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GAME-BASED LEARNING DESIGN FOR INTEGER OPERATIONS USING DOJUKU TO ENHANCE MATHEMATICAL REPRESENTATION AND INTEREST

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ABSTRACT

Matematika merupakan mata pelajaran wajib mulai tingkat SD hingga SMA. Namun masih banyak siswa SMP yang merasa kesulitan terutama pada operasi bilangan bulat karena bersifat abstrak. Salah satu penyebabnya adalah rendahnya kemampuan representasi dan minat belajar siswa. Untuk mengatasi permasalahan tersebut diperlukan inovasi dalam pembelajaran. Observasi pada kelas VII SMP se-Jawa Barat menunjukkan bahwa siswa sangat menyukai permainan. Penelitian ini menggunakan *Formative Evaluation* Tessmer (1993) dengan subjek siswa sebanyak 30 orang, pendidik dan ahli pendidikan matematika. Instrumen penelitian meliputi lembar validasi ahli, tes evaluasi, angket dan wawancara. Penelitian ini bertujuan untuk mengetahui validasi, kemampuan representasi matematis, dan minat belajar siswa melalui media pembelajaran berbasis permainan Domino Jumlah Kurang (DoJuKu). Hasil analisis menunjukkan bahwa DoJuKu dapat memfasilitasi kemampuan representasi matematis dan minat belajar siswa pada kategori tinggi.

Mathematics is a compulsory subject from elementary to high school levels. However, many junior high school students still find it difficult, especially in integer operations, because they are abstract. One of the causes is the low representational abilities and learning interest of students. To overcome this problem, innovation in learning is needed. Observations in class VII of junior high school in West Java show that students really like games. This research used Formative Evaluation (Tessmer, 1993) with subjects of 30 students, educators and mathematics education experts. Research instruments include expert validation sheets, evaluation tests, questionnaires and interviews. This research aims to determine validation, mathematical representation abilities, and students' interest in learning through the game-based learning media Domino Jumlah Kurang (DoJuKu). The results of the analysis show that DoJuKu can facilitate students' mathematical representation abilities and learning interest in the high category.

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1. INTRODUCTION

Mathematics is a crucial component of the educational curriculum, taught from elementary school to higher education. As one of the subjects taught in formal educational institutions, mathematics plays a vital role in enhancing the quality of education (Novitasari, 2016). One of the objectives of mathematics in the 2013 curriculum, as stated in the annex of the Minister of Education and Culture Regulation No. 58 of 2014 (Permendikbud, 2014; Suningsih & Istiani, 2021) is: "The Mathematics Subject Guidelines aim to enable students to comprehend mathematical concepts, demonstrating competence in explaining the relationships between concepts and applying concepts and algorithms flexibly, accurately, efficiently, and appropriately in problem-solving. One of the indicators of achieving this competence is the ability to present concepts in various forms of mathematical representation, such as tables, graphs, diagrams, pictures, sketches, mathematical models, or other forms".

Based on an interview with a teacher at a junior high school in West Java on March 19, 2024, the primary issue is the low ability of mathematical representation and students' interest in learning mathematics, particularly in integer operations. Many students experience difficulties in understanding and interpreting mathematical concepts, resulting in poor problem-solving skills and negative attitudes towards the subject. The lack of conceptual representation and the perception that mathematics is difficult and boring are the primary factors contributing to the decline in students' interest in learning. Excellence in mathematics depends on the understanding and interpretation of concepts, where representation is a crucial component in learning (NCTM, 2000). In addition to mathematical thinking skills, interest also plays a vital role in the success of learning (Sirait, 2016). Developing interest encourages focus, perseverance, and concentration, and helps students retain information better and reduces boredom in learning.

The urgency of this research lies in the importance of enhancing the quality of mathematics learning to make it more engaging and easily understood by students. One way to achieve this is by developing an educational game-based learning model, such as DoJuKu (Domino Jumlah Kurang). An enjoyable and engaging learning model can be implemented through well-designed games, making it easier for students to understand and for teachers to deliver in the classroom. This approach is expected to facilitate students' understanding of the material more easily (Meitriani et al., 2023). This model is designed to assist students in understanding integer operations interactively, thereby enhancing their mathematical representation abilities and learning interest. This research is based on the fact that educational games have been proven to increase student engagement in learning, make abstract concepts more concrete, and create a pleasant learning atmosphere. Therefore, the DoJuKu-based learning design becomes an innovative solution relevant to addressing the issue of low understanding and learning interest in mathematics among seventh-grade junior high school students.

This research aims to develop and evaluate the feasibility of an interactive learning design for Integer Operations based on DoJuKu to enhance students' mathematical representation abilities and learning interest. To address this issue, the study will be conducted through several stages, including the development of an interactive learning design, implementation and testing in seventh-grade junior high school classes, and analysis and evaluation of learning outcomes. Data will be collected through validation sheets, mathematical representation tests, and learning interest questionnaires following the use of DoJuKu. The analysis results are expected to demonstrate the feasibility of DoJuKu in facilitating students' mathematical representation abilities and learning interest, providing an innovative alternative in mathematics education.

