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Development of *congklak*-based ethnomathematics media for teaching fractional numbers to grade V students

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Article info

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Abstract

This study aims to (1) develop traditional learning media using Congklak for teaching fractions in grade 5 elementary school with an ethnomathematics approach and (2) assess its effectiveness in improving student learning outcomes. Congklak was chosen for its ability to contextualize fractions engagingly, linking local culture with mathematics. The ethnomathematics approach provides a cultural framework that enhances students' understanding of fractions through meaningful cultural experiences. The research adopts the ADDIE development model (Analysis, Design, Development, Implementation, Evaluation), covering needs analysis, media design, product development, implementation, and evaluation. Instruments include validation sheets, practicality assessments, response questionnaires, and summative tests. Results show that ethnomathematics-based Congklak media significantly improves students' understanding of fractions, achieving a 96.78% success rate. Students also responded positively to its use in mathematics learning. This study contributes to the development of culture-based learning media that enhance the quality of mathematics education while promoting the preservation of local cultural values.

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1. Introduction

Mathematics is crucial in cultivating students' logical reasoning, analytical thinking, and problem-solving abilities. Despite its critical role, mathematics teaching frequently encounters obstacles, particularly a paucity of innovation in educational media. This limitation leads many students to struggle with grasping abstract mathematical concepts. In many classrooms, instructional tools remain traditional, often restricted to textbooks and basic teaching materials (Fitri, 2023). Therefore, increasing demand for more engaging and contextually relevant learning innovations is increasing.

The limitations of the media used in teaching fraction concepts in 5th-grade primary school classes significantly impact students' understanding of these concepts. Most teachers still rely on lecturing methods and use simple media, such as folding paper and fraction illustrations, which are insufficient for helping students understand the concept. Research indicates that the lack of teaching aids and interactive learning media makes it difficult for students to understand fraction operations, such as subtraction and fraction comparison (Wulandari and Yuliandari, 2023). Moreover, teachers often fail to emphasize conceptual understanding, instead focusing more on how to solve problems, which contributes to low student achievement. Conventional learning media, such as textbooks,

often only present theory without providing concrete learning experiences relevant to real-life situations, making it difficult for students to visualize the relationship between the numerator, denominator, and fraction representations in real contexts. It causes students to feel bored and less motivated, leading to poor understanding and learning outcomes. Therefore, there is a need for innovation in the use of more engaging and contextual learning media that offer better visualization and increase interactivity. Using relevant teaching aids can provide a more enjoyable learning experience and help students connect fraction concepts with real-life situations. With a more creative and contextual approach, it is hoped that students will overcome difficulties in understanding fractions and develop their critical thinking and problem-solving skills.

One promising approach is incorporating traditional culture-based educational media aligned with the principles of ethnomathematics. This method connects mathematical ideas to cultural and everyday activities, offering students a richer and more meaningful learning experience (Khoiron, 209). For instance, in Indonesia, traditional games like congklak serve as a form of recreation and involve mathematical operations such as addition, subtraction, and distribution (Fauzi, 2022).

2. Literature Review

Numerous studies have demonstrated the positive impact of integrating ethnomathematics into mathematics education. The study by Fitriatunnisa, Hastuti, and Mariyati (2024) and Zulaekhoh and Hakim (2021) highlights how this approach enhances students' comprehension of mathematical concepts. Additionally, various traditional games have proven effective for teaching arithmetic, including congklak for addition and subtraction (Arlianda, Triyogo, and Egok 2022), dakon for introducing multiplication in third grade (Choiriyyah, Fitriah, and Bilqish 2023), It is imperative to acknowledge the invaluable contributions of educators who have been instrumental in imparting fundamental mathematical concepts, such as the least common multiple (LCM) and the greatest common divisor (GCD), to students in the fourth grade. (Nurhayati, Hawanti, and Irianto 2016). Further studies by Supriyanto (2021) and Sari, Yetti, and Hapidin (2020) demonstrate how traditional game media, grounded in Bruner's theory, effectively enhance children's arithmetic skills. However, most of these investigations focus on fundamental operations like addition, subtraction, multiplication, LCM, and GCD, with limited attention to teaching fractions.

