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Development of Dakota Game to Enhance Conceptual Understanding of GCF and LCM Using a Design Thinking Approach

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Abstract. *The Industrial Revolution 4.0 has significantly impacted various aspects of life, including education, particularly using information and communication technology in learning processes. This study employs the Research & Development (R&D) method, aiming to develop the Dakota Game to Improve Conceptual Understanding of GCF (Greatest Common Factor) and LCM (Least Common Multiple) among fifth-grade students. The Dakota educational game was developed using the 4-D development model, although its distribution was limited to the school where the research was conducted. The study involved fifth-grade students at BUQ Betengan Demak Elementary School. Validation results from material and media experts indicate that the developed Dakota educational game is suitable for learning. Additionally, student responses were positive, with an average percentage of 92%. Meanwhile, the pretest results before students used the Dakota Game showed an average score of 75.25, while post-treatment scores after using the game averaged 84.45. This result demonstrates that the Dakota educational game for GCF and LCM material can enhance students' conceptual understanding and meet the criteria for being an effective and appropriate mathematics learning medium for fifth-grade classrooms.*

Keywords: *Dakota Game, Conceptual Understanding, GCF, LCM*

INTRODUCTION

Mathematics is one of the subjects at all levels of education in schools, because learning mathematics is the most important part so that students can continue to the next level. Because learning mathematics trains students to think critically and actively and creatively in solving problems (Nurhayati & , Langlang Handayani, 2020). Mathematics education aims to cultivate students' problem-solving abilities in real-life contexts while enhancing their capacity for logical reasoning through mathematical symbols and numerical operations (Ismail in Basir, 2015;(Nur Hidayat, 2017). Nurhamidin & Buhungo (2020) emphasize that education constitutes a deliberate and systematic effort to facilitate learning processes, encompassing the transfer of knowledge, values, and skills via diverse

instructional methods such as teaching, training, and guided learning. In the application of mathematics learning, students are invited to think critically according to the level of education needed to solve problems related to everyday life, in the students' assumption that mathematics lessons are counting, memorizing formulas, and analyzing a problem (Yusuf Al-Amin, 2021). Within this framework, media integration is pivotal in simplifying abstract mathematical concepts, making them more accessible to students (Wibowo et al., 2021). In today's modern era, technological developments demand more innovation in efforts to improve the quality of education today, namely in the development of learning media so that learning is more interesting and innovative. Maximizing media utilization will help students maximize the learning process.(Vemsi Damopolii, Nursiya Bito, 2019). Anderson and Krathwohl (2010) further posit that genuine understanding occurs when learners construct meaning from instructional information, a principle echoed by Ubaidah & Aminudin (2018) in the context of mathematics education. The general objective of mathematics lessons in elementary school is to train students to think logically, carefully, honestly, rationally, effectively and so that students can apply mathematics in their lives and apply it to various sciences (Nurohmah, 2019).The learning process is a method used by an institution to plan an educational program carried out with various activities with the aim of realizing educational targets for students, because the main key to achieving national progress is the start of quality education (Susilowati, Y., & Sumaji, 2024).

Mathematics learning has one of the goals, namely conceptual understanding. Conceptual understanding is the ability that is related to ideas so as to form a comprehensive and functional understanding. Mathematical concepts have a structured nature, therefore students should have a deep conceptual understanding so that students can solve contextual problems related to various mathematical concepts (Buchori et al., 2022). Understanding is a person's ability which includes translating, interpreting, or stating something in his own style of language according to the knowledge he has received (Tia et al., 2024). NCTM (Bartell, Webel, Bowen, & Dyson,2013:58) states that conceptual understanding is the most fundamental goal in learning mathematics. Students will find it easy to

