, of which the construction is formed from repeated addition. In learning arithmetic, students need adaptive skills, which involve functional academic skills in the basic operations of addition, subtraction, division, and multiplication (Polspoel et al., 2019). These adaptive skills are needed for everyday life because they involve communication, social life, work, and functional academic skills such as reading, writing, and arithmetic (Ainsworth & Baker, 2004; Hodapp, 2002). Thus, learning arithmetic requires both psychomotor and cognitive abilities, especially if arithmetic problems are in the context of students' everyday problems. However in fact, there are still many students who are afraid of learning mathematics because it is considered difficult and complex (Laurens et al., 2018).

The results of an initial study conducted by the researcher in November 2022 in three elementary schools in the Municipality of Yogyakarta and Bantul Regency show that grade III students still do not understand the concept of multiplication operations and often have difficulty solving contextual problems, especially multiplication abstraction which correlates with modeling problems and the procedure for solving it. Meanwhile, the teacher still uses the rote method to teach multiplication. Students' lack of understanding of multiplication often causes boredom, laziness, and a lack of interest in learning multiplication. This is similar to Thai and Yasin (2016) research on multiplication teaching methods. Therefore, we need alternatives in thinking processes and developing problem-solving strategies, including computational thinking (Wing, 2006).

Along with technological advances in recent years, computational thinking has become an important topic in various fields of life (Lindberg et al., 2019). Various countries have attempted to promote computational thinking education in schools, universities, industries, and government sectors (Lin et al., 2020). A large number of researchers attempt to identify students' computational thinking abilities. For example, research by Yadav et al. (2017) and Denning (2017) which investigated the development of computational thinking-based teaching guidelines for students; research by Shute et al. (2017) regarding the design of a model for assessing student computing learning outcomes; as well as research by Sullivan and Bers (2018) and P´erez-Marín et al. (2020) on computational thinking-based learning performance. These studies are clear evidence that computational thinking has become a basic skill needed in learning in this digital era.

Based on the problems experienced by students in learning the concept of multiplication operations above, the researcher considers it necessary and important to design game-based learning with the help of interactive learning media that can stimulate students' cognitive and psychomotor capabilities. The developed interactive learning medium is a digital game filled with computational thinking core to help students understand the concept of arithmetic operations, especially multiplication. By integrating computational thinking cores, students learn to understand the concept of multiplication operations by solving contextual problems presented in the digital game.

LITERATURE REVIEW

Cognitive and psychomotor capabilities have an important role in the formation of adaptive skills, which are the main elements in the elementary school mathematics curriculum (National Math Panel, 2008) and play a fundamental role in solving more complex mathematical problems (Juliana & Hao, 2018; Prendergast et al., 2017). Therefore, teachers need to train these skills to students for mastery of mathematical concept, including the arithmetic concepts. Knowledge of basic arithmetic operation can be achieved if students understand the concept of operations and the links between operations (Rahman et al., 2017).

Cognitive skill is an ability related to a person's thinking activity in receiving, processing, and transmitting the information obtained (Basri, 2018; Darouich et al., 2017). Cognitive capability is often associated with acquiring information for the short term (Darouich et al., 2017), and the long term is seen as an adaptive function of humans to the cultural, social, and emotional environment (Anderson, 1994). In its development, this cognitive ability is significantly influenced by students' thinking activities (Basri, 2018). In mathematics learning, the completion of mathematical tasks is a basis for starting and practicing various students' mathematical thinking activities, including thinking about solving mathematical problems and understanding mathematical content so that the thinking operations that occur become parts of students' conceptual and procedural understanding (Swanson & Williams, 2014). Developing a person's cognitive abilities is directly related to developing psychomotor, social, affective, and adaptive skills.

Psychomotor skill is the ability to perform motor-physical movements related to learning outcomes in cognitive activity (Murrihy et al., 2017). Yet, the link between motor coordination and learning outcomes is largely neglected in the psycho-educational domain. The results of research related to this have been widely published, with the results of a statistically significant relationship between motor difficulties and academic achievements such as language, reading, spelling, and arithmetic (Archibald, L. & Alloway, 2008; Lopes et al., 2013). This shows that cognitive and psychomotor abilities are closely related to achieving meaningful mathematics learning goals. According to Vallori (2014), meaningful learning is signified by some important principles below:

(a) Open work enables all learners to learn;
(b) Motivation helps to improve the classroom environment, making learners interested in their tasks;
(c) Means must be related to the learners' environment;
(d) Creativity strengthens imagination and intelligence;
(e) Concept mapping helps learners to link and connect concepts;
(f) Educational curricula must be adapted by considering learners with special needs.

These six important principles show the need for teachers to employ fun learning strategies that can accommodate various characteristics of the student's environment so that students can receive complete information by associating new information with relevant concepts in students' previous cognitive structures. One effective and suitable learning strategy to implement is digital game-based learning (Owston, 2009; Yang & Chen, 2010; Yien et al., 2011). The implication of digital educational games is motivating users in a fun learning atmosphere (Kirriemuir & McFarlane, 2004). These educational games tend to arouse curiosity and challenge users to actively explore games until they feel happy when they can finish the game well so that students are motivated and enjoy learning through the games (Chen et al., 2007; Hong et al., 2009; Moon & Baek, 2009).

Games are designed with various systematic, visual, and kinetic activity loads to stimulate students' skills and awareness of specific knowledge (Besgen et al., 2015; Shuqin, 2012). Various student skills are oriented towards achievement by integrating games into learning, including learning basic mathematics. Through games, students are trained to make decisions by controlling objects in the game for a specific purpose designed in a system or program (Jason in Aprilianti et al., 2013).

Regarding the selection of learning strategies that can increase student learning motivation and develop the skills needed, the education system has integrated Information and Communication Technologies (ICT) especially to improve the quality of student learning in schools (Malik et al., 2017). By utilizing ICT, students can become active learners through dynamic and collaborative learning so that the interactivity and communication of learning increase. In addition, students are stimulated to use their ability to think logically, systematically, and skillfully when making the right decisions facing numerous different possibilities (Munir, 2014).

An alternative learning strategy that follows the achievement of this stimulus and has a wide area of application to solve problems is computational thinking approach (Malik et al., 2017). Furthermore, Malik et al. (2017) explain that in a computational thinking approach, instead of thinking like computers, students think about computing which includes the ability to: (1) formulate problems in the form of computational problems; and (2) develop a good computational solution in the form of an algorithm or explain why no suitable solution is found.

According to Ioannidou (2011), the computational thinking approach contains the cores of (1) decomposition, or the ability to break down complex tasks into smaller, more detailed tasks; (2) pattern recognition, or the ability to recognize general similarities or differences which will later help in making predictions; (3) generalization of patterns and abstractions, or the ability to filter information to solve problems; (4) algorithm, or the ability to arrange steps to solve a problem; and (5) debugging, or checking and re-checking every step of problem-solving to ensure the process is correct. If it is incorrect, then exploring why the appropriate solution is not found is necessary.

METHOD

This study aims to describe the development of instructional media designs that accommodate student activities through game-based learning to stimulate cognitive and psychomotor capability in conceptual arithmetic operations. The research subjects were ten third-grade students from an elementary school in the District of Yogyakarta for the small class trial and 123 third-grade students from three elementary schools, two from Bantul Regency and one from the District of Yogyakarta, for the large class trial. A total of four classes were involved in the large class trial with the latter school consisting of two study groups. Data collection techniques consisted of test and non-test while data analyses included both quantitative and qualitative. Quantitative data analysis was carried out by calculating the mean score of students' tests, validation questionnaire, and student response. The mean score from the last two instruments were converted into the product validity and practicality category by referring to the criteria guidelines on five Likert scales: 'Not Good' for 1; 'Less Good' for 2; 'Good Enough' for 3; 'Good' for 4; and 'Very Good' for 5 (Widoyoko, 2018). The product was said to reach validity and practicality standards if it reached at least "Good" or score 4.

The procedure in this research consisted of an analysis stage, a design stage, a development stage, an implementation stage, and an evaluation stage, or latter abbreviated as ADDIE (Branch, 2009; Sugiyono, 2019). The researcher chose ADDIE model to develop learning media in digital games because it facilitated the construction of students' knowledge and skills in instructional guided learning plans. In addition, this model was also devoted to solving problems related to gaps due to students' lack of knowledge and skills. Furthermore, the ADDIE model contained generative processes by applying concepts and theories to a particular context.

At the analysis stage, the researcher identified the probable causes of incongruity/differences between learning outcomes and theories, concepts, or other learning problems in the multiplication concept material. Identification is based on experiences, preferences, abilities, and student motivation during learning. In addition, the researcher also identified the resources needed during the development process, including the curriculum, the concept of multiplication, the learning models or methods used, teaching materials, facilities, learning environment, technology, and the characteristics of the students involved during the development process. To determine the characteristics of the students at the research site, the researcher conducted written tests at three elementary schools to measure students' understanding of multiplication concepts presented through contextual problems.

