Improving Elementary Students' Understanding of LCM and GCF Through a Traditional Dakon Game

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Abstract
Low student ability in determining the Least Common Multiple (LCM) and Greatest Common Factor (GCF) of a number is caused by a lack of student motivation in learning. Nowadays, a learning innovation based on local wisdom is highly needed, one that is not only fun but also educates students according to their needs in the academic field. One local wisdom that can be developed is the Dakon/Congklak game. This research was also conducted to assess the validity, practicality, and effectiveness of traditional Dakon game-based media based on assessments from design experts, media experts, and learning practitioners. The research sample consisted of 40 fourth-grade students with LCM and GCF material. The method used was R&D (Research and Development) with a 4-D development model, namely define, design, development, and disseminate. The methods used to collect data in this research were questionnaires and interviews so that the data obtained would be more accurate and the resulting media would be more useful for users in the future. The results of the learning design expert review showed that the LCM and GCF learning media was categorized as very feasible (94%), the results of the learning media expert review showed that the LCM and GCF learning media was categorized as feasible (82%), the results of individual trials of the LCM and GCF learning media were categorized as very practical (92%), the results of small group trials of the LCM and GCF learning media were categorized as very practical (93%), and the results of field trials of the LCM and GCF learning media were categorized as very practical (97%). Meanwhile, the effectiveness of the development of the developed LCM and GCF learning media effectively improved LCM and GCF learning outcomes based on the results of the Wilcoxon Signed Ranks Test analysis which indicated that the median pre-test rank (Mdn = 5.00) was significantly different from the median post-test rank (Mdn = 9.00), $Z = 5.540$, $p = 0.000$. This means that it is known that Sig. $0.000 < 0.05$ so there is a significant difference between the pre-test and post-test.
Keywords: mathematics, LCM, GCF, dakon, traditional games.

Introduction

Mathematics is a subject often perceived as challenging and is feared by many students, including those at the elementary school level, a stage where learning should ideally incorporate elements of play. This is because of the characteristics of mathematics which are difficult to understand, the lack of adequate learning resources and media, and the need for high concentration and accuracy(Astika Desanti et al., 2023; Fuji Amanda et al., 2024; Utami et al., 2023; Yolanita & Ruswendi, 2024) . The characteristic of mathematics being difficult to understand means that mathematics is an abstract basic object (Hendriana & Fitriani, 2019; Wójtowicz & Skowron, 2022). This becomes a crucial problem for educators and students themselves in mathematics learning. During learning activities,

students must be presented with realistic problems, where they can learn while reflecting on their surrounding environment (Pramartha et al., 2022). Therefore, mathematics learning requires learning media to support students' learning abilities (Atika et al., 2022; Kusumawati & Lestari, 2022). Learning media is an intermediary tool for delivering learning. According to the Association of Education and Communication Technology (AECT), media is any form that functions as a tool for conveying messages and information (Nurrita, 2018). Then, the National Education Association (NEA) explains that media is a tool for communication, both audio and visual. Learning media is a set of communication tools that involve someone in the learning process (Raditya & Sujana, 2021). The use of media in learning is useful for increasing students' abilities in creative, logical, systematic, and interactive thinking (Khoiriyah et al., 2021; Murtianingsih & Astono, 2023).

Observations conducted on Tuesday, September 17, 2024, in grade IV at Susut Village revealed low average daily test scores in mathematics, particularly in the Least Common Multiple (LCM) and Greatest Common Factor (GCF) material. Many students demonstrated difficulty with these concepts, often stemming from a weak grasp of multiples and common factors, leading to diminished interest and motivation. Interviews with the teacher confirmed that adequate media specifically for teaching LCM and GCF were lacking, with reliance primarily on textbooks potentially hindering student engagement and comprehension. Students often avoided LCM/GCF problems due to confusion, and the teacher attributed this partly to a lack of enthusiasm for mathematics learning, a situation where students may become disengaged. Based on this preliminary needs analysis identifying LCM and GCF as particularly challenging topics for fourth-graders in this context, the current research focuses specifically on developing a targeted intervention for these concepts. The mechanics of the Dakon game, involving distribution and collection of items, also naturally lend themselves to modeling the principles of multiples and factors.

To foster more engaging and meaningful mathematics learning, particularly for LCM and GCF, innovative approaches are needed. Traditional game-based learning media present a promising solution, leveraging local wisdom to create enjoyable yet educational experiences. Such media can facilitate material delivery and encourage active student participation. Indeed, studies have shown that incorporating traditional games into mathematics education can positively impact numerical literacy and conceptual understanding (Arlianda et al., 2022; Khoerunnissa et al., 2023; Ningtiasih & Hadiyanto, 2023; Qomariyah et al., 2021; Siregar & Lestari, 2018). One such traditional game with

potential is Dakon (also known as Congklak). While previous research explored using Dakon media for LCM and GCF between two numbers, this study develops an enhanced version. The proposed "3-Number Geometry Dakon" media aims to address LCM and GCF for three numbers while incorporating geometric shapes in the game board design to increase visual appeal and student enthusiasm. This media is designed to be portable, lightweight, colorful, and safe for student use.