solve problems in mathematics when they understand the concept of mathematics itself. Radiusman (2020) foundational grasp of mathematical concepts—defined by Ruseffendi (2006) as abstract ideas enabling the classification of objects and phenomena—is critical. Wardhani (2008) elaborates that conceptual understanding entails articulating relationships between objects with precision, a competency Anggraeni (2017) identifies as indispensable for students to apply mathematical knowledge autonomously. However, contemporary classroom practices often remain teacher-centred, relying on passive methods like lectures and conventional tools such as worksheets and textbooks. Bruner stated that learning mathematics is learning about the mathematical concepts and structures being studied in the material, and looking for relationships between mathematical structures and concepts (Fujianti, 2023). The ability that needs to be developed during mathematics learning is mathematical communication ability. Mathematical communication ability is a student's ability to organize things into spoken language or written form. So that a student will be able to communicate to convey certain ideas or thoughts both verbally and in writing (Mimin Ulyawati, Agung Handayanto, 2020).

This approach contrasts with the pedagogical imperative to foster active, creative student engagement (Istiani & Arnidha, 2018). The use of information technology is a very effective and relatively efficient way to convey information, as one of the media that has many advantages in conveying information in today's era as an effort to improve the quality of learning, namely with computer media (Imansari & Sunaryantiningsih, 2017). Learning media is a method to provide concrete concepts regarding the material being taught and as a supporting tool for teachers when teaching their students, so that teachers can convey the material easily (Ardhia et al., 2019). Dakota media is used to explain concepts related to LCM and GCF, with Dakota media students are expected to understand the factorization and multiples explained by the teacher and students are also able to think critically when encountering questions related to everyday life by applying the concepts of LCM and GCF (Zahra Shintya Dewi, 2025). Design Thinking is an innovative, solution-oriented approach to problem solving. This method is carried out iteratively with a focus on deep understanding of users, systems, or products,

and by questioning existing assumptions and reformulating problems to produce solutions that are in accordance with user needs and desires (Assaufa & Arifin, 2022).

According to Kelley & Brown, Design Thinking is a human-centered approach, utilizing design tools to combine user needs, technical possibilities, and business feasibility to achieve organizational or company goals. This method is effective in addressing complex and complicated problems, allowing designers to find new, innovative approaches to solving the challenges faced.

Preliminary observations and interviews with fifth-grade teachers at SD Bustanu Usysyaqil Qur'an Betengan Demak (e.g., Ibu Fatimatuzzahra, S.Pd.) revealed persistent student difficulties in comprehending Greatest Common Factor (GCF) and Least Common Multiple (LCM) concepts. To address this, we propose the development of Dakota, an Adobe Animate-based educational game designed to synergize play and learning while enhancing student motivation. Unlike prior interventions—such as Rico Baskara Putra's (Yogyakarta State University) physical *Dakon Mathematics* board game with marbles—this study's digital iteration leverages smartphone/computer accessibility and interactive features to optimize engagement.

The novelty of the Dakota game lies in its Adobe Animate platform, which introduces dynamic functionalities absent in traditional implementations (e.g., pegboard designs with static numerical displays; Istiani & Arnidha, 2018). By adopting a design thinking approach, this research evaluates the efficacy of the Dakota game in improving students' conceptual understanding of GCF and LCM, thereby contributing to innovative, technology-driven mathematics pedagogy.

RESEARCH METHOD

According to Sembiring (2022), Research and Development (R&D) is a method aimed at producing a specific product and testing its effectiveness. In the preliminary study stage, the researcher conducted observations and interviews with a fifth-grade teacher at Bustanu Usysyaqil Qur'an Elementary School, Mrs. Fatimatuzzahra, S.Pd. Subsequently, the researcher distributed a needs analysis

questionnaire to fifth-grade students. This study aims to examine the effectiveness of the Dakota media in enhancing students' conceptual understanding of the Greatest Common Divisor (GCD) and Least Common Multiple (LCM) using a design thinking approach, which includes the initial stages of empathize, define, ideate, and Prototype.