At the design stage, the researcher designed a prospective product based on the analysis results of the previous stage and began by selecting the digital games with core computational thinking to stimulate cognitive and psychomotor capability. Next, the researcher prepared the initial design of the media by making a representation of the interactions between the system and its environment in the form of a diagram until it produces a product blueprint. At this stage, the researcher also formulated specific, measurable, applicable, and realistic learning objectives based on appropriate learning strategies.

At the development stage, the researcher developed an initial prototype according to the initial blueprint, including developing test instruments, validation questionnaires and student responses. Likewise, the initial prototype of the media was also validated by experts in the field of learning media and mathematics learning materials. Furthermore, the researcher revised the prototype by accommodating the validators' suggestion, from six validators in total, so the digital game was declared valid and ready to be implemented in both small and large classes.

At the implementation stage, the researcher formulated concrete steps to implement the previously designed learning system. The researcher initially tested the game product in a small trial to 10 third-grade students at an elementary school in the District of Yogyakarta. The try-out was carried out in three meetings, and then the researcher gave a response questionnaire to students as product users. The student responses served as inputs to revise the product. The researcher tested the product again on third-grade students from four classes at three elementary schools. Of the three elementary schools, two were located in Bantul Regency, and one was from Yogyakarta Municipality with two study group classes. To find out the responses of the large trial classes, the researcher distributed response questionnaires of which the results were used as a basis to determine the practicality of the game products.

At the evaluation stage, the researcher continuously evaluated and revised to reach final product. Evaluation was carried out through qualitative and quantitative data analysis. Based on the need analysis results at the first development stage, the researcher analyzed the quantitative data from the results of the test to find out the characteristics of the students regarding their understanding of the multiplication concept in contextual problems. The validation results at the development stage and field trials at the implementation stage were also analyzed. Qualitative data from input, suggestion, and expert criticism were interpreted as a basis for gradual revisions. Furthermore, a quantitative analysis of the validation and student response questionnaires was carried out to assess validity and practicality of the media. All stages of this evaluation were aimed for the feasibility of the final product in terms of content, design, and user-friendliness.

RESULTS

1. Analysis Stage

At this stage, the researcher identified the corresponding curriculum as a guideline for developing digital games. Next, the researcher assessed the learning materials related to the concept of multiplication. In this case, the researcher interviewed a mathematics teacher about the implementation of the school curriculum in teaching multiplication. It was revealed that the teacher taught multiplication only limited to calculating two or more integers with time allocation of 4 × 45 minutes per week distributed in two meetings. To check student understanding, the teacher added one meeting in the form of written test. The limited time allocation turned out to cause problems for students, in which students only memorized multiplication and were oriented towards counting skills only.

The interview also addressed the teacher's teaching method in the expository form. The teacher conveyed the multiplication of two or more numbers directly while teaching the meaning of multiplication as a number multiplied according to the multiplier number. Students who found it difficult to accept the abstraction of the multiplication meaning would eventually choose to memorize the multiplication of integer numbers within the range of 1-10. This was the consequence of the difficulties they experienced in interpreting the teacher's explanation which tended to lead only to calculating numbers. Subsequently, students looked less enthusiastic about participating in learning and were unable to solve contextual problems given by the teacher.

In addition to the learning method, the interview discussed the teacher's teaching materials as well. Books, which are universally textual, served as the main materials. This dissuaded students' interest in learning, which during the Coronavirus pandemic, was often carried out online and utilized more digital learning resources than ever. Therefore, we need interactive digital learning media that can accommodate their learning needs through new post-pandemic habits. Moreover, the initial test result regarding students' understanding of multiplication concept in contextual problems shows that it falls within low category, with a mean score below 50 out of 100. The test result can be seen in Figure 1 below.

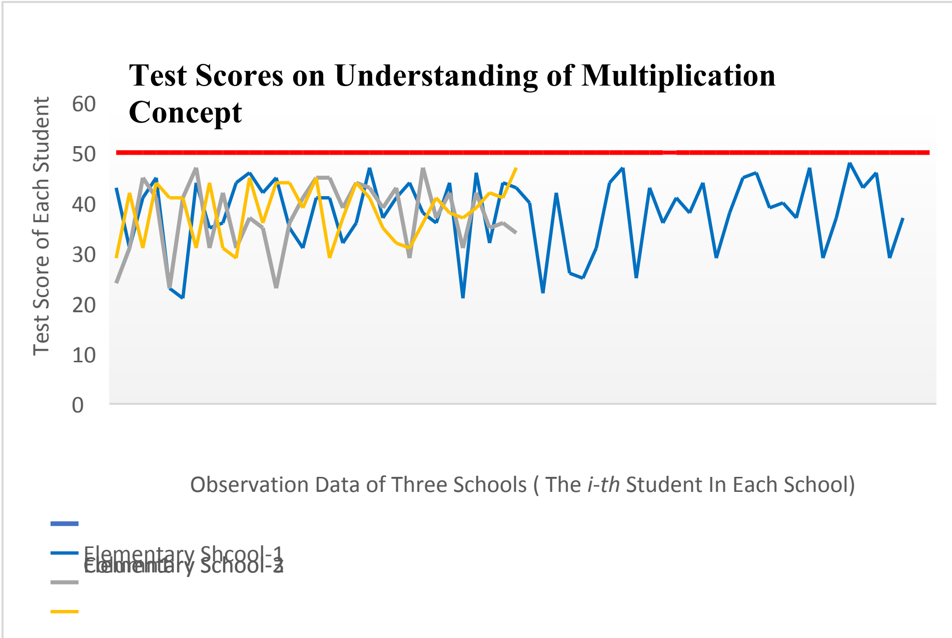
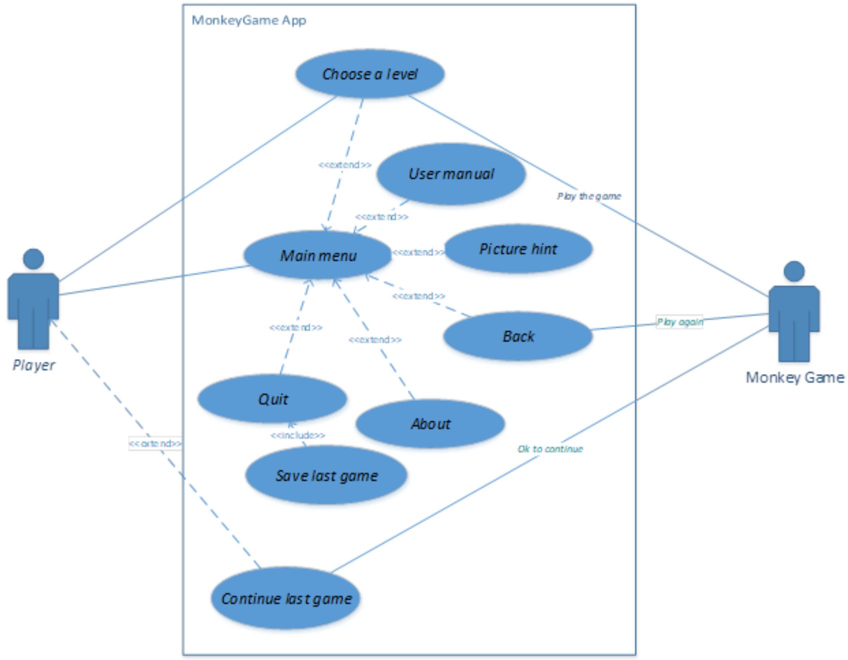


Figure 1. Level of Students' Understanding of Multiplication Concept

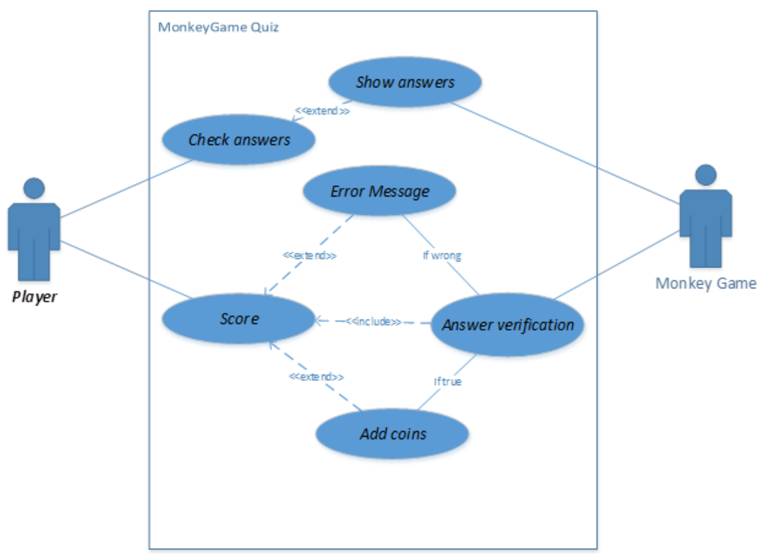
From Figure 1 above, we can conclude that students' cognitive and psychomotor capabilities are less than half the maximum score or less than 50. So, on this basis the researcher intends to develop a digital game with core computational thinking to support multiplication concept learning. With this game, it is hoped that students can understand the abstraction of multiplication concepts by solving contextual problems that were previously difficult for students to solve.