2. METHOD

The research approach employed by the researcher is qualitative. The method used in this study is Design Research (DR) type, which is particularly suitable for this study as it allows for iterative development and refinement of the DoJuKu media through a systematic cycle of design, implementation, evaluation, and revision. Unlike experimental or quasi-experimental methods, which primarily focus on testing the effectiveness of a predefined intervention, Design Research emphasizes the progressive improvement of educational tools

in authentic classroom settings (van den Akker, Gravemeijer, McKenney, & Nieveen, 2006). This iterative nature ensures that the learning media aligns with students' needs and real-world learning contexts, leading to more effective and meaningful instructional outcomes. Furthermore, Design Research has been widely used in the development of game-based learning media, as it provides a structured yet flexible framework for integrating pedagogical principles with engaging and interactive learning experiences (Plomp & Nieveen, 2013). This research was conducted in grade VII on the material of Operations on Integers. The research subjects were students at one of the Junior High Schools in West Java. This research design follows the Formative Evaluation model by Tessmer (1993), which facilitates the systematic refinement of the learning media through expert reviews, one-to-one evaluations, small group trials, and field tests.. The research development design flow is as follows:

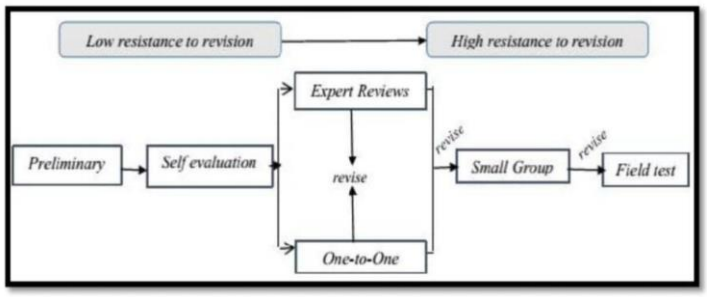

Figure 1. Design Flow of Formative Evaluation Type

The Preliminary Stage (in 4 weeks) of this study involved several essential analyses to establish the foundation for the DoJuKu-based learning design. The researcher conducted a student analysis to identify learners' characteristics, prior knowledge, and common difficulties in understanding integer operations. A material analysis was also performed to ensure the learning content was appropriate, accurate, and aligned with mathematical principles. Additionally, a needs analysis was carried out to determine both students' and teachers' requirements for effective learning media. To ensure alignment with educational standards, a curriculum analysis was conducted to integrate the learning design with national learning objectives. The outcome of this stage was the initial development of a DoJuKu-based learning framework tailored to support students in mastering integer operations effectively.

Following the preliminary phase, the research proceeded to the **Self-Evaluation Stage** (in 5 weeks), during which the researcher critically analyzed the initial design and sought peer feedback. This phase aimed to identify obvious errors, inconsistencies, or limitations in content presentation and instructional strategies. The researcher refined the design based on self-reflection and constructive feedback, leading to the development of Prototype 1. This prototype served as the first tangible version of the learning media, which was then subjected to further evaluation in subsequent stages.

In the **Expert Review and One-on-One Evaluation Stage** (in 3 weeks), Prototype 1 was assessed by subject matter and instructional design experts, and teachers. The Expert Review focused on evaluating the accuracy of content, the effectiveness of instructional design, and the technical quality of the media. Experts provided insights into potential improvements to enhance clarity, engagement, and usability. The feedback obtained from both experts and teachers was systematically analyzed and used to make necessary modifications, resulting in the development of Prototype 2.

The **Small Group Evaluation Stage** (2 weeks) followed, in which Prototype 2 was tested with a small group of students consisting of 5 participants. This phase aimed to assess the practicality and ease of use of the learning media. Students interacted with DoJuKu-based learning materials while the researcher observed their engagement levels, learning difficulties, and overall responses. Feedback from this phase was crucial in refining the instructional approach, correcting any remaining usability issues, and ensuring that the learning media was accessible and effective for a wider audience. The results from this stage informed the revision process, leading to the development of Prototype 3.

Finally, the **Field Test Stage** (3 weeks) was conducted to evaluate the effectiveness of Prototype 3 in real classroom settings. This stage involved implementing the refined learning media with the actual research participants to assess its impact on students' mathematical representation skills and their interest in learning. Data were collected through assessments (test), and student feedback to determine whether DoJuKu successfully enhanced students' understanding of integer operations. The findings from the field test provided the final validation of the learning media's effectiveness and potential for broader implementation in mathematics education.