Interviews with fifth-grade teachers at SDN Sumbersuko reveal that fractions are among the most challenging mathematics topics, particularly multiplication and division. The abstract nature of fractions makes them difficult for students to comprehend. Moreover, mathematics is frequently regarded as an arduous and daunting discipline due to its extensive reliance on numerical data and formulas, which often results in the marginalization of its practical applications in everyday life. Therefore, innovative strategies are essential to simplify abstract concepts while fostering students' enthusiasm and reducing anxiety. One such innovation involves utilizing congklak as a learning tool, where students practice addition and subtraction by distributing seeds in a specific sequence. This activity can enhance students' understanding of patterns and complex mathematical principles (Fitriatunnisa et al., 2024). Students must distribute the seeds in the Congklak game following a specific sequence, indirectly aiding them in recognizing patterns and grasping more advanced mathematical concepts.

A comprehensive review of existing literature and previous research indicates that integrating traditional congklak-based learning media into mathematics education leads to positive outcomes and significantly enhances the learning experience. This study aims to thoroughly evaluate the validity, practicality, and potential effectiveness of using congklak-based media as an educational tool to strengthen students' mathematical skills, with a special focus on topics related to fractions. By evaluating these key dimensions, the study seeks to determine how effectively this approach can assist students in understanding and mastering fractional concepts and whether it can provide a more engaging and interactive learning environment that promotes better academic performance in mathematics.

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3. Method

This investigation utilized a Research and Development (R&D) methodology to develop an educational product derived from the traditional Congklak game. The study was executed among 31 students in the fifth grade from SDN Sumbersuko 1, focusing on the topic of fractional numbers. The development process was conducted following the ADDIE model, a structured instructional design framework comprised of five distinct phases: analysis, design, development, implementation, and evaluation. (Andi Rustandi and Rismayanti 2021). A detailed explanation of each phase is provided below:

3.1 Analysis

The initial phase of this research involves conducting a detailed and systematic review before the study begins. This process includes a comprehensive examination of the curriculum currently implemented at SDN Sumbersuko 1, aiming to understand its alignment with national educational objectives and identify areas where students may experience difficulties, particularly in mathematics. This research seeks to delve deeper into the factors that affect students' understanding of

 [e-**ISSN 2598-5949** | p-**ISSN 2303-1514**]

mathematical concepts, especially fractions, which are often challenging for learners. This stage also includes a thorough evaluation of the available resources, teaching materials, and facilities used in the learning process to assess their adequacy and effectiveness in supporting successful learning outcomes. Based on the results of this evaluation, the most appropriate and effective learning media are carefully selected, considering the need to enhance the quality of learning and facilitate the achievement of the desired educational outcomes. One of the selected media in this research is traditional games, which are expected to increase student engagement in learning and facilitate their understanding of mathematical concepts more interactively. Traditional games are anticipated to capture students' interest and create an enjoyable learning experience, allowing students to relate the material they are learning to their daily lives and making the learning process more applicable and meaningful. Through this approach, it is expected that students will be able to overcome the difficulties they face in understanding mathematical concepts and gain a deeper understanding and critical thinking skills required for everyday life.

3.2 Design

In this stage, the learning media are designed based on the previously identified needs. The design of the learning media is then tailored to the characteristics and learning preferences of the students, aiming to enhance the learning process's effectiveness. This adjustment ensures that the media used aligns with the unique learning styles of each student, thereby optimizing their understanding and engagement with the subject matter. This stage also includes the planning of relevant instructional materials and the development of question cards within the learning media, designed to help students understand the concepts more effectively and engagingly. These question cards will assist in assessing students' understanding of the material learned while providing an opportunity for students to learn through enjoyable and contextual games.