In this research, the researcher collected two data types for analysis: qualitative and quantitative. Qualitative data were obtained from feedback and suggestions from the supervising lecturer, subject matter experts, media experts, and the fifth-grade teacher at Bustanu Usysyaqil Qur'an Elementary School in Betengan, Demak. Additionally, qualitative data were derived from evaluations assessing the quality of the Dakota educational game media after its trial implementation. Meanwhile, quantitative data consists of assessment scores from learning media evaluation instruments, including expert media validators, teacher and student evaluations via instrument sheets, and student learning test results. Quantitative data plays a crucial role in evaluating the effectiveness of the developed media, serving as an indicator of learning success. Data collection was carried out through observation, interviews, and questionnaire distribution.

The analyzed data in this study included pretest and posttest results conducted during the learning process. The data analysis techniques employed were qualitative descriptive analysis to interpret narrative data from questionnaires and observation sheets and quantitative analysis to process numerical data, such as student learning scores.

Furthermore, quantitative data analysis techniques were used to process numerical data from media and material validation assessments. A Likert scale was also applied to student questionnaires to gauge their responses to the Dakota media after the learning process. To measure student needs and test media validity, a Guttman scale was utilized, allowing binary responses ("Yes" or "No") as explained by Sugiyono (2015:139). The quantitative data were then analyzed by calculating percentages using the following formula:

$$\text{Precentage} = \frac{\text{Total Score Amount}}{\text{Maximum Score Amount}} \text{ x } 100$$

Table 1. Assessment Scale of Material Expert Validation, Media Expert Validation, Teacher Response, and Student Response

Level Criteria	Achievement
81%-100%	Very worthy
61%-80%	Eligible
41%-60%	Less Eligible
21%-40%	Not Eligible
< 20 %	Very Unworthy

The feasibility of the instructional media is determined based on success indicators derived from assessment results obtained through validation by content experts and media experts, as well as feedback from teachers and students.

RESULT AND DISCUSSION

This medium is designed to make the mathematics learning process more varied and less monotonous, enabling students to grasp and reason through the taught concepts more effectively, per the Research and Development (R&D) procedure. The steps in the development process of the Dakota educational game media are as follows:

1. Definition Stage (Define): Aims to establish and define the requirements for product development learning that align with user needs. Learning is a process that provides a form of reinforcement and the attainment of educational objectives (Sutiah, 2016).
2. Design Stage: Aims to create a learning medium by transforming visual media into an electronic format.
3. Development Stage (Develop): Aims to produce the finalized educational game through validation by subject matter experts and media specialists. The validation sheet is designed to evaluate the Dakota educational game.

The stages of the 4D model development can be outlined as follows:

1) Definition Stage (Define)

At this stage, there are several phases, namely:

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Initial-Final Analysis

The researcher conducted school observations in this analysis phase and distributed pretest and posttest questions to students. The pretest scores of learning outcomes can be seen in the following table 2.

Table 2. Recapitulation of pretest scores

Group	Variable	Data	Score
Control	Learning Outcome	Average	69,25
		Highest score	78
		Lowest score	52
Experimental	Learning Outcome	Average	75,46
		Highest score	80
		Lowest score	64

The posttest learning outcome value data can be seen in the table 3.

Table 3. Recapitulation of posttest scores

Group	Variable	Data	Score
Control	Learning Outcome	Average	69,25
		Highest score	78
		Lowest score	52
Experimental	Learning Outcome	Average	75,46
		Highest score	80
		Lowest score	64

The following are the average test results, which can be seen in the Figure 1.