Throughout each stage, feedback played a critical role in improving the design of the DoJuKu-based learning media. The iterative nature of the Formative Evaluation process allowed for continuous refinement, ensuring that each version of the prototype addressed previously identified weaknesses while maintaining alignment with pedagogical objectives. This structured approach ensured that the final product was both theoretically sound and practically effective in supporting student learning.

2.1. Research Subjects

The data sources in this study consist of two main groups: validators and respondents. The validators include two experts, namely a material expert and a teacher expert, who were selected based on their expertise and experience in mathematics education. The material expert was chosen for their specialization in mathematical content and curriculum alignment, while the teacher expert was selected based on their extensive teaching experience and familiarity with student learning difficulties in integer operations. Their role was to assess the accuracy, clarity, and pedagogical effectiveness of the DoJuKu-based learning media.

The respondents in this study were selected using purposive sampling, a technique that allows researchers to deliberately choose participants based on specific criteria relevant to the research objectives. The small group evaluation involved five students who represented a diverse range of mathematical abilities, ensuring that the feedback gathered reflected the perspectives of both high-achieving and struggling learners. These students were selected to provide in-depth insights into the practicality, usability, and potential challenges of the learning media before wider implementation.

For the field test, a total of 30 students participated, representing a broader sample of the target population. These students were from a junior high school in West Java and had varying levels of prior mathematical achievement. The selection of this sample ensured that the effectiveness of the DoJuKu-based learning media could be evaluated across students with different learning needs and abilities. The combination of expert validation and student feedback allowed for a comprehensive assessment of the instructional design, ensuring that the learning media was both theoretically sound and practically applicable in real classroom settings.

2.2. Data Collection

The researcher employed a comprehensive approach to data collection, utilizing multiple methods to ensure a thorough evaluation of the DoJuKu-based learning media. These methods included validation sheets, tests, questionnaires, and interviews, each serving a distinct purpose in the research process.

The validation process was conducted before the implementation of the learning media, involving assessments by two experts: a material expert and a teacher expert. They evaluated the content accuracy, instructional design, and technical feasibility of the DoJuKu media using structured validation sheets. Their feedback was instrumental in refining the learning media before its application in the classroom.

Following the implementation of the DoJuKu-based learning media, the researcher administered tests and questionnaires to assess its effectiveness. The test was designed to measure students' mathematical representation abilities, evaluating their capacity to interpret and express mathematical concepts after engaging with the learning media. The questionnaire aimed to assess students' interest in learning mathematics, providing insights into their engagement and motivation. Both instruments were distributed after the field test phase to capture the impact of the intervention on students' cognitive and affective learning aspects.

In addition, the researcher conducted semi-structured interviews with selected students and teachers to gain a deeper understanding of their experiences with the learning media. This interview method was chosen because it offers a balance between structured and open-ended questions, allowing for flexibility in responses while ensuring that key topics are covered. The advantage of semi-structured interviews lies in their ability to provide rich, detailed insights while allowing interviewees to elaborate on their thoughts, which might not be captured through standardized questionnaires alone. The interviews focused on identifying strengths, potential challenges, and areas for improvement in the DoJuKu-based learning design.

By integrating quantitative (tests and questionnaires) and qualitative (interviews and expert validation) data collection techniques, the study ensured a comprehensive assessment of the DoJuKu media's effectiveness. This mixed-method approach enabled a more nuanced understanding of both the measurable learning outcomes and the subjective experiences of students and teachers, strengthening the overall validity of the research findings.

Expert Validation

The researcher aimed to collect data related to the validation of the learning design, mathematical representation abilities, and students' learning interest. The validation sheet was presented to expert validators, comprising media experts and subject matter experts, namely lecturers from the Mathematics Education Study Program at Islamic University of Nusantara and mathematics teachers at the junior high school level. Table 1 presents the validation sheet's rubric for expert review (Modified from Nesri, 2020).

Table 1. Expert Validation Checklist Template

No	Assessment Criteria	Number of Instrument Items
1	*Content*	5
2	*Design*	11
3	*Technical Quality*	3
Total		**19**

In addition to expert review, one-to-one validation is also required to serve as a validator. The following is the validation rubric for subject matter expert teachers (Modified from Putra etc, 2019).

Table 2. Expert Teacher Validation Checklist Template

No	Assessment Criteria	Number of Instrument Items
1	Clarity	6
2	Relevance	4
3	Common Error	5
	Total	**15**

Evaluation Test

Representation refers to students' ability to communicate mathematical ideas or concepts learned through a specific method. According to Sumarmo (2010) (Rahmadian et al., 2019), the indicators of mathematical representation ability are: 1) identifying relationships among various representations of concepts and procedures, 2) understanding relationships between mathematical topics, 3) applying mathematics to other fields or in everyday life, 4) understanding equivalent representations of a concept, 5) identifying relationships between one procedure and another in everyday life, and 6) applying relationships between mathematical topics.