2. Design Stage

At this stage, the researcher designed a digital game based on the need analysis result at the previous stage. The researcher then chose digital game media with core computational thinking to stimulate students' cognitive and psychomotor capabilities. Furthermore, at the game design stage, the researcher began creating use case diagrams that describe or represent the interactions between the system and its environment, as shown in Figure 2 (a)-(b) below.



(a) Main Use Case Diagram

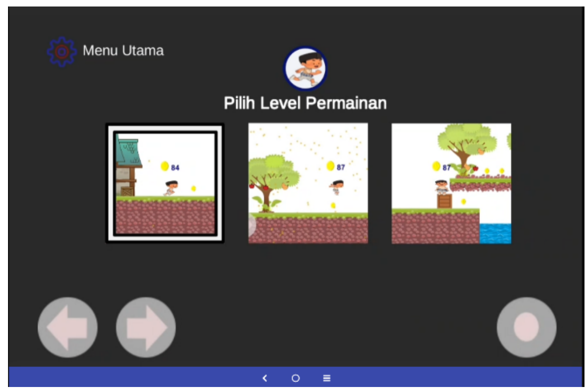


(b) Part Diagram of Main Use Case Containing Checking Answers and Feedback

Figure 2. Digital Game Use Case Diagram

The researcher utilized the use case diagram above to define the functional modeling and operational system requirements by determining the scene method used to build the system from the results of the previous application analysis. At this stage, the researcher decided the name for the game; Monkey Game Arithmetic-CT. In this digital game, there is a monkey character. Monkey is selected since it is a fable main character that sticks in the memories of many children in Indonesia. Children often hear it from their parents during their golden age in reading and listening activities. The fable's monkey character represents an agile animal with a lot of senses and likes to eat fruits, especially bananas and apples. Then the researcher formulated the digital game concept according to the achievement orientation of students' cognitive and psychomotor capability, which were leveled from 1 to 3 on the menu as presented in Figure 3 (a)-(b) below.

(a) Game Main Menu



(b) First to Third Level Game

First column translation:

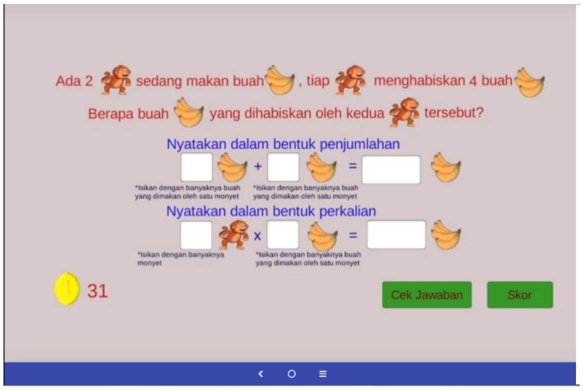
Main Menu
User Manual
Picture Hint
Choose a Level
Back
About
Quit

Second column translation:

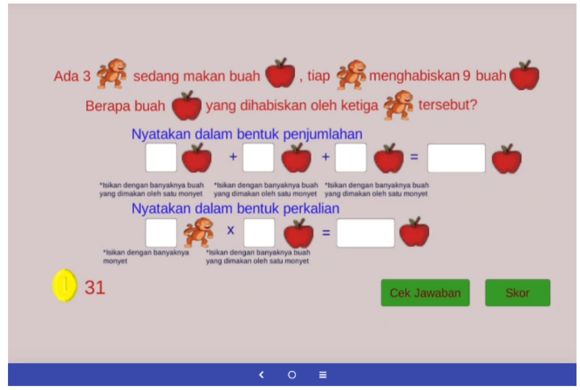
Choose a Game Level

Figure 3. Game Leveling on the Main Menu

The game level represents the complexity of the contextual problems as shown in Figure 4 (a)-(c) below.



(a) First Level



(b) Second Level

Translation Column*:*

There are two eating , and each eats four . How many do the two eat?

Express in addition statement

+ =

Fill in the number of fruits eaten by one monkey | *Fill in the number of fruits eaten by one monkey*

Express in multiplication statement

× =

Fill in the number of monkeys | *Fill in the number of fruits eaten by one monkey*

Check answers | *Score*

There are three eating , and each eats nine . How many do the three eat?

Express in addition statement

+ + =

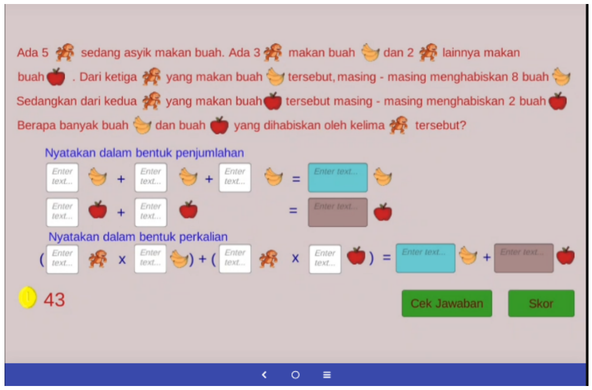
Fill in the number of fruits eaten by one monkey | *Fill in the number of fruits eaten by one monkey* | *Fill in the number of fruits eaten by one monkey*

Express in multiplication statement

× =

Fill in the number of monkeys | *Fill in the number of fruits eaten by one monkey*

Check answers | *Score*



(c) Third Level

Translation Column:

There are five eating fruits; three eating and two eating . Of the three eating the , each eats eight . At the same time, the two eating the , each eats two . How many and do the five eat?

Express in addition statement

+ + =

+ =

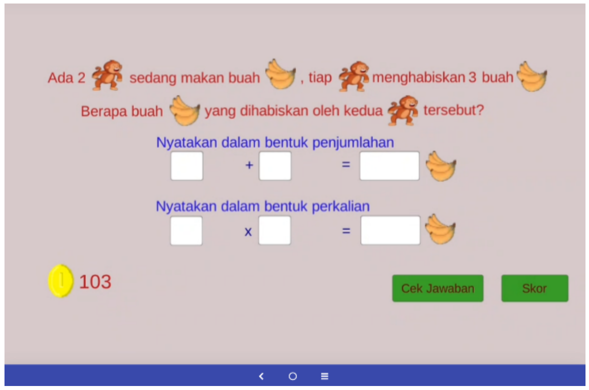
Express in multiplication statement

(×)+(×) =

+

Figure 4. Examples of Contextual Problems from First to Third Level

Computational thinking core loads, namely abstraction, algorithm design, pattern recognition, decomposition, and debugging in digital games, are represented in problem-solving activities as presented in Figure 5 below.



Translation Column:

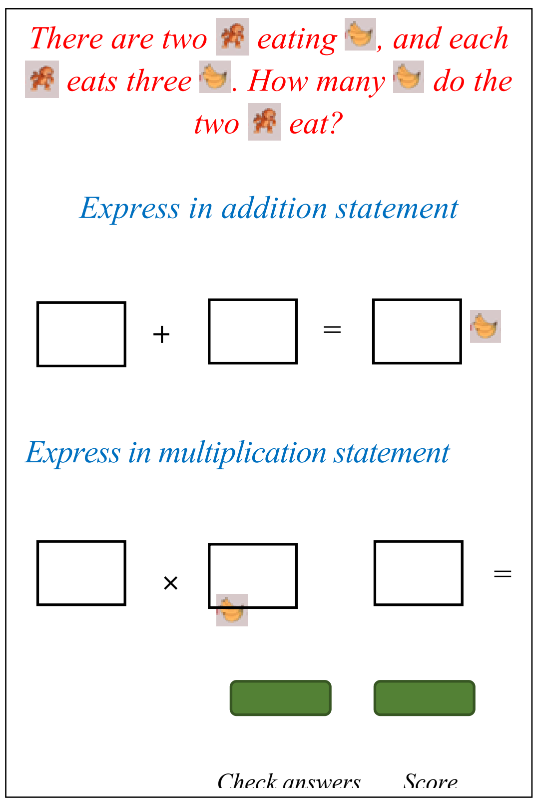


Figure 5. The Abstraction Core of Computational Thinking

Figure 5 shows that students must generalize and identify common cores by accommodating specific details and necessary patterns and ignoring unrelated data to solve the problem. In this game, students must be able to sort out the number of both the monkeys and fruits to fill in each answer box in the addition and multiplication statements. In the game's display, there are not fruit picture or instruction hints to fill the answer box. So, students have to filter the details of the data as their abstraction entities. The core loads of the algorithm design are presented in problem-solving steps, as shown in Figure 6 below.