3.3 Development

This phase aims to develop learning media that aligns with the design specifications established during the planning phase. Once the learning media is created, the next step is to conduct a thorough validation process. During this phase, subject matter experts and media specialists collaborate to assess various important aspects of the developed media. They carefully evaluate the media's alignment with the established learning objectives, ensure its effectiveness in supporting the applicable curriculum, and determine whether it provides students with an engaging and beneficial learning experience. Additionally, the validation process includes evaluating technical aspects such as ease of use, visual appeal, and the diversity of interactive features that can enhance student engagement. This process aims to ensure that the developed media can be effectively implemented in the classroom, meets the desired quality standards, and provides maximum benefits in supporting students' understanding of the material.

3.4 Implementation

The media that have undergone validation are initially evaluated through a preliminary trial to assess their practicality, user-friendliness, and overall functionality in a real-world classroom setting. Following this initial evaluation, a more comprehensive trial is conducted to thoroughly examine the effectiveness and validity of the media in enhancing learning outcomes. This subsequent phase aims to determine whether the media successfully supports students in achieving the intended educational objectives while evaluating its capacity to facilitate meaningful learning experiences and foster improved academic performance.

3.5 Evaluation

The final phase involves gathering feedback and recommendations for the developed learning media and a comprehensive evaluation to determine its overall feasibility. The present study employed a data collection instrument—specifically, a questionnaire—to assess the practicability of the newly

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developed learning media. The study subjects and their validators were assigned to evaluate the mentioned media. The instrument was divided into five sections;

a) a material validation form to evaluate the appropriateness of the content,
b) a media validation form to review the quality of the media,
c) a teacher response form to gather teachers' feedback on the media's effectiveness,
d) a student response form to capture students' opinions and
e) data from summative tests to measure student learning outcomes.

Two experts, a content specialist, and a media specialist, conducted a feasibility assessment of the designed learning media by providing evaluations aligned with their respective areas of expertise. The content specialist, a University lecturer in elementary education focused on mathematics, ensured that the presented learning material was accurate, relevant, and aligned with the applicable curriculum. Meanwhile, the media specialist, an expert in instructional media design, evaluated how effectively the designed media supported an interactive and engaging learning process and its appeal to students.

The data analysis in this study involved both qualitative and quantitative approaches. The qualitative analysis involved a detailed review of the input and feedback provided by subject matter experts, educators, and learners. This review aimed to understand whether the learning media met the needs and expectations of the users. On the other hand, the quantitative analysis involved processing the data collected from the questionnaires to determine the feasibility level of the designed media. The Likert scale was used to analyze the questionnaire responses, measuring respondents' attitudes, opinions, and perceptions toward the tested learning media (Sugiyono, 2020). First, the validity analysis summarized in **Table 1**, to assess the alignment of the content with the learning objectives; second, the practicality analysis based on the feedback from teachers and students, presented in **Table 2**, to evaluate how easy and acceptable the media was in daily learning contexts; and third, the effectiveness analysis of the media presented in **Table 3**, to assess how well the media helped achieve the desired learning outcomes.

Table 1. Expert validation criteria

Score	Criteria
4,21 – 5,00	Very good
3,41 – 4,20	Good
2,61 – 3,40	Fair
1,81 – 2,60	Poor
1,00 – 1,80	Very Poor

The learning media is deemed valid if the average score provided by the experts falls within the "Good" category or higher. Should the score fall below the predetermined threshold, revisions are promptly made based on the feedback and recommendations offered by the experts. These adjustments aim to enhance the media's quality, functionality, and effectiveness, ensuring that it meets the desired educational standards and better supports the learning objectives.