Therefore, this research and development study has several objectives. Specifically, it aims to develop a traditional Dakon game-based learning medium ('3-Number Geometry Dakon') for teaching LCM and GCF material to fourth-grade elementary school students. The study also seeks to assess the validity and practicality of the developed learning medium based on expert reviews and student trials. Finally, it will evaluate the effectiveness of the '3-Number Geometry Dakon' medium in improving students' learning outcomes related to LCM and GCF.

Method

This study employed a Research and Development (R&D) methodology to develop and evaluate traditional game-based learning media for mathematics (Andayani et al., 2022; Primaharani et al., 2024). The research procedure followed the 4-D development model (Define, Design, Develop, and Disseminate) proposed by Thiagarajan, Semmel, and Semmel (Arigunawan et al., 2020). The research was conducted between November 2024 and January 2025 during the odd semester of the 2024/2025 academic year.

The study took place at a public elementary school located in the Gianyar Regency, Bali, Indonesia. The participants were 40 fourth-grade students who were currently studying the Least Common Multiple (LCM) and Greatest Common Factor (GCF) material. Convenience sampling was used based on the accessibility of the school and the relevance of the curriculum timing.

The implementation followed the four stages of the 4-D model as visualize on figure 1:

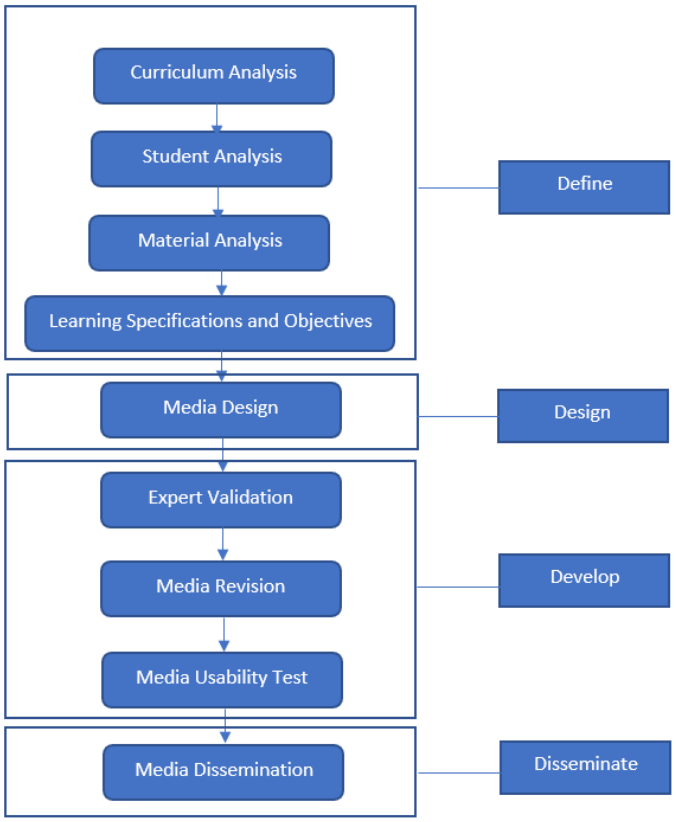

Figure 1. 4-D Model

1. *Define:* This initial stage aims to establish the instructional problem and needs. It involved analyzing the background issues by reviewing student documents (specifically identifying low mathematics scores in LCM/GCF material), conducting semi-structured interviews with the grade IV teacher to understand existing teaching practices and challenges, and administering preliminary questionnaires to students to gauge their learning preferences and perceived difficulties with mathematics.
2. *Design:* Based on the needs identified in the Define stage, this stage focused on designing the learning media. This involved conceptualizing the "3-Number Geometry Dakon," designing its physical form, appearance (incorporating geometric shapes and colors), and drafting supporting materials including a user manual and initial lesson plans.
3. *Develop:* This stage involves producing the actual learning media and evaluating its feasibility and practicality. It included:

- *Production:* Creating the physical "3-Number Geometry Dakon" game board, playing pieces (beads), and packaging, along with finalizing the user manual, lesson plans (RPP), and student worksheets (LKPD).
- *Validation:* Submitting the media prototype and supporting materials for review by experts (one learning design expert and one media expert) using validation questionnaires.
- *Revision:* Modifying the media and materials based on the feedback and suggestions received from the experts.
- *Trials:* Conducting trials to assess practicality: an individual trial with 5 students (representing high, medium, and low abilities), a small group trial with 10 students, and a field trial with all 40 participating fourth-grade students. Questionnaires were used to gather practical data during these trials. The field trial also included administering a pre-test before using the media and a post-test after the learning session to evaluate effectiveness.