The test administered was in the form of descriptive questions on integer operations, taking into account the indicators of mathematical representation ability. The following is the test evaluation question grid, as shown in Table 3 below:

Table 3. Test Specification for Evaluation

Competency Indicator	Learning Objective	Question Number
Identifying relationships among various representations of concepts and procedures.	Determining the results of addition and subtraction operations with integers.	1
Understanding the relationships between mathematical topics.	Determining the results of addition and subtraction operations with integers.	2
Applying mathematics to other fields or real-life situations	Solving real-world problems involving integers.	3
Understanding equivalent representations of a concept..	Determining the results of addition and subtraction operations with integers.	4
Identifying connections between procedures in everyday life.	Solving real-world problems involving integers.	5

Applying connections between mathematical topics.	Determining the results of addition and subtraction operations with integers.	6

2.3. Data Analysis

This research employs a mixed-methods approach, utilizing both qualitative and quantitative data analysis. Qualitative data were obtained from feedback provided by validators, subject matter experts, language experts, and media experts. In contrast, quantitative data revealed the outcomes of developing a mathematics learning design based on DoJuKu. Subsequently, data processing involved assessing the validity of the DoJuKu design by tabulating the validation results and assigning a scoring assessment. The scoring criteria, adapted from (Sugiyono, 2010) are presented in Table 4 below:

Table 4. Validation Scoring Criteria

No	Score	Rating Scale
1	0	Not Yet
2	1	Yes

Furthermore, the average score was converted to a qualitative value based on the evaluation criteria, as referenced in (Fatmawati, 2016), presented in Table 5 below:

Table 5. Criteria for Validation Evaluation

No	Percentase	Level of Validity
1	85,01% s.d 100%	Highly Validity
2	70,01% s.d 85%	Validity
3	50,01% s.d 70%	Less Validity
4	0% s.d 50%	No Validity

To calculate the validation score, the following formula was used, as proposed by (Fatmawati, 2016):

$$Validity\ (V) = \frac{\text{Score Obtained}}{Maximum\ Score} \times 100\%$$

In addition to analyzing the validation sheet, a clear scoring guideline is required to accurately measure students' mathematical representation abilities. This guideline serves as a reference for assigning scores to each question indicator. The following is the scoring guideline for mathematical representation abilities, adapted from (Abdurahman & Haryadi, Dinda Ramadhia, Sarah Inayah, 2023):

Table 6. Scoring Rubric for Ability Tests

Indicator	Score	Description
Verbal Representation	3	Writing logical, accurate, and complete explanations.
	2	Writing logical explanations that are either incomplete or inaccurate.
	1	Writing illogical explanations.
	0	Failed to provide an answer or demonstrated a lack of understanding of the concept
Figure Representation	3	Creating complete and accurate drawings.
	2	Creating complete drawings with some error.
	1	Creating incomplete drawings.
	0	Failed to respond or demonstrated a lack of understanding of the concept

Indicator	Score	Description
Symbol Representation	3	Developing a correct mathematical model and performing accurate calculations.
	2	Developing a correct mathematical model but making errors in calculations
	1	Developing an incorrect mathematical model.
	0	Failed to respond or demonstrated a lack of understanding of the concept.

Following the scoring process, the research results were categorized into three levels: high, moderate, and low. According to (Ananda & Fadhil, 2018), the categorization of test results for ability is presented in Table 7 as follows:

Table 7. Categories of Answers for Ability Tests

Score Criteria	Categori
$X > Mi + 1{,}5\ .SDi$	Very Good
$Mi + 0{,}5\ SDi < X \leq Mi + 1{,}5\ SDi$	Good
$Mi - 0{,}5\ SDi < X \leq Mi + 0{,}5\ SDi$	Adequate
$Mi - 1{,}5\ SDi < X \leq Mi - 0{,}5SDi$	Poor
$X \leq Mi - 1{,}5\ .SDi$	Extremely Poor

Furthermore, a questionnaire analysis was employed to measure students' interest in mathematics learning. The respondents' data were tabulated and evaluated by assigning scores to each aspect. The scoring utilized a Likert scale with five options: strongly agree, agree, undecided, disagree, and strongly disagree. The scoring guidelines for the students' interest in learning questionnaire can be seen in Table 8 as follows:

Table 8. Scoring Rubric

No	Scale	Score	
		Positive	Negative
1	Strongly Agree	5	1
2	Agree	4	2
3	Neutral	3	3
4	Disagree	2	4
5	Strongly Disagree	1	5

Next, the average scores obtained were converted into qualitative values according to the evaluation criteria. The evaluation criteria, as proposed by (Fatmawati, 2016) are as follows:

Table 9. Assessment Criteria for Students' Interest

No	Percentase	Level of Interest
1	85,01% s.d 100%	Very Interested
2	70,01% s.d 85%	Interest
3	50,01% s.d 70%	Less Interest
4	0% s.d 50%	No Interets

3. RESULT AND DISCUSSION

3.1. Result

This chapter presents the results of data analysis in accordance with the objectives outlined in Chapter I, which employed the Design Research (DR) method with the Formative Evaluation model (Tessmer, 1993) as explained in Chapter II. The following are the stages of the research findings.