Table 2. Practicality response criteria for teachers and students

Score	Criteria
$85 < N \leq 100$	Very good
$70 < N \leq 85$	Good
$55 < N \leq 70$	Fair
$N \leq 55$	Poor

Learning media is considered practical when teachers' and students' average response score reaches at least 70, placing them in the "Good" category. Achieving this score indicates that the media is perceived as effective, user-friendly, and suitable for use in actual educational settings. This

 [e-**ISSN 2598-5949** | p-**ISSN 2303-1514**]

threshold reflects positive feedback from users regarding both the functionality and ease of implementation in the classroom, contributing to the smooth and successful execution of the learning process.

Table 3. Minimum mastery criteria

Score	Criteria
87 < A ≤ 100	Very Good
73 < B ≤ 87	Good
60 < C ≤ 73	Fair
< D 60	Need Improvement

To successfully achieve the desired learning outcomes for the summative assessment, a minimum of 75% of the students must attain a score of no less than 73, which is categorized as a "good" grade. It indicates that, for the test results to be considered to meet the expected learning objectives, most students must perform satisfactorily, demonstrating a clear understanding of the material and reflecting the effectiveness of the instructional methods applied throughout the learning process.

4. Results

This section outlines the results and discussions corresponding to each phase of the ADDIE model utilized in this study. The subsequent sections provide a detailed analysis of each stage, incorporating the outcomes of the data collected throughout the research process. By presenting the findings in this structured manner, the aim is to offer a comprehensive and in-depth understanding of how each phase contributed to the overall research objectives, ensuring that the results are thoroughly examined and interpreted across all stages of the study. This approach facilitates a more detailed and holistic comprehension of the study's impact and effectiveness.

4.1 Analysis stage

The analysis phase constitutes the foundational stage in the development process, where initial data are collected to evaluate the context and needs of the school environment. This phase entails a meticulous school observation to understand the prevailing teaching practices and classroom dynamics, supplemented by interviews with key stakeholders, including the principal and the fifth-grade teacher at SDN Sumbersuko 1. The observations revealed that the learning process at SDN Sumbersuko 1 made very limited use of concrete learning media. Interviews with the principal and fifth-grade teacher uncovered a problem: many students felt bored and disengaged during mathematics lessons. It resulted in difficulties for students in understanding mathematics, particularly fractions. This issue was further compounded by using teaching materials heavily reliant on student or teacher textbooks, which failed to capture students' interest in mathematics.

4.2 Planning stage

Following the analysis phase, the planning stage is pivotal in the overall development process. The strategies, methodologies, and frameworks are meticulously outlined during this stage. Following the conclusions drawn from the analysis phase, this stage focuses on designing and developing learning media that incorporates the traditional game of congklak into the mathematics curriculum. This integration is intended to provide an engaging, interactive learning experience for students, with a clear objective of improving their understanding of fractional concepts in mathematics. Through this innovative approach, the planning stage aims to create a dynamic and enjoyable learning environment that effectively supports students' academic growth and mastery of the subject matter.

 [e-**ISSN 2598-5949** | p-**ISSN 2303-1514**]

4.3 Development stage

The next stage involved developing the learning media by adding a new element in the form of knowledge cards. These cards appear when players stop at certain holes on the *congklak* board and are stored in a specially provided compartment. The purpose of adding these knowledge cards is to provide additional challenges for students while deepening their understanding of fractions. Each card contains relevant questions designed to encourage critical thinking as students answer the provided questions. The creation of these cards adhered to feasibility criteria encompassing material, media, and language aspects. Consequently, the evolution of the Congklak-based traditional game into a pedagogical tool has been accomplished.

As illustrated in **Figure 1**, the initial version of the learning media was presented prior to undergoing the development process. This preliminary iteration reflects the foundational design and structure of the media, which served as the starting point for further enhancements. In subsequent stages, key elements were subjected to analysis and refinement to align with the learning objectives and enhance the effectiveness of the media in facilitating the teaching of fractions.