Translation Column:

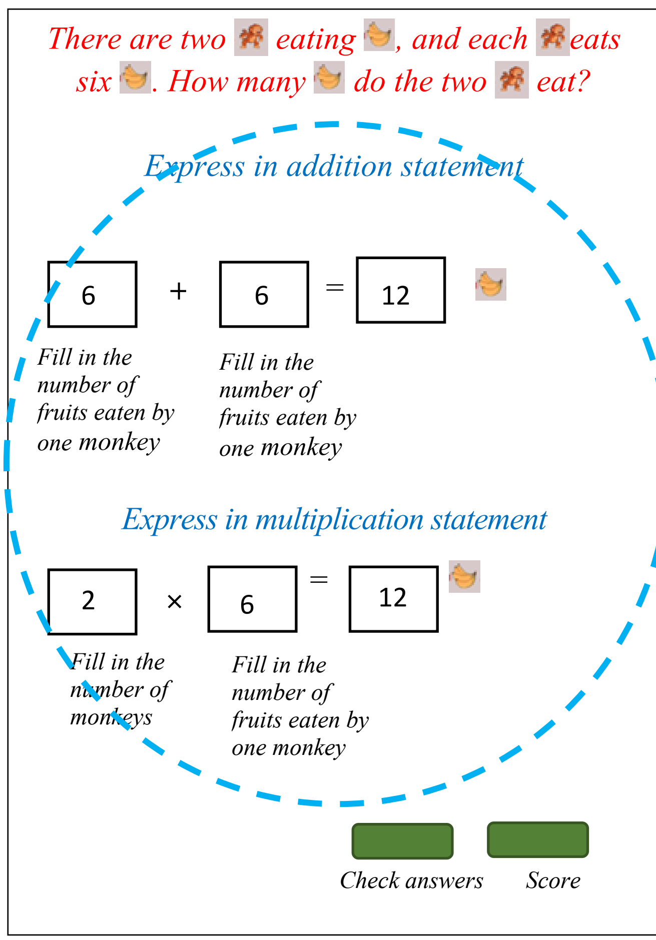
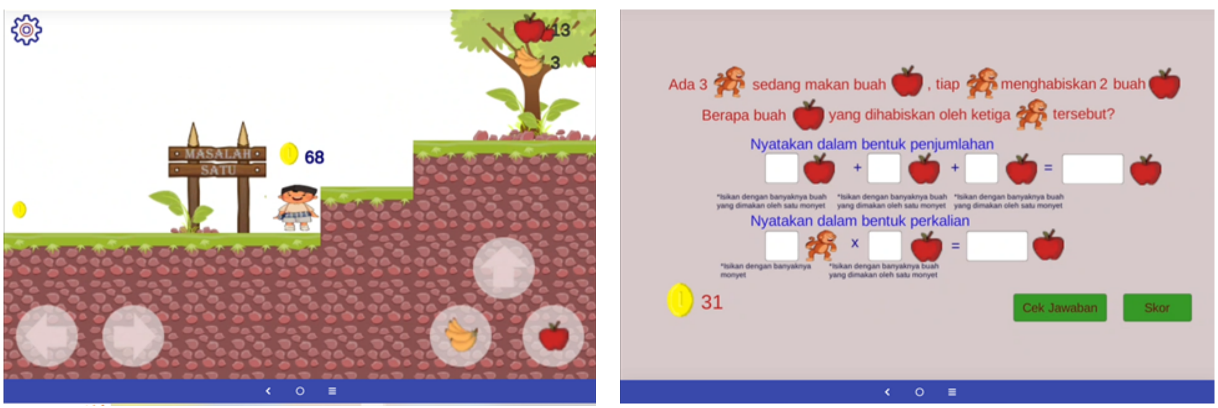


Figure 6. The Algorithm Design Core of Computational Thinking

Figure 6 shows that students must develop logical and systematic problem-solving instructions to solve problems. In the first step of this game, students must fill in the number of fruits eaten by one monkey in each statement box of the addition model. In the second step, students must fill in the number of monkeys in the first statement box of the multiplication model. Afterwards, students must fill in the number of fruits each monkey eats in the second statement box of the multiplication model. In the final step, students check their answers by clicking the 'check answers' button, followed by pushing the 'score' button to check the achievement of the problem-solving score.

The core load of pattern recognition is presented in the problem-solving steps, as shown in Figure 7 (a)-(b) below.



(a) The First Problem and Its Content on The Digital Game

Translation Column:

The First Problem

There are three eating , and each eats two . How many do the three eat?

Express in addition statement

[ ] + [ ] + [ ] = [ ]

Fill in the number of fruits eaten by one monkey | *Fill in the number of fruits eaten by one monkey* | *Fill in the number of fruits eaten by one monkey*

Express in multiplication statement

[ ] × [ ] = [ ]

Fill in the number of monkeys | *Fill in the number of fruits eaten by one monkey*

Check answers | Score

(b) The Second Problem and Its Content on The Digital Game

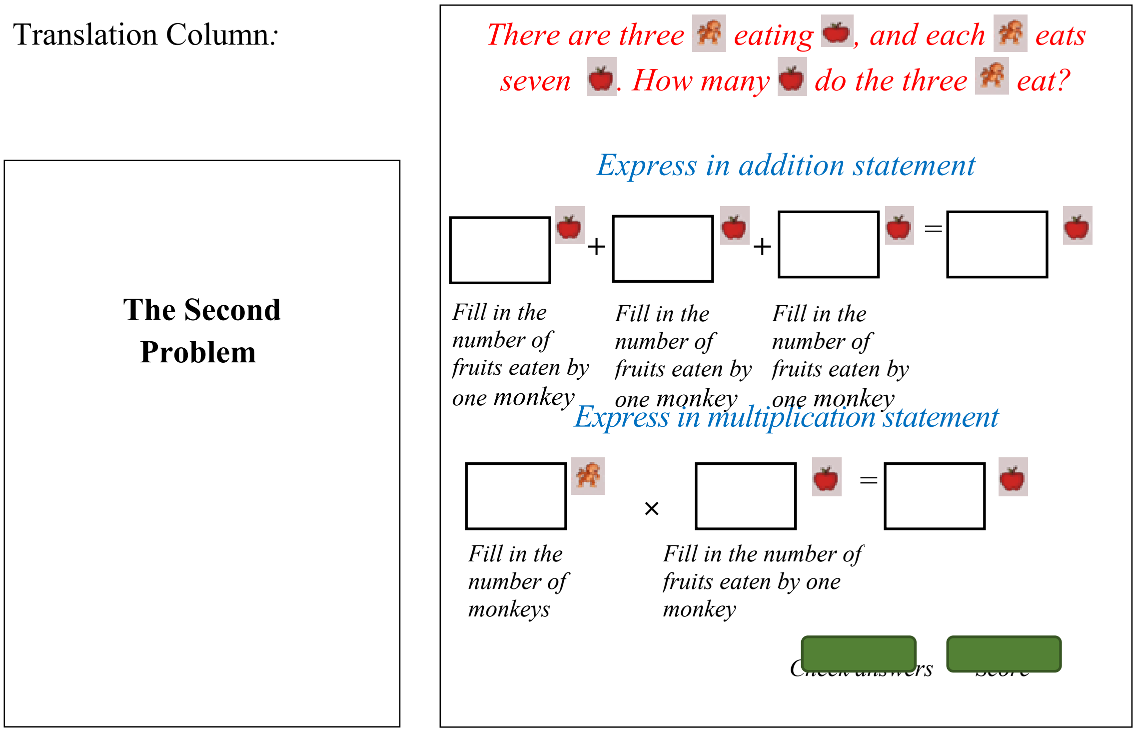


Figure 7. The Pattern Recognition Core of Computational Thinking

Figure 7 (a)-(b) shows that students must be able to see similarities or differences in patterns and methods in the data that will be used in predicting and presenting data to classify problems and provide appropriate solutions. This pattern recognition uses previous experience and prior knowledge as the basis for logical thinking. Then, from this logic, students get new experience and knowledge to solve various identical problems according to patterns they already know. In this game, students must be able to see the data pattern and the regularity of solving the first problem, as shown in Figure 6 (a) above. The first problem presents a data pattern about three monkeys eating apples, and each monkey eats two. Students are asked to determine how many apples the three monkeys eat.