Preliminary Research

The results of the interviews with junior high school teachers revealed that the majority employed conventional methods in their teaching practices, although some had attempted to incorporate games into mathematics instruction. When asked about the importance of games, most teachers considered them essential and predicted that students would feel enthusiastic, interested, and motivated, with the hope that games would enhance their interest in learning mathematics. In line with this, interviews with students revealed that almost all enjoyed playing games, particularly online games, but the majority struggled with and lacked understanding of mathematics instruction. Additionally, the school's policy prohibiting students from bringing mobile phones to school also had an impact. Based on these findings, the researcher designed a Games-Based Learning instructional design to improve students' mathematical representation abilities and interest in learning mathematics. The resulting design is presented in Figure 2.

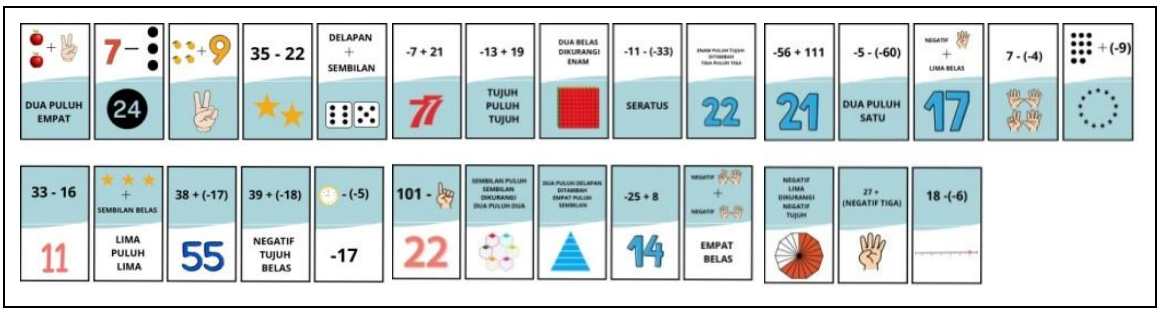

Figure 2. Preliminary Design

In the initial design, the researcher developed a paper-based game that adapted the domino game with 28 cards, each having two sides. The game was named Domino Mathematic (Do-Math) and aimed to facilitate students' mathematical representation abilities and learning interest. Do-Math incorporated mathematical materials and problems in a game format, where students had to connect problem cards in sequence by solving operations on the cards to match them with the answers on other cards, thus connecting the cards like a domino game.

Prototyping Phase Self Evaluation

At this stage, the researcher re-examined the media design developed in the preliminary stage. Based on the results of the re-examination, the initial design that adopted a conventional domino game with 28 cards was revised to 20 cards with three levels of difficulty. The revision was made because the game took a long time to play and did not show significant differences in cognitive aspects between cards, as well as for moral considerations and to expand the scope of media usage. The name of the media was also changed from "Do-Math" to "Domino Jumlah Kurang (DoJuKu)" to focus on addition and subtraction operations. The results of this re-examination produced Prototype 1 along with a user manual, as shown in Figure 3 and Figure 4.