Figure 1. The initial appearance of the *Congklak* game

The subsequent image illustrates the congklak-based learning media that has been meticulously designed by integrating innovative elements to align with educational objectives. These enhancements include modifications to the traditional congklak game to make it more relevant and engaging for teaching mathematical concepts, specifically fractions. The design incorporates visual and functional adjustments to facilitate active learning and cultural appreciation. This improved version of the media is presented in **Figure 2**, providing a clear representation of its structure and features.

Figure 2. *Congklak* game after development

The congklak game that has been developed incorporates several essential elements, including knowledge cards that are specifically designed to align with and support the learning objectives, as illustrated in Figure 3. Additionally, the operational guidelines, which provide a comprehensive, step-by-step framework for implementing the congklak game in the classroom, are outlined in Figure 4. These guidelines are designed to provide clear and structured instructions, ensuring that the game is utilized effectively to facilitate learning and maximize its educational benefits.

 [e-**ISSN 2598-5949** | p-**ISSN 2303-1514**]

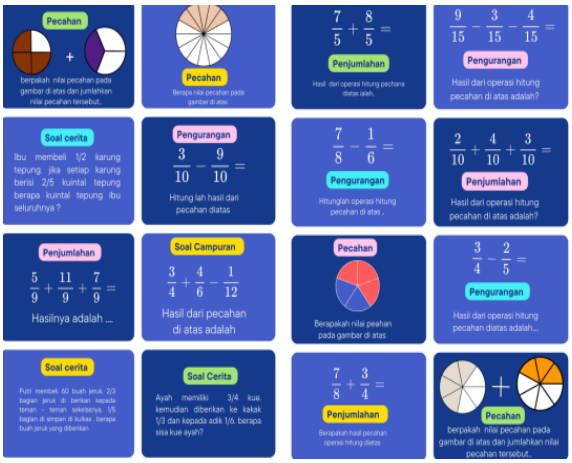

Figure 3. Knowledge cards

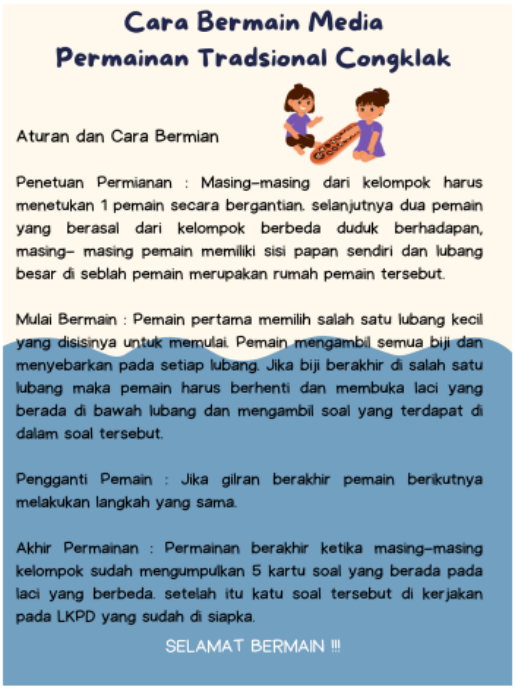

Figure 4. Rules of the *congklak* game

A validation assessment was conducted on the developed congklak-based learning media at this stage. The media was validated by a subject matter expert and a media expert, both lecturers or professors in their respective fields. The objective of the validation process was to assess the appropriateness of the congklak-based learning media for use in an educational setting. Additionally, there was a section for comments or suggestions for improvement to ensure this traditional game-based learning media is ready for trial. The results of the validation assessment by the subject matter and media experts can be presented in **Table 4**.

Table 4. Validation analysis by experts

No	Aspect	Average	Criteria
1	Material	3,5	Good
2	Media	3,5	Good
	Total	3,5	Good

 [e-**ISSN 2598-5949** | p-**ISSN 2303-1514**]

Based on the expert validation assessment results outlined in Table 4, the media achieved an average of 3.5, with a "Good" rating. Therefore, the *congklak*-based learning media meets the criteria and is ready to proceed to the implementation stage. Suggestions and input were provided concerning elucidating the fraction idea, which requires further clarification. The general appearance of the learning media was deemed satisfactory.