The second problem is presented using an identical multiplication problem. It shows the existence of three monkeys eating apples, and each monkey eats seven. Students are asked to determine how many apples the three monkeys ate. To solve the first problem, students design a solving algorithm that begins with applying the concept of repeated addition. Then, they continue with the solution step by applying the multiplication concept related to the previous repeated addition concept. Using the patterns and regularities of the data in the first problem, students design solutions to the second problem by predicting the same steps for solving the multiplication problems.

The core load of decomposition is presented in the problem-solving steps, as shown in Figure 8 below.

Figure 8. The Decomposition Core of Computational Thinking

Translation Column:

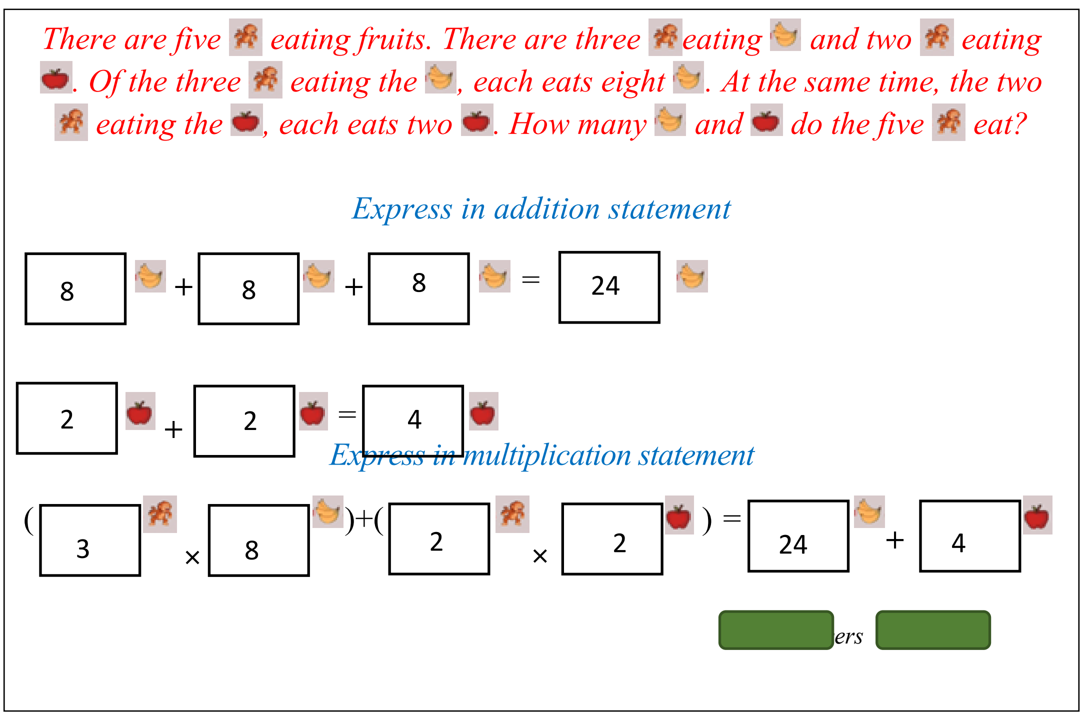
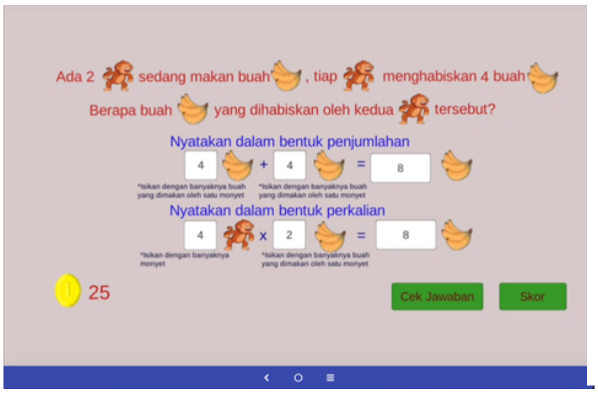


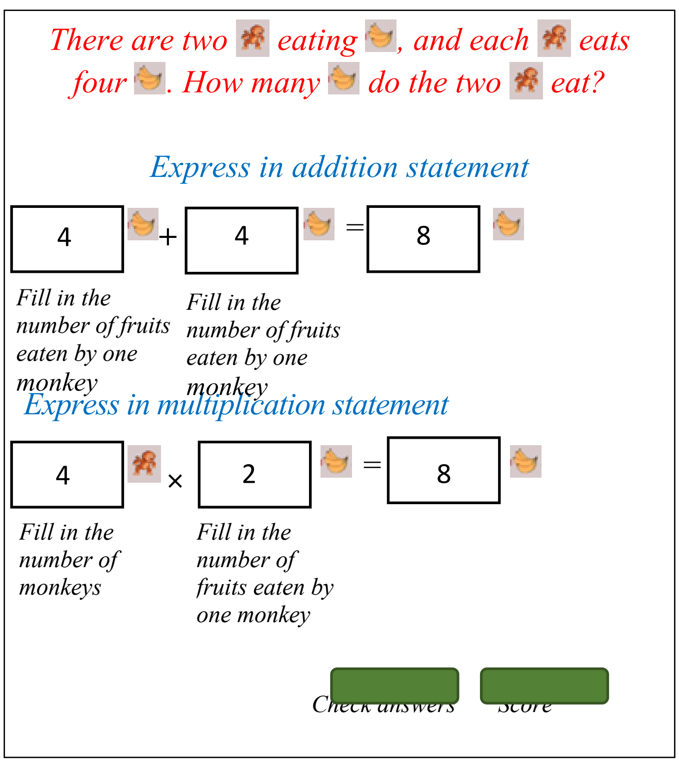
Figure 8 shows that students must be able to break down complex data, problems, or processes into smaller and simpler parts. So, if there is a complex problem, it can be more easily solved by breaking it down. In this case, students must be able to separate the number of bananas and apples eaten by the monkeys.

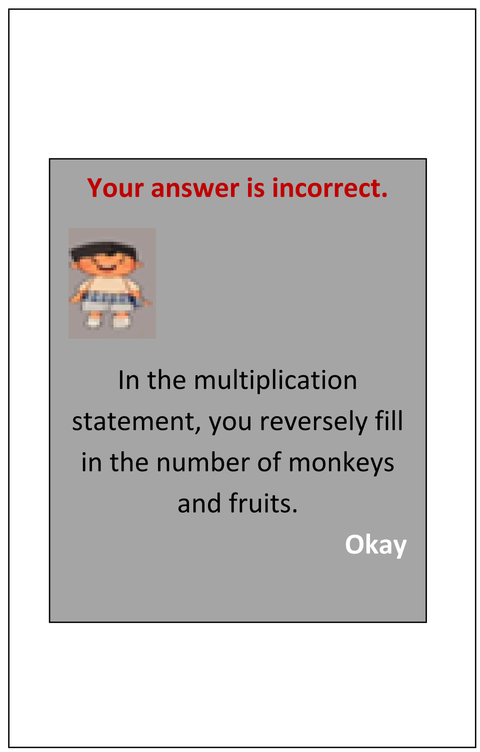
The core load of debugging is presented in the problem-solving steps, as shown in Figure 9 below.



(a) Problem-solving

(b) Result of Rechecking Process





(c) Result of Error Correction from Rechecking Process

Translation Column:

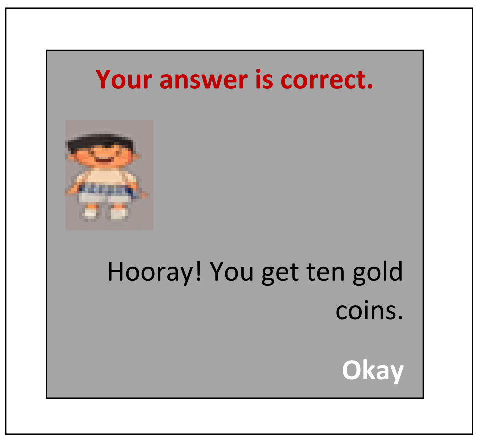


Figure 9. The Debugging Core of Computational Thinking

In Figure 9, it is shown that students must carry out an inspection or process of rechecking each step of problem-solving to ensure the accuracy. If students make mistakes while solving the problem, the system will provide feedback in the form of notifications, as shown in Figure 9 (b). The picture states that the multiplication form is not accurate as the boxes for the number of fruits and monkeys are switched. Students are also given a chance to improve their problem-solving and recheck their answers. If the answer is correct, the system will pop up a notification saying that ten gold coins are obtained as a prize.