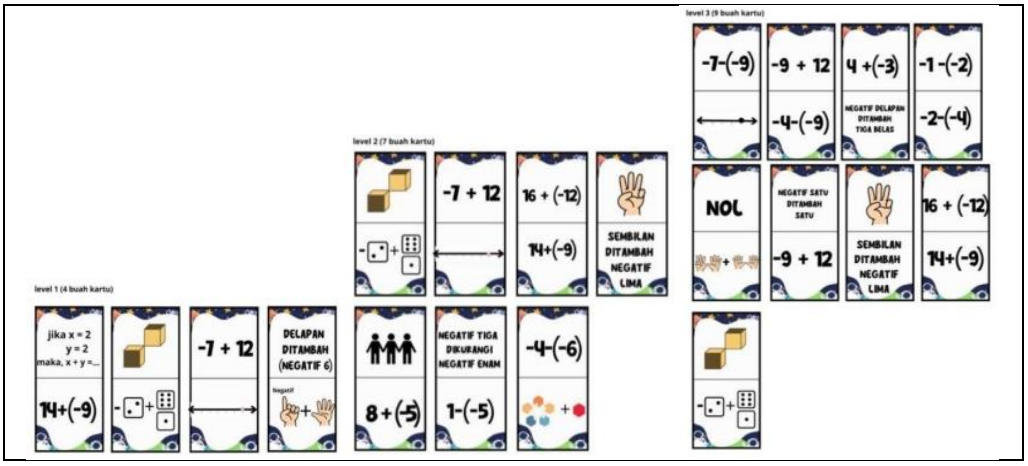

Figure 3. Prototype 1 of DoJuKu Media

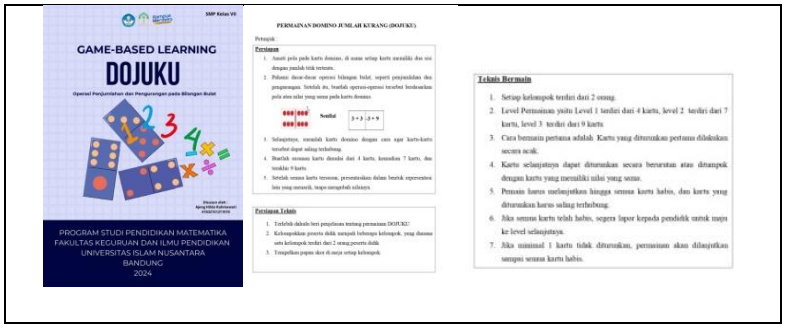

Figure 4. Pre-Revised DoJuKu Guidebook

Expert Review and *One-To-One*

During the expert review stage, Prototype 1 and the user manual, which had been compiled and revised, were validated by a subject matter expert validator from the Mathematics Education Study Program at the Islamic University of Nusantara. The validation results indicated that the media was feasible for development with several revisions. Two major revisions suggested were improvements to the cover, scenario, and game stages, as well as the addition of more detailed instructions. The validator also recommended using thicker paper for printing the domino cards. The validation assessment results from the validator are presented in Table 10 as follow:

Table 10. Expert Validation of Learning Materials

Validator	Assessment Aspects	Number of Items	Maximum Score	Score Obtained	Criteria
Subject Matter Expert	Aspect of *Content*	5	5	5	$V = \frac{\sum x}{\sum xi} \times 100\%$ $= \frac{19}{19} \times 100\%$ $= 100\%$
	Aspect of *Design*	11	11	11	
	Aspect of *Technical Quality*	3	3	3	
Quantity		19	19	19	Highly Valid

Based on Table 10, the validation results from the subject matter expert validator showed a score of 19 with a percentage of 100%, indicating that the DoJuKu-based learning design is highly valid. Therefore, the DoJuKu media was declared highly valid in terms of content, design, and technical quality, making it suitable for field testing with students.

During the One-To-One stage, Prototype 1 and the user manual, which had been compiled and revised, were field-tested by a mathematics teacher validator from a Junior High School in West Java. The validation results indicated that the media was feasible for development with several suggested improvements, including the addition of game instructions to clarify understanding and enhance the clarity of media usage. The validation assessment results from the subject matter expert validator can be seen in Table 11.

Table 11. Teacher Expert Validation

Validator	Assessment Aspects	Number of Items	Maximum Score	Score Obtained	Criteria
Expert Teacher	Aspect of Clarity	6	6	6	$V = \frac{\sum x}{\sum xi} \times 100\%$ $= \frac{15}{15} \times 100\%$ $= 100\%$
	Aspect of Attractiveness	4	4	4	
	Aspect of Common Errors	5	5	5	
Quantity		15	15	15	Highly Valid

Based on Table 11, the validation results from the teacher validator showed a score of 15 with a percentage of 100%, indicating that the DoJuKu media is highly valid. Therefore, the DoJuKu media was declared valid in terms of clarity, attractiveness, and common errors, making it suitable for field testing with students.

Based on the validation from the subject matter expert and teacher expert, the researcher revised the media and user manual, resulting in Prototype 2, which is presented in Figure 5 and Figure 6.