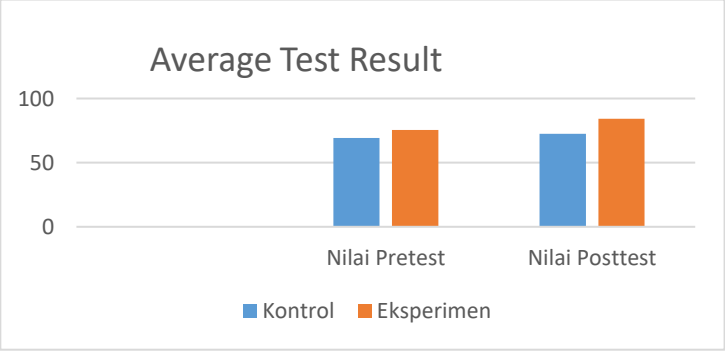

Figure 1. Average Test Result Graph

2) Stage design (*Design*)

Design Dakota Games

In designing the Dakota educational game, in addition to choosing suitable references and applications, researchers made the Dakota game according to the

characteristics of children who like to play games with attractive displays. Children can choose the game they want; namely, they can choose to work on the LCM or GCF game.

Figure 1. Dakota Game View

In the cover section, the researcher developed a front *cover design* with the help of Adobe Animate, which was designed according to the characteristics of the students and made as attractive as possible to arouse the students.

Figure 2. LCM game display

It can be seen that the LCM of the numbers 12 and 18 is 36. It can be seen from the different colours of the sticker on the number 36. Then, children can try using other numbers when playing the Dakota game.

3) Stage development (*Development*)

Expert validation

a. In this research, the validator's role is Mrs Fatimatuzzahra.S.Pd, as a grade V mathematics teacher, then gave an assessment of the questionnaire that had

been given and gave suggestions and criticisms of the material presented in the powerpoint during the validation of the material expert which was carried out on April 9, 2025, several revisions needed to be fixed, and the percentage results obtained were 89%.

b. The expert media validator in this study was Dr Achmad Buchori, M.Pd, who lectured at Universitas PGRI Semarang on April 11, 2025. Then, the researcher gave a questionnaire to assess the learning media used, and the media validation results were 85%.

c. Design Revision

After media validation, several revisions must be fixed, adding more practice questions. Meanwhile, for revisions from media expert validation, namely by adding instructions on how to play the game on the HOME menu. This study obtained validation results with a percentage of media experts of 85% and material experts of 89%. Therefore, the validation results received the predicate "Very Good".

Product Trial Results

a. Teacher Response Questionnaire Results

Based on the results of the questionnaire assessment filled out by teachers based on five aspects as follows: ease and understanding in using the game, student activity in the learning process, interest in the media used, interesting media presentation, and the advantages of the Dakota educational game learning media, a picture of the teacher's response was obtained. The questionnaire results obtained from grade V teachers of Bustanu Usysyaqil Quran Betengan Demak Elementary School showed 82.5% with the category "Very Good".

b. Student Response Questionnaire Results

Students assessed the Dakota educational game after completing the learning process using the Dakota educational game. The results of the student response questionnaire were obtained with a percentage of 92% with the predicate "Very Good".

Table 4. Summary of the Results of the Teacher Response Questionnaire and Student Response Questionnaire

Category	Percentage	Criteria
Class Teacher Response Questionnaire	82.5%	Very Good/Decent
Student Response Questionnaire	92%	Very Good/Decent

c. Pretest and Posttest Results

The pretest results before students received Dakota game treatment obtained an average student score of 75.25. After treatment with Dakota, the educational game obtained an average student score of 84.45. The Dakota educational game for GCF and LCM materials can improve students' conceptual understanding. It has met the criteria that this learning media can be feasible and good as a mathematics learning media for GCF and LCM materials in grade V.

4) Stage distribution (Disseminate)

Educational games are distributed on a small scale, namely BUQ Betengan Demak Elementary School students in grade V, by sharing a link so that they can be accessed anywhere and can use educational games anytime. But it was not done on a larger scale. So, this research is limited.