4. *Disseminate:* This final stage, following successful development and evaluation, involves preparing the validated learning media for wider distribution or use within the target educational context.

Data Collection Instruments

Multiple instruments were used to gather data throughout the development process:

- *Questionnaires:*
  - *Expert Validation Questionnaires:* Administered to the learning design expert and media expert to assess the content validity, construct validity, and technical quality of the media and supporting materials. Items measured aspects like material accuracy, pedagogical suitability, design attractiveness, and technical execution, using a 4-point Likert scale (1=Not Feasible, 4=Very Feasible) (Ardianty et al., 2023).
  - *Student Practicality Questionnaires:* Administered to students during individual, small group, and field trials to assess the media's ease of use, engagement level, clarity of instructions, and perceived helpfulness in learning LCM/GCF. These also used a 4-point Likert scale (1=Not Practical, 4=Very Practical).
- *Objective Test:* A pre-test and post-test consisting of 10 multiple-choice questions were administered during the field trial. The test was designed to measure students'

understanding of LCM and GCF concepts before and after using the Dakon learning media. The validity of the test items was confirmed through expert review prior to use.

- *Interviews:* Semi-structured interviews were conducted with the classroom teacher during the Define stage to gather in-depth information about teaching challenges and student difficulties with LCM/GCF.
- *Document Analysis:* Existing student score records for mathematics were analyzed during the Define stage to identify specific areas of difficulty, corroborating the need for intervention in LCM/GCF.

Data Analysis

A sequential mixed methods approach was used for data analysis (Dai et al., 2023; Lozano et al., 2023).

- *Qualitative Data Analysis:* Qualitative data, comprising criticisms, suggestions, and comments from expert reviews and student feedback during trials, were analyzed descriptively. Key themes and specific points were identified to guide revisions and improvements to the learning media throughout the development process.
- *Quantitative Data Analysis:*
    - *Questionnaire Data:* Data from the Likert scale questionnaires (expert validation and student practicality) were analysed quantitatively. Scores for each item were summed, and average scores were converted into percentages. These percentages were then interpreted using predefined categories to determine the level of validity ("Very Feasible," "Feasible," etc.) and practicality ("Very Practical," "Practical," etc.).
    - *Objective Test Data:* Pre-test and post-test scores were analysed to determine the effectiveness of the learning media. Due to the nature of the data (paired scores from the same group, potentially not normally distributed), the Wilcoxon Signed Ranks Test, a non-parametric test for related samples, was used to compare the median scores before and after the intervention (Susdarwono, 2021). A significance level of $p < 0.05$ was used to determine statistical significance.

Results and Discussion

The development of the "3-Number Geometry Dakon" learning media followed the 4D model stages (Define, Design, Develop, Disseminate). This section presents the findings related to the media's validity, practicality, and effectiveness obtained during the development and evaluation phases.

Media Validity and Practicality

The validity and practicality of the learning media were assessed through expert reviews and student trials using questionnaires with a 4-point Likert scale. The results are summarized in Table 1. The review by the learning design expert yielded a score of 94%, categorizing the media as "Very Feasible". The learning media expert review resulted in a score of 82%, indicating a "Feasible" categorization. Student trials consistently showed high practicality: individual trials resulted in 92% ("Very Practical"), small group trials yielded 93% ("Very Practical"), and the field trial resulted in 97% ("Very Practical"). Qualitative feedback gathered during these stages guided iterative improvements to the media prototype.

Table 2. Percentage of Learning Media Development Validity Results

No	Trial Subjects	Validition-Result (%)	Categories
1.	Expert Validation of Learning Design	94	Very Worthy
2.	Expert Validation of Media	82	Worthy
3.	One-to-One Evaluation	92	Very Practical
4.	Small Group Evaluation	93	Very Practical
5.	Field Trial	97	Very Practical

Media Effectiveness

The effectiveness of the "3-Number Geometry Dakon" media in improving student understanding of LCM and GCF was assessed using a pre-test/post-test design with 40 fourth-grade students during the field trial. The Wilcoxon Signed Ranks Test was used to compare the scores before and after the learning intervention using the Dakon media. The analysis revealed a statistically significant difference between the pre-test and post-test scores ($Z = -5.540$, $p = 0.000$). The median rank for the post-test (Mdn = 9.00) was significantly higher than the median rank for the pre-test (Mdn = 5.00). As the significance value ($p=0.000$) is less than 0.05, this indicates that the use of the "3-Number Geometry Dakon" learning media effectively improved student learning outcomes for LCM and GCF.