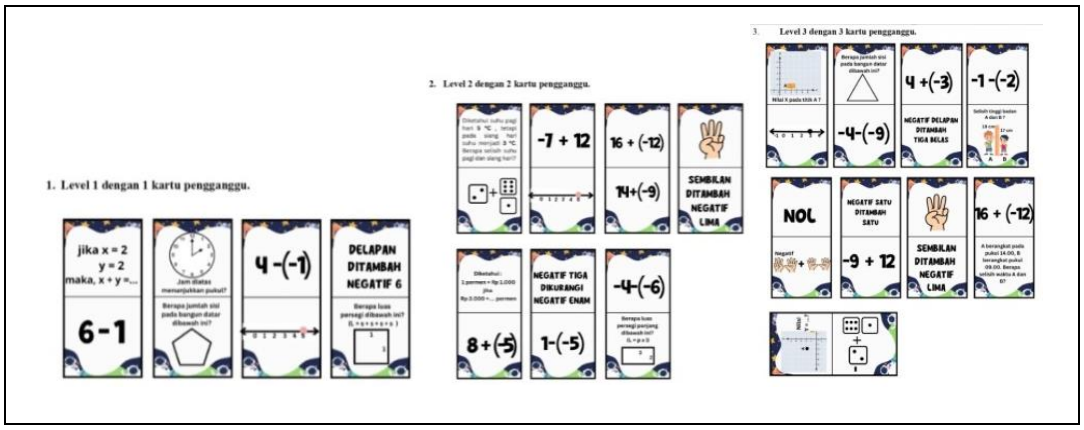

Figure 5. Revised DoJuKu Media Prototype 2

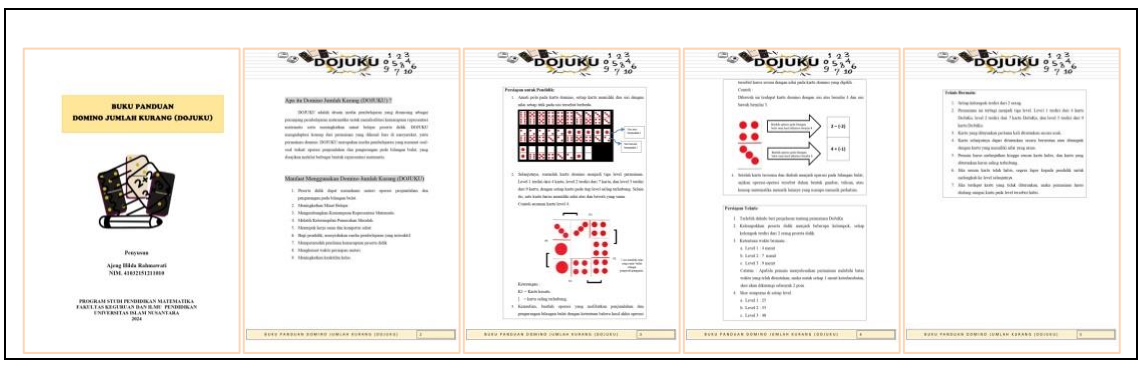

Figure 6. The Revised DoJuKu Instructional Manual

Small Group

Prototype 2 was tested on five grade VII junior high school students. Based on the participants' feedback regarding the error in writing the final result assistance, the researcher revised the media and produced Prototype 3, which is presented in Figure 7.

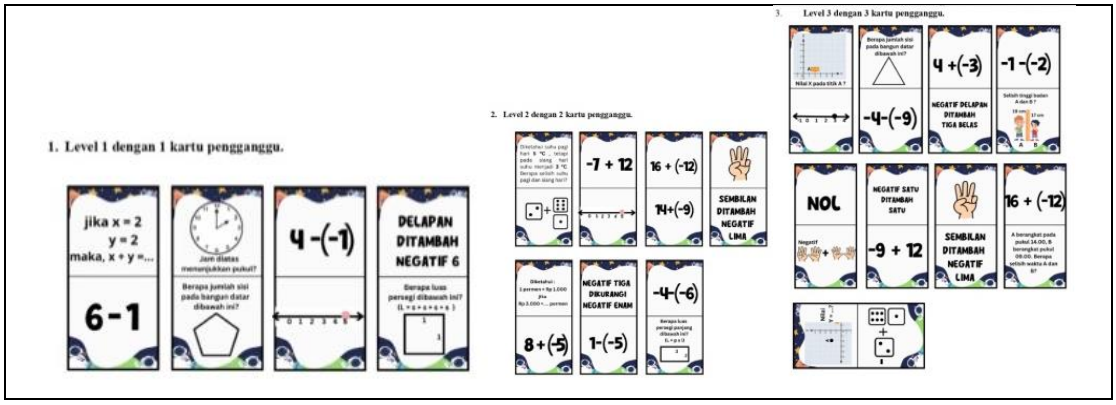

Figure 7. Prototype 3 DoJuKu Media

Field Test

At this stage, a field test was conducted for Prototype 3. In this stage, students were given a time limit of 20 minutes to complete three levels of the DoJuKu game. The final average score obtained by the students was 90.93

The next stage was the evaluation through a test assessing mathematical representation ability and a questionnaire on students' learning interest. The evaluation test results were used to measure students' mathematical representation ability in integer operations through six essay questions after learning with DoJuKu. The students' test results can be seen in Table 12 as follows:

Table 12. Mathematical Representation Skills Evaluation Test Score Summary

Description	Quantity/Value
Number of Students	30
Maximum Score	18
Minimum Score	0
Total Test Score	371
Mean Ideal (Mi)	9
Standar Deviasi Ideal (SDi)	3

Based on Table 12, the overall score of the evaluation test on students' mathematical representation ability was 371. This result was categorized into three levels - high, moderate, and low - to facilitate data analysis and interpretation. The complete categorization can be seen in Table 13 as follows:

Table 13. Individual Ability Test Categorization Results Data

Scoring Criteria	Categori	Quantity	Percentase
$X > 14$	Excellent	8	26,7%
$11 < X \leq 14$	Good	13	43,3%