3. Development Stage

This stage began with an instrument feasibility assessment in the form of a product validation questionnaire regarding media and materials and student response questionnaire. The validity test was carried out using expert judgment or reviewing the grid, especially the instrument suitability with the research objectives and questions. Based on the results of expert judgment, the three instruments were declared valid. Furthermore, the material substance and media design of the product were assessed by three validators. The material substance validation is presented in Figure 10 and Table 1 below.

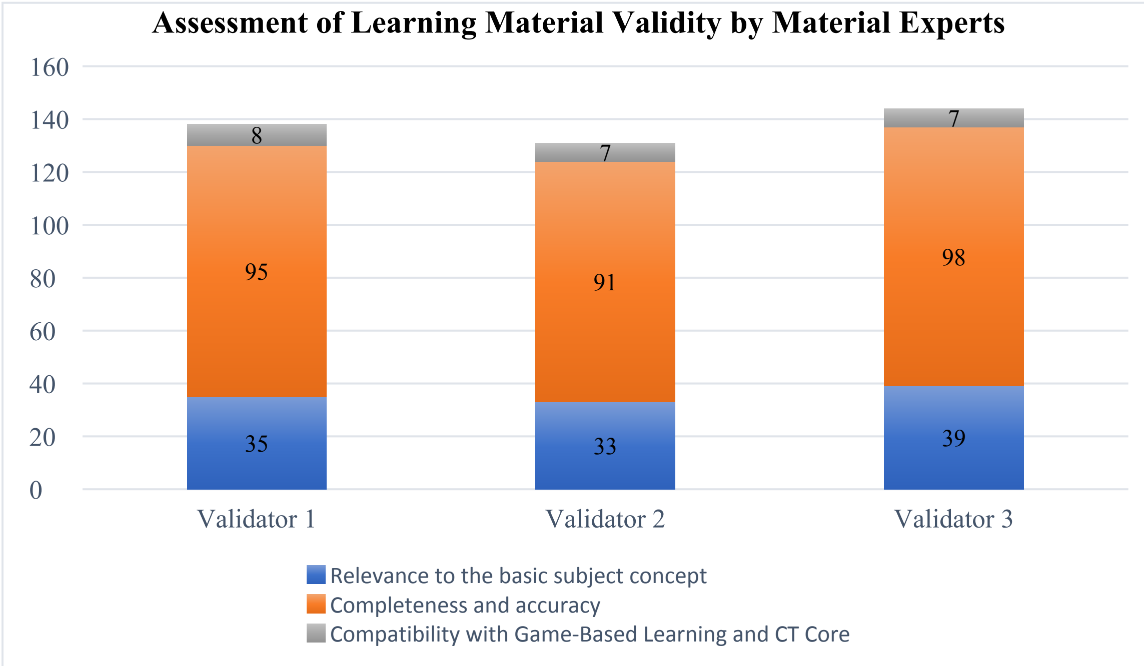


Figure 10. Description of the Assessment Result by Material Experts

Component	Validator-1	Validator-2	Validator-3
Mean	**138**	**135**	**144**
Mean total		**139**	

Table 1: Average assessment of learning material validity by material experts

Based on the material expert validation, it is known that the mean score of validator 1, 2, and 3 correspondingly are 138, 135 and 144 which fall in “Very Good”, “Good”, and “Very Good” categories. The mean total is 139 belonging to "Very Good" category. Thus, it can be concluded that the material aspect of the learning media is valid. This validity assessment is presented in Figure 11 and Table 2 below.

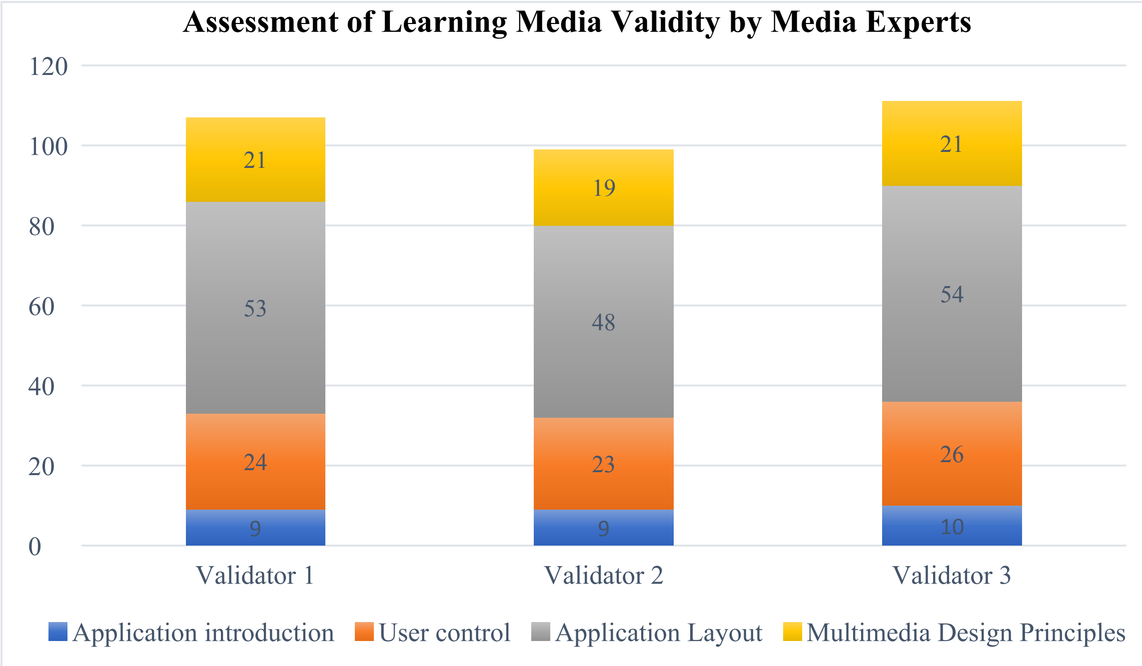


Figure 11. Description of the Assessment Result by Media Experts

Component	Validator-1	Validator-2	Validator-3
Mean	**107**	**99**	**111**
Mean total		**105.67**	

Table 2: Average assessment of learning media validity by media experts

The means obtained from the three validators are 107 (Very Good), 99 (Good), and 111 (Very Good) with the overall mean score of 105.67 (Very Good). Thus, it can be concluded that the media aspect of the learning media is valid. Conclusively, the interactive digital game based on computational thinking developed in this study has achieved the validity criteria of a product development in the aspects of material and media.

4. Implementation Stage

At the implementation stage, the researcher conducted a small class trial from which was found that the product being developed reached "Very Good" criteria. Next, the researcher conducted a large class trial of four classes of students from three elementary schools. The result of student responses in large classes was 81.9 in "Very Good" criteria. Therefore, we can conclude that students' assessments of the digital game developed in this study reach the practicality principle. 98 out of 123 students showed a very good impression regarding their experience in playing the game.

5. Evaluation Stage

At this stage, the researcher conducted a continuous evaluation which began with evaluating the test result of students' understanding of the multiplication concept in contextual problems. The mean score of the test was less than half of the maximum score, or more precisely less than 50. The evaluation was also carried out on the validation result at the development stage. The researcher made several revisions to the game, especially in the illustration of contextual problems and the appearance of game characters from a media perspective. Regarding the material perspective, the researcher also revised the legibility of contextual problems. According to students' assessment on the use of the game, researchers did not need to make revisions because more than 90% of students was very appreciative and enthusiastic to welcome the user-friendly game.

DISCUSSION

The use of the digital game integrated into mathematics learning generates a positive impact from students as users. In this game-based multiplication learning, the teacher uses a digital game specially designed to assist students' understanding of multiplication concepts by presenting contextual problems. This educational digital game is called Arithmetic-CT Monkey Game. This game gives students a fun and attractive learning experience with structured game content. Monkey Game Arithmetic-CT trains students' adaptation skills to solve various problems with varied difficulty levels. Even to win the game, students must use their creativity in passing challenges or solving contextual problems. While using this game, students get feedback from the system when they access the answer-checking feature. In this case, students can improve their answers because the game is designed with specific tasks to guide students 'learning by gaming'. Various supporting features are also designed to attract students' attention to this game with a storyline of everyday life. So emotionally, students also encounter meaningful experiences.