4.4 Implementation stage

A small-scale study, including only five students, was undertaken at this stage to evaluate their response to the generated learning material. Following that, a large-scale trial was carried out involving all fifth-grade students at SDN Sumbersuko 1 to evaluate and confirm the practicality and effectiveness of the developed learning media and to ensure that it is suitable for use in the classroom. Moreover, to assess the practicality of the congklak-based learning media, the teacher's response to it was collected and analyzed. The results of the students and teachers' responses regarding the practicality of the learning media utilizing traditional games are displayed in **Table 5**.

Table 5. Practicality response results

No	Implementation	Score	Criteria
1	Small scale	72	Good
2	Large scale	7	Good
3	Teacher	95	Very good
	Average	82	Good

Referring to the practicality test results in Table 5, both students and the teacher provided an average score of 92 for the congklak-based learning media, categorizing it as "Good.". It indicates that using the *congklak*-based traditional game learning media during the lesson was successfully implemented, and positive feedback was received from both students and the teacher.

After conducting the practicality test of the *congklak*-based traditional game learning media, which received positive responses, a summative test was carried out with all 31 fifth-grade students at SDN Sumbersuko 1. During this summative test, the students achieved an average score of 92, with a success rate of 96.78% and a failure rate of 3.22%. These findings demonstrate significant success in the student's learning outcomes. The summative test results from 31 students at SDN Sumbersuko 1 are detailed in Table 6.

Table 6. Recap of the summative test achievement results

Score	Predicate	Frequency
$87 < A \leq 100$	Very good	21
$73 < B \leq 87$	Good	9
$60 < C \leq 73$	Satisfactory	0
$< D 60$	Needs guidance	1
	Total	31

4.5 Evaluation stage

The assessment of the developed *congklak*-based learning media is essential after implementation. This assessment seeks to ascertain the media's efficacy and relevance in facilitating the teaching and learning process. At this point, the conclusive modification of the learning media was conducted, incorporating feedback and recommendations from both educators and learners. The fifth-grade instructor recommended diversifying the knowledge cards utilized in the *congklak* game to captivate students' interest and improve their engagement in the learning process; implementing this idea is anticipated to enhance the interactivity and enjoyment of the learning media, hence improving students' comprehension of the educational content.

 [e-**ISSN 2598-5949** | p-**ISSN 2303-1514**]

5. Discussion

The results of this study provide strong evidence that the integration of congklak-based learning media has significantly contributed to improving students' academic performance. This finding is consistent with the findings of Nursafitri, Fatmawati, and Asmah (2022) and Melani Nur Asri and Ibnu Muthi (2024), who also emphasized that the use of congklak as an educational tool in mathematics classrooms has led to significant improvements in students' learning outcomes. Such consistency in findings underscores the potential effectiveness of incorporating traditional games such as congklak into modern educational practices to support and enhance student's understanding of key mathematical concepts. This study is also supported by Wibowo et al. (2021), who found that the use of *congklak* game media helps students understand the material being taught. It is further substantiated by the students' average score of 92 on the summative test, with a success rate of 96.78%, exceeding the 75% success threshold, thus indicating success, according to Andriani (2018).

The use of game-based learning media in educational environments has proven to be a highly effective tool, contributing significantly to improving students' academic outcomes while also playing an essential role in enhancing their overall engagement and encouraging active participation throughout the learning process. This innovative approach has garnered increasing attention in recent years due to its ability to transform traditional teaching methods, providing students with a more interactive, engaging, and enjoyable learning experience. Research conducted by scholars such as Nurhayanti, Hendar, and Wulandari (2021), along with Sulkhana, Niam, and Saifudin (2022), consistently supports the positive impact of game-based learning, demonstrating that it can motivate students, spark their interest in the subject matter, and foster deeper cognitive engagement. Studies have shown that when educational content is delivered through game-based platforms, students are more likely to remain focused, retain information more effectively, and actively participate in the learning process instead of passively absorbing knowledge in a traditional classroom setting.