$8 < X \leq 11$	Adequate	6	20%
$5 < X \leq 8$	Poor	2	6,7%
$X \leq 5$	Extremely Poor	1	3,3%

Table 14. Classroom Ability Test Categorization Results Data

Number of Students	Score Obtained	Percentase	Categori
30	371	68,7%	Good

Furthermore, the results of the students' learning interest questionnaire, which was completed by students after learning with DoJuKu and finishing the test, are presented in Table 15:

Table 15. Summary of Learning Interest Questionnaire Score Achievement

No	Percentase	Level of Interest	Percentage of Students
1	85,01% s.d 100%	Very Interested	76,7%
2	70,01% s.d 85%	Interest	23,3%
3	50,01% s.d 70%	Less Interested	0%
4	0% s.d 50%	No Interest	0%

3.2. Discussion

The Validation Results

The validation results of this learning design aim to ensure the feasibility of field testing. According to theory, learning design facilitates the learning process through short-term and long-term stages, encompassing analysis, design, development, implementation, and evaluation (Mudlofir, 1967). The validation of the learning design aims to measure its feasibility and gather input for refining the media to ensure its readiness for implementation. This process was conducted by one media expert and one subject matter expert, with the following validation results.

The subject matter expert's validation results indicated that the media is feasible for testing with revisions based on the suggestions provided. The main revisions include improvements to the cover, scenario, game stages, and the addition of more detailed instructions. The validator also recommended using thicker paper for the domino cards. The average evaluation score reached 100% (Table 10), indicating that the integer operation-based learning design using DoJuKu is highly valid.

Following the subject matter expert's validation results, the teacher validator, a mathematics educator at a junior high school in West Java, stated that the DoJuKu media is feasible for testing without revision, but with notes and suggestions for improvement. The validator recommended adding game instructions to enhance the clarity of media usage, which was subsequently revised by the researcher. Based on Table 11, the validation results showed a score of 15 with a percentage of 100%, categorizing DoJuKu as "Very Valid." With aspects of clarity, attractiveness, and minimal errors, this media is suitable for testing in integer operation learning.

Mathematical Representation

Mathematical representation ability enables students to communicate mathematical concepts through various forms of expression and plays a crucial role in conceptual understanding (Sari et al., 2019). To support this, the researcher developed a learning design that facilitates mathematical representation ability and measures it using the developed

media. Based on Table 4.4, the majority of students fell into the categories of "Excellent" (26.7%), "Good" (43.3%), "Fair" (20%), "Poor" (6.7%), and "Very Poor" (3.3%). Overall, one class achieved a score of 371 with a "Good" category (Table 4.5). This success was supported by an interactive classroom atmosphere and students' enthusiasm towards the new learning method.

Students with a 'Fair' score experienced difficulties due to errors in answering, incomplete problem-solving, and distractions from peers. The less conducive classroom environment after physical education also affected their concentration. Meanwhile, students with 'Poor' and 'Very Poor' scores tended to have low focus levels and limitations in reading and writing. In contrast, students with 'Good' and 'Excellent' scores demonstrated improvements in calculation, particularly addition, subtraction, and positive-negative number operations. Their learning interest and enthusiasm for game-based learning motivated them to be more enthusiastic, spirited, and interactive throughout the learning process.

Based on the measurement of test answer categories (Ananda & Fadhil, 2018), the majority of students who learned with DoJuKu demonstrated good mathematical representation abilities. This result indicates that DoJuKu can be a viable solution in facilitating mathematical representation abilities, particularly in mathematics learning.

Students' Interest in Learning

Besides mathematical representation ability, students' interest in learning mathematics is also crucial to ensure they feel enjoyable and motivated throughout the learning process. Learning interest refers to the acceptance of the relationship between oneself and the environment (Sitompul, 2018), where a stronger relationship leads to greater learning interest. This study aimed to develop a learning design for integer operations based on DoJuKu to enhance students' learning interest. The measurement of learning interest was conducted through a questionnaire administered after the learning process.

The questionnaire results presented in Table 15 show an average score of 90%. Referring to the measurement of students' learning interest interpretation (Fatmawati, 2016), students who learned with DoJuKu demonstrated an excellent interpretation of learning interest. Therefore, DoJuKu can be a solution to address the low learning interest in mathematics.

4. CONCLUSION

Based on the research findings, the DoJuKu media was determined to be appropriate for use without requiring any revisions. The study indicated that students demonstrated a high level of mathematical representation ability, reflecting their capacity to effectively interpret and express mathematical concepts. Furthermore, their interest in learning was classified within the excellent category, suggesting strong engagement and enthusiasm for the subject matter. These results highlight the effectiveness of the DoJuKu media in supporting both cognitive and affective aspects of students' learning experiences, as it not only enhances their ability to understand and represent mathematical concepts but also fosters a positive attitude toward learning, ultimately contributing to a more meaningful and engaging educational process.

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