This study aims to develop Dakota educational games in mathematics learning, especially GCF and LCM materials, to help students understand these concepts. This study uses a design thinking approach, and the initial step is the empathize stage, which is to identify the difficulties students face in conceptually understanding GCF and LCM. The second stage is to Determine the main problem based on observation results, such as students' difficulties in visualizing common factors and multiples of a number. The third stage is to Ideate, developing ideas by

designing Dakota media with features that make it easier for students to understand the concept; the last stage is Prototype, which is to develop Dakota media and test it on a small scale on a group of students. The validation results from the material and media experts show that the Dakota educational game developed is suitable for learning with very good criteria. The initial stage of this study involved designing an effective Dakota educational game using the 4-D development model, which went through a systematic and structured process.

Based on the questionnaire, almost all aspects received an assessment of more than 70%, with an average percentage of positive responses reaching 84%. According to Yamasari (Damopolii, Bito, & Resmawan, 2019), student responses are considered positive if more than 70% give positive responses to each assessed aspect. During the pretest before students used the Dakota educational game, they obtained student scores with an average score of 75. After *a* posttest was held, namely after students received treatment in the form of the Dakota educational game, the average student score was 84. This study is also in line with the research conducted by Fadia Nur Farikah and Sri Sukasih entitled "The Effect of Dakota-Assisted TGT Model on Interest and Mathematics Learning Outcomes of Class V of Jatisari Elementary School with the Results of the Hypothesis Test on the Influence of student interest and learning outcomes using the t-test obtained a significant value <0.05 and the tcount value> ttable then Ha is accepted, and Ho is rejected. So, it can be concluded that there is a significant influence between the Dakota-assisted TGT model on interest and mathematics learning outcomes of GCF and LCM materials for class V of Jatisari Elementary School. (Farikah & Sukasih, 2024).

Table 5. Student Learning Outcomes

Description	*Pre-test*	*Post-test*
Lowest Score	64	62
Highest Score	80	93
Average	75.25	84.45

It can be seen from Table 5 that the lowest pre-test score was 64 and the highest was 80, with an average of 75.25, while the lowest post-test score was 62, the highest score was 93, and the average was 84.25. The KKM in this learning is

76. Thus, it can be said that there is an increase in learning outcomes in grade V students. The results of the class teacher response questionnaire obtained 82.5% with the "Very Good" category, and the student response questionnaire obtained 92% with the "Very Good" qualification. This study is also in line with the research of Yuyuk Yusantika et al. entitled "Development of Dakota Media (Dakon Mathematics) on LCM and GCF Materials in Class V of SD Negeri Kajar 01 Pati. In the study conducted, the results obtained were an average of 87.25. It was based on the evaluation of learning using learning media. It can be said that Dakota Media can improve students' abilities. Therefore, it can be concluded that the Dakota learning media used is valid and practical (Yusantika et al., 2025).

Researchers finally created a digital product in the form of Dakota educational game media based on Adobe Animate to improve students' conceptual understanding. The study results showed that the media was said to be valid with a percentage of 89% from material experts and 85% from media experts, so this learning media received a predicate with the category "Very Good". The results of the study also showed the results of the teacher response questionnaire with a percentage of 82.5%, with the category "Very Good", which means that this media is very suitable for use as a learning medium. In comparison, the results of the student response questionnaire obtained a percentage of 92%. So, it shows that grade V students received the Dakota learning media product well. In comparison, the pretest results before being given an educational game obtained an average of 75.25 and a posttest value of 84.45. So, it can be concluded that the Dakota educational game media based on *Adobe Animate* is appropriate and capable of improving students' understanding of the LCM and GCF materials.

CONCLUSION

This study developed a learning media as an educational game, Dakota (Dakon Matematika), to improve fifth-grade students' understanding of LCM and GCF. The validation results showed that this media has a "Very Good" category. Based on the results of the questionnaire filled out by the fifth-grade mathematics subject teacher at SD Bustanu Usysyaqil Qur'an, this media also received a rating of "Very Good". In addition, the questionnaire results showed that students had a

very positive acceptance of the Dakota game. Before using this game, the average pretest score of students was 75.25, which then increased to 84.45 in the posttest. Thus, the Dakota learning media is declared feasible and effective in improving students' understanding of the LCM and GCF material.

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