Additionally, the effectiveness of game-based learning media has been clearly demonstrated through empirical evidence collected from small-scale and large-scale educational trials. In an initial small-scale trial, students showed a positive response, achieving an average score of 72, reflecting their favorable reception of the learning media and its ability to engage them meaningfully. An even more promising outcome followed this success during a large-scale trial, where students' performance improved significantly, reaching an impressive score of 79. This improvement not only underscores the potential of game-based learning to enhance academic achievement but also illustrates how students engage with the content in a more immersive and interactive manner. These findings align with the conclusions drawn by Brezovszky et al.(2019), who argued that incorporating gaming media into mathematics education can be a highly effective pedagogical tool, especially for elementary school instruction.

In addition to these positive outcomes, game-based learning has proven beneficial in enhancing students' overall educational experience. Direct experience through games provides real-life contexts for students to apply the material they have learned in class, which helps them retain and understand the concepts better (Trajkovik et al., 2018). Moreover, it fosters the development of key social and cognitive skills, such as collaboration, communication, and problem-solving, which are crucial for their future endeavors (Mraz Kristine, Porcelli Alison 2020). These gaming elements align closely with the research of Vasileva-Stojanovska et al.(2014), which suggests that games encourage student interaction, promoting teamwork and the exchange of ideas in ways that traditional learning methods often do not. Incorporating such traditional game-based media into the curriculum has been shown to enrich the learning experience and significantly enhance learning outcomes, offering a more interactive and engaging approach to education (Noemí and Máximo 2014). This comprehensive method supports academic growth and prepares students for real-world challenges by encouraging them to think critically and collaborate effectively in diverse settings.

 [e-**ISSN 2598-5949** | p-**ISSN 2303-1514**]

6. Conclusion and Implications

The results of this study suggest that the development of learning media based on traditional games, specifically congklak, has a positive impact on the academic performance of 5th-grade students at SDN Sumbersuko 1. It is evidenced by an average score of 92, significantly higher than the minimum passing score of 73 set by the Ministry of Education and Culture (Kemendikbud, 2018). The study's findings indicate that using congklak as a game-based learning tool improves students' understanding of fraction concepts in mathematics. Furthermore, validation tests conducted by subject matter and media experts, as well as positive feedback from teachers and students regarding the medium's effectiveness, further validate these findings, resulting in a success rate of 96.78%.

Based on these findings, it can be concluded that the congklak-based learning media meets the essential criteria required to significantly enhance student engagement while effectively supporting cognitive development and the acquisition of various skills. Given the promising results, future research should consider addressing the current limitations, particularly the relatively limited application of interactive learning media in numerous elementary schools. It would be beneficial to broaden the selection of data subjects, ensuring a more diverse and relevant sample for a more comprehensive understanding. Moreover, the ongoing improvement of congklak-based learning media should focus on diversifying its content, gameplay elements, and design features. These enhancements would better align with the overarching educational objectives and further stimulate and sustain student interest and motivation in the learning process, ultimately contributing to a more effective and engaging educational experience.

7. Limitation

The study's sample size and scope are limited in generalizability due to its exclusive implementation with fifth-grade students at a single educational institution. Additionally, the study's relatively brief duration may not adequately capture the long-term implications of congklak-based learning media on academic performance and engagement. The study's exclusive emphasis on congklak, excluding other traditional games that may offer comparable educational benefits, is a further limitation.

Credit authorship contribution statement

Alfinda Dwi Ninggar : Developed the learning media, collected and analyzed the data, and synthesized the findings. **Arina Restian** : Supervisor, provided guidance on the pedagogical approach and media alignment with educational goals. **Murtyas Galuh Danawati** : Supervisor 2 assisted with the technical aspects of media design and data analysis, ensuring the study's validity.

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