Game-based learning supported by the Arithmetic-CT Monkey Game application on the Android platform contains twelve characteristics of digital learning, some of which are enjoyment and fun, rule, control, challenge, stimulant censor, interaction, setting, realism, and victory condition, as stated by Prensky (2003). This learning also refers to two things- education and gameplay-, as well as achieving learning goals and a means of entertainment (Lin et al., 2020). Furthermore, Lin et al. (2020) state that the use of digital games in learning is designed by integrating the system into the experience of playing games. Because of this, a content design model and game features are often adapted to the behavioral habits of its users, such as rule, target, imagination, mystery, sensory stimulation, and control abilities (Garris et al., 2002). This underlies the conduct of several studies on computer use by children under seven years of age, which is considered to reduce children's important developmental tasks in terms of social and intellectual as well as other types of learning (Healy, 2000).

On the other hand, this game-based learning also loads core computational thinking. There are three levels with different levels of difficulty, namely level one for simple contextual problems that contain one particular variable and involve integers 1-5 as the numbers to be operated on; level two for simple contextual problems that contain one particular variable and involve integers less than ten; and level three for complex contextual problems that contain more than one variable. These problems are posed to assess students' cognitive abilities in sorting concepts into several components (the concept of addition and the concept of multiplication), then linking them together to understand the concept as a whole (the concept of multiplication is constructed from a repeated addition). In this case, core computational thinking abstraction is significant in determining students' success in solving contextual problems in games through analytical activities. The development of logical and systematic problem-solving instructions and the process of rechecking the correctness of each problem-solving step are indicators of students' cognitive capability achievement. Students' cognitive achievement is an implication of the ease of operation, and the continuous interaction between students and games during learning will build students' thinking habits while playing.

The contextual problems of multiplication that students must solve at each level are also used to assess students' psychomotor capability, which can be seen from their attitude or manipulation in the problem-solving process. Students must link various skills based on similarities or differences in patterns to predict or produce appropriate solutions just like core computational thinking pattern recognition. Students should know how to break down complex data or problems in order to effectively solve them, such as decomposition in the core of computational thinking. It is also an indicator of psychomotor abilities that students can achieve. Thus, the experience of 'learning by doing' is obtained by students when playing games, affecting their behavior and psychomotor capability when solving problems. Because with learning game-based mathematics, students transfer the abstractness of mental objects in their cognition into external representations or behaviors that can be observed so that their computational thinking skills increase. This is in line with the research result from Andriyani and Maulana (2019), which shows that a good learning experience is needed to acquire mathematical knowledge with abstract and hierarchical objects. With digital games in learning, students look enthusiastic about using interactive technology. Because technology reduces the abstractness of learning concepts, the students understand a learning situation more quickly (Buliali et al., 2022; Panthi et al., 2021).

CONCLUSION

The current interactive digital game as a support device for game-based learning can be said to meet the validity principle based on the results of the product feasibility test as indicated by the fulfillment of the "Very Good" category in the aspect of material and media. The practicality of learning media is also indicated by the achievement of "Very Good" criteria regarding student responses. Hence, digital games have effectively addressed contextual multiplication problems that previously posed challenges to students due to their limited grasp of multiplication concept. However, the researcher has not measured the overall effectiveness of digital games in game-based learning, so this possibility opens up as material for further research. Digital games can be an alternative to support students' cognitive achievement by facilitating the translation of abstract images of multiplication concepts and training students' psychomotor capability in solving multiplication contextual problems. By incorporating core computational thinking content, digital games have demonstrated their capability to facilitate cognitive development tasks and enhance psychomotor skills, exemplified by progressive level advancements. As a result, students become accustomed to a "learning by gaming" approach. Furthermore, students' feedback has provided evidence that the core of computational thinking heightens their enthusiasm for learning multiplication. With this core loads, students feel assisted in determining the optimal solution strategy through problem formulation activities and appropriate information processing.

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APPENDIX

ASSESSMENT SHEET OF THE LEARNING MATERIAL VALIDITY BY MATERIAL EXPERTS

A. PURPOSE

To assess the validity of the Arithmetic-CT Monkey Game of interactive learning media for application compatibility with Game-Based Learning and CT core quality, completeness, accuracy, and relevance to the basic subject concept by material experts.

B. INSTRUCTIONS

1. To Mr./Miss, please assess by giving a tick (√) in the column that has been provided that is appropriate with the following assessment criteria:
   1: Not Good
   2: Less Good
   3: Good Enough
   4: Good
   5: Very Good
2. To Mr./Miss, please advise on improvement by writing in the comment line suggestions that have been provided.

No	Assessment Criteria	Score				
		1	2	3	4	5
Compatibility with Game-Based Learning and CT Core						
1	The game content present problems whose solutions contain the abstraction core of computational thinking					
2	The game content present problems whose solutions contain the algorithm design of computational thinking					
3	The game content present problems whose solutions contain the pattern recognition of computational thinking					
4	The game content present problems whose solutions contain the decomposition of computational thinking					
5	The game content present problems whose solutions contain the debugging of computational thinking					

6	Games contain special learning that helpzs to solve problems related to the concept of multiplication.						
Completeness and accuracy							
7	Coherent in the preparation of material from simple concepts to more complex concepts						
8	Diversity in giving examples related to the concept of multiplication						
9	The accuracy of the problem given with the concept of multiplication						
10	Correctness of the problem-solving feedback						
11	Readability and clarity of information contained in-game issues						
Relevance to the basic subject concept							
12	Suitability of the material with the core competencies and basic competencies in the referenced curriculum						
13	The usefulness of games as learning media needed by students and facilitates the achievement of learning objectives						
14	Conformity of material with the truth of its substance						
15	Examples of clarity in illustrating the abstract concept of multiplication						
16	Coverage (breadth/depth) of the material						
17	Factual material and material actualization						
18	Appropriateness of the language used with the level of the cognitive and intellectual development of students						
19	Interactivity between students and games that attract student learning motivation						
20	Instruction traction						

Comment and Suggestion:
……………………………………………………………………………………………
..…………………………………………………………………………………………..
…..………………………………………………………………………………………..

C. CONCLUSION

In terms of material aspects, the Arithmetic-CT Monkey Game of interactive learning media states:

1. Worth
2. Worth using after revision
3. Not worth

Please give a circle sign of the choice of numbers provided as the assessment result.

..........., ……………… 2022

Validator,

………………………………….....

Matrix of Improvement

Title: Stimulation of Cognitive and Psychomotor Capability by Game-Based Learning with Computational Thinking Core

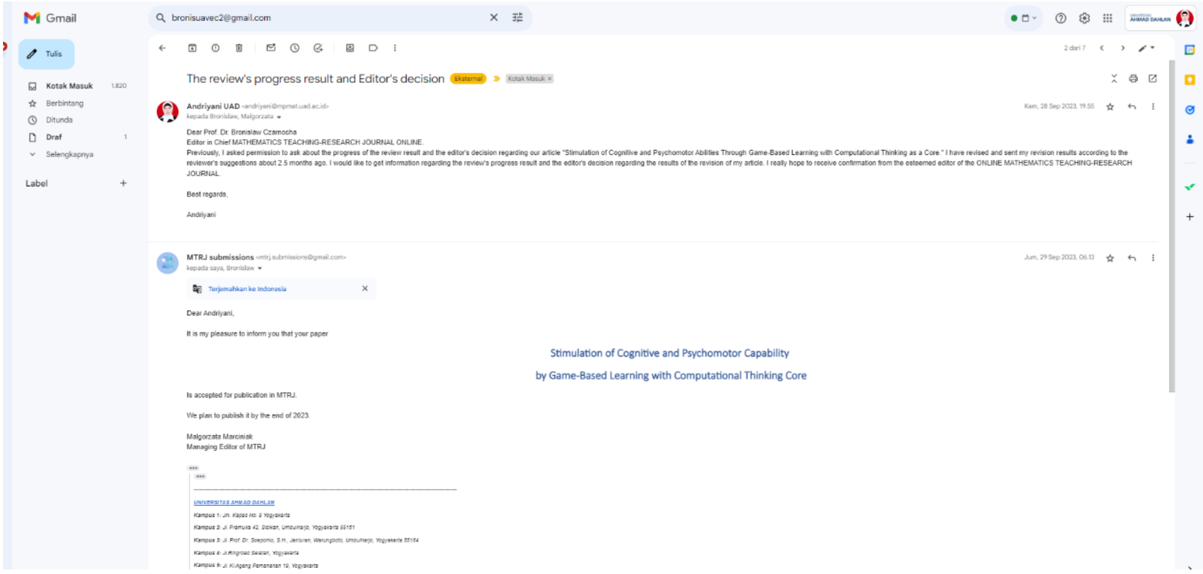
No	Original Text	Reviewer's Comment	Revised Text
1.	2. Tahap Desain	On page 8 explain the meaning of "Tahap Desain". (From Reviewer 1)	2. Design Stage (The previous text was still written in the author's native language.)
2.	The original text still uses the author's native language.	Figure 2. Digital Game Use Case Diagram needs to be translated into English completely. (From Reviewer 1)	Each explanation section related to the game product has been provided with a translation column.
3.	"…so the students easier to understand a learning situation (Buliali et al., 2022; Dikovic, 2009; Panthi et al., 2021)."	On page 24 fix "so the students easier to understand a learning situation", "easier" is not a verb. It is actually the comparative form of the adjective "easy." The verb form of "easy" is "ease." For example, you can say, "He eased the burden" or "She eased into the new routine." (From Reviewer 1)	"…the students understand a learning situation more quickly (Buliali et al., 2022; Panthi et al., 2021).
4.	Therefore, digital games are proven to solve contextual multiplication problems that were previously difficult for students due to their lack of understanding of the multiplication concept." "With core computational thinking content, digital games are proven to help with cognitive development tasks and psychomotor enhancement, represented by increasing each level. So that students are conditioned in the mode of 'learning by gaming.' The students' responses have also proven that the core of computational thinking increases their interest in learning	**In the conclusion the word "proven" is too "strong".** Change "Therefore, digital games are proven to solve contextual multiplication problems that were previously difficult for students due to their lack of understanding of the multiplication concept." For something like this: "Hence, digital games have been shown to effectively address contextual multiplication problems that previously posed challenges to students due to their limited grasp of	"Hence, digital games have been shown to effectively address contextual multiplication problems that previously posed challenges to students due to their limited grasp of the multiplication concept." "By incorporating essential computational thinking content, digital games have been demonstrated to facilitate cognitive development tasks and enhance psychomotor skills, exemplified by progressive level advancements. As a result, students become accustomed to a "learning by gaming" approach. Furthermore, the students' feedback has provided evidence