Observations During Implementation

During the implementation phase, particularly the small group and field trials, observations indicated high student enthusiasm and engagement when using the Dakon media. Students actively communicated, shared opinions, experimented with the game mechanics after observing demonstrations, and showed creativity in finding solutions. A noticeable increase in student confidence was also observed, particularly when presenting their work or explaining their steps to classmates, compared to their reported reluctance before the intervention. The student-centered, play-based nature of the activity seemed to reduce the perceived difficulty of the LCM and GCF topics. (See Figure 4 and Figure 5 for depiction of student activities).

Figure 4. Student Group Activities

Figure 5. Student Presentation

This study successfully developed and evaluated a traditional Dakon game-based learning medium, the "3-Number Geometry Dakon," for teaching LCM and GCF concepts to fourth-grade students. The findings indicate that the media is valid, practical, and effective in improving student learning outcomes. This discussion interprets these findings in the context of relevant literature and educational theories.

The high validity and practicality ratings from both experts and students suggest that the developed media adheres to sound principles of instructional design and is well-suited for the target users(Wahyuni Anggraini et al., 2024; Wijaya et al., 2024). The positive student feedback aligns with research highlighting the importance of engaging and user-friendly learning tools in elementary education(Harry Pratama Figna Kasman Rukun, 2020; Yulyani et al., 2023).

The significant improvement in student post-test scores demonstrates the effectiveness of the Dakon media intervention. This result supports a growing body of literature advocating for game-based learning in mathematics education(Andayani et al., 2022; Ardianty et al., 2023; Lozano et al., 2023). Specifically, it aligns with studies showing the potential of traditional games to enhance conceptual understanding and numerical skills (Arlianda et al., 2022; Khoerunnissa et al., 2023; Ningtiasih & Hadiyanto, 2023; Siregar & Lestari, 2018) who used a Congklak adaptation for two numbers, by demonstrating effectiveness for LCM/GCF involving three numbers and incorporating geometric design elements.

The effectiveness of the "3-Number Geometry Dakon" can be partly attributed to its alignment with constructivist learning principles (Nalle et al., 2024; Tsai et al., 2023). The hands-on, interactive nature of the game allowed students to actively construct their understanding of abstract concepts like multiples and factors through concrete manipulation. The game mechanics, involving distributing 'seeds' into holes, provide a tangible representation of division, grouping, and identifying commonalities, potentially making the procedures for finding LCM and GCF more intuitive and less reliant on rote memorization. This aligns with theories of embodied cognition, suggesting that physical interaction with learning materials can deepen conceptual understanding (Ale et al., 2022; Loginov et al., 2022).

Furthermore, the use of a traditional game familiar within the local culture likely contributed to increased student motivation and engagement, as observed during the trials. This underscores the potential of culturally relevant pedagogy, leveraging local wisdom and

familiar contexts to make learning more meaningful and accessible (Sani et al., 2024; Subechina & Ratnawati, 2024). The positive shift in student confidence and participation further suggests that such approaches can foster a more positive attitude towards mathematics, a subject often perceived as difficult.

Despite the positive findings, this study has limitations. The research was conducted in a specific school context in Bali, which may limit the generalizability of the findings. Additionally, the study employed a pre-test/post-test design without a control group, making it difficult to definitively attribute all learning gains solely to the Dakon media intervention. Future research could address these limitations by employing quasi-experimental designs with control groups and testing the media in diverse school settings. Investigating the long-term retention of concepts learned through the game would also be valuable.

Conclusion and Suggestion

Based on the development process and evaluation results, it can be concluded that the "3-Number Geometry Dakon" learning media is valid, practical, and effective for teaching LCM and GCF material to fourth-grade elementary school students. The media received high validation scores from experts ("Very Feasible" and "Feasible") and demonstrated high practicality in student trials ("Very Practical"). Most importantly, its use led to a statistically significant improvement in students' understanding of LCM and GCF concepts, as evidenced by the pre-test/post-test results ($p < 0.05$).

Based on these findings, the following suggestions are offered:

1. *For students:* It is recommended that students actively utilize the "3-Number Geometry Dakon" learning media to enhance their understanding and mastery of LCM and GCF concepts.
2. *For teachers:* This learning media can serve as a valuable alternative tool for fourth-grade teachers to explain LCM and GCF concepts in a more engaging and effective manner, stimulating student interest and facilitating comprehension.
3. *For schools:* Schools are encouraged to support teachers in developing and utilizing innovative learning models and media, such as the "3-Number Geometry Dakon." Providing adequate facilities and infrastructure to support such active learning approaches can enhance the overall effectiveness of the teaching and learning process.

4. *For other researchers:* This study can serve as a reference and source of information for further research in educational media development. Future studies could explore the application of this media in different contexts, investigate other variables influencing its effectiveness, or adapt the concept for other mathematical topics.

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