	multiplication."	the multiplication concept." Change "With core computational thinking content, digital games are proven to help with cognitive development tasks and psychomotor enhancement, represented by increasing each level. So that students are conditioned in the mode of 'learning by gaming.' The students' responses have also proven that the core of computational thinking increases their interest in learning multiplication." For something like this: By incorporating essential computational thinking content, digital games have been demonstrated to facilitate cognitive development tasks and enhance psychomotor skills, exemplified by progressive level advancements. As a result, students become accustomed to a "learning by gaming" approach. Furthermore, the students' feedback has provided evidence that the core of computational thinking heightens their enthusiasm for learning multiplication. In general, in the conclusion avoid using the word "proven". (From Reviewer 1)	that the core of computational thinking heightens their enthusiasm for learning multiplication." The word 'proven' has been avoided and replaced with other more relevant words.
5.	- Abstract exceeds 200 words. - Caption for table needs adjustment.	The paper should be placed in the new journal template (can be found on the	- Abstract has been reduced to 196 words.

		journal webpage). (From Reviewer 2)	- Caption for both figures and tables have been adjusted according to the template and custom (APA-based).
6.	No horizontal axis note is presented.	In Picture 1 (which should be properly labeled as Figure 1) the meaning of the horizontal axis is unclear. (From Reviewer 2)	The diagram has been completed with both horizontal and vertical axis notes.
7.	No reason is provided underlying the selection of the animal and fruits used in the game.	What is the reasoning for using monkeys, apples, and bananas? (From Reviewer 2)	Relevant reasons underlying the selection are presented on page 10. “In this digital game, there is a monkey character. Monkey is selected since it is a fable main character that sticks in the memories of many children in Indonesia. Children often hear it from their parents during their golden age in reading and listening activities. The fable's monkey character represents an agile animal with a lot of senses and likes to eat fruits, especially bananas and apples.”
8.	Below are few examples of original texts being revised. a. Next, the researcher prepares the initial design of the media by making a picture or representation of the interactions between the system and its environment or making a model of the behavior of the information system in the form of a diagram until it produces a product blueprint. b. In this case, the researcher interviewed mathematics teachers about the application of the curriculum used by schools to teach	The article has minimal typographical errors. (From Reviewer 1) The paper needs proofreading for spelling, grammar and wordy sentences. (From Reviewer 2)	Below are few examples of the revised texts. a. Next, the researcher prepared the initial design of the media by making a representation of the interactions between the system and its environment in the form of a diagram until it produces a product blueprint b. In this case, the researcher interviewed a mathematics teacher about the implementation of the school curriculum in teaching

	multiplication material in class. Based on the results of interviews with the mathematics teacher, it is known that the teacher delivers multiplication material limited to calculating two or more integers with an allocation of time per week is 4 × 45 minutes or two meetings with an allocation each session of 2 × 45 minutes. c. In addition to the learning methods used by the teacher, the researcher also conducted interviews about the teacher's teaching materials. The results of the interviews showed that the teacher's teaching materials were books that tended to be textual. This certainly does deficient attract students' interest in learning, which during the Coronavirus pandemic, often carried out online learning and accessed digital learning resources. d. The basis of game levelling refers to the complexity of the contextual problems presented at each level so that each level of the game has contextual problems with different levels of difficulty solving, as shown in Figure 4 (a)-(c) below.		multiplication. It was revealed that the teacher taught multiplication only limited to calculating two or more integers with time allocation of 4 × 45 minutes per week distributed in two meetings. c. In addition to the learning method, the interview discussed the teacher's teaching materials as well. Books, which are universally textual, served as the main materials. This dissuaded students' interest in learning, which during the Coronavirus pandemic, was often carried out online and utilized more digital learning resources than ever. d. The game level represents the complexity of the contextual problems as shown in Figure 4 (a)-(c) below.

Pada tanggal 28 September 2023, penulis meminta konfirmasi kepada editor terkait status artikel yang sudah dikirimkan oleh penulis dan pada tanggal 29 September 2023 editor mengkonfirmasi terkait status "Accepted" artikel penulis pada jurnal MTRJ (Mathematics Teaching-Research Journal).



Pada tanggal 19 Desember 2023, editor mengirimkan pemberitahuan terkait publikasi artikel di MTRJ Vo. 15 No 5 tahun 2023.

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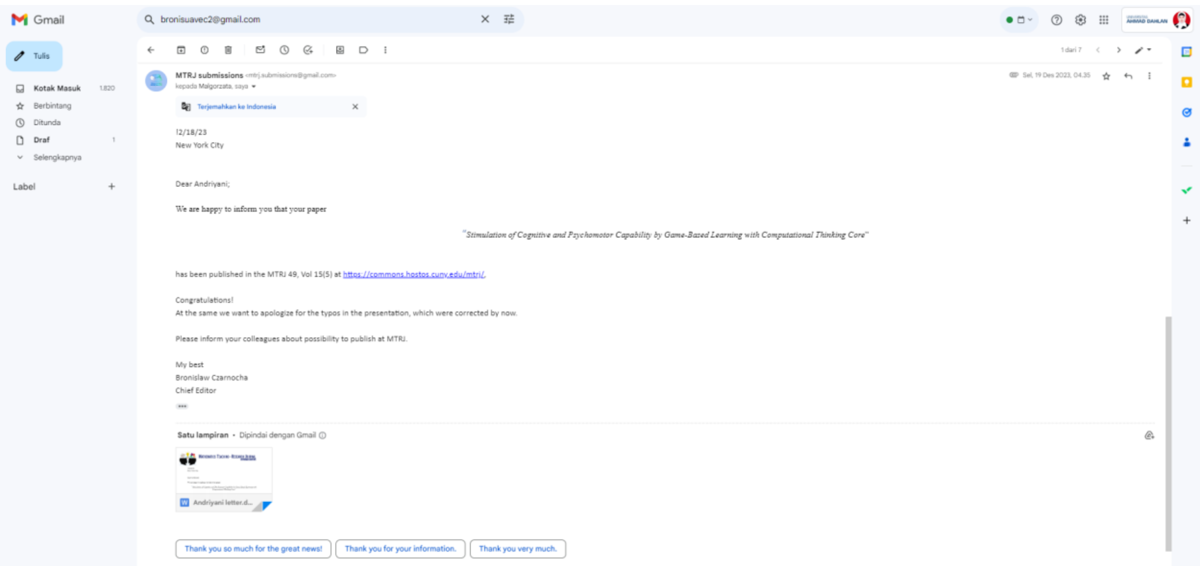

MATHEMATICS TEACHING—RESEARCH JOURNAL
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!2/18/23
New York City

Dear Andriyani;

We are happy to inform you that your paper

"*Stimulation of Cognitive and Psychomotor Capability by Game-Based Learning with Computational Thinking Core*"

has been published in the MTRJ 49, Vol 15(5) at https://commons.hostos.cuny.edu/mtrj/,

Congratulations!
At the same we want to apologize for the typos in the presentation, which were corrected by now.

Please inform your colleagues about possibility to publish at MTRJ.

My best
Bronislaw Czarnocha
Chief Editor

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