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Implementation of "E-Lens" inquiry-based learning game to improve literacy and numeracy skills

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ABSTRACT

Literacy and numeracy are two fundamental skills that play a crucial role in the elementary education process. Literacy encompasses not only reading and writing skills but also the ability to understand information effectively. Meanwhile, numeracy includes the ability to understand and interpret mathematical concepts in everyday life. This research used the ADDIE model to develop a learning media in the form of E-Lens board game, namely Exploring Literacy, Numeracy, Math, and English. This research was conducted at Taji State Elementary School, located in a rural area, in the easternmost village on the slopes of Mount Bromo. In terms of infrastructure, the school has limited accessibility, especially regarding internet and conventional learning resources. The learning media was validated by media and material experts. Media expert assessment obtained an average percentage of 79.2% and the material expert has an average percentage of 77%. The validation results indicated that E-Lens board game, which is based on bilingual inquiry, are very good to be used as a learning media for developing numeracy literacy at the elementary level. Based on research stages and feedback from media, material experts, and respondents, E-Lens as learning media can improve elementary students' literacy and numeracy skills.

Keywords: literacy, numeracy, Mathematic, English, inquiry

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INTRODUCTION

The explosive rise of information and communication technology (ICT) has resulted in major developments in many areas of life, especially education. One of the most prominent impacts is the emergence of various innovations in learning methods, which aim to improve the effectiveness and efficiency of the teaching and learning process. During this digital era, technology-based learning, such as learning games, has become one of the most interesting alternatives to be implemented in elementary schools. Salamah (2024) stated that stated that it is difficult to dispute the rapid pace of scientific and technological advancement today. However, one critical issue that remains is the imbalance between the speed of life transformation and the pace of educational adaptation. This is supported by research by Khan & Khan (2024), who found that the extensive use of the Internet in conventional fields, combined with the rapid rise of digitization, multimedia material, and fast communication technologies, is driving transformation and innovation in all aspects of life. The continuous development of information technology has led to significant changes in learning methods at the elementary school level. The conventional approach that relies solely on books and blackboards as learning media is now complemented by innovations such as learning apps, educational games, and other digital resources specifically designed to support children's literacy and numeracy development.

Literacy and numeracy are two essential skills that are very important in the education process in elementary schools. According to Conica et al., (2023), children's literacy and numeracy abilities are crucial for early academic achievement and subsequent academic success,

as well as mental health and adult employment prospects. Literacy skills include not only reading and writing skills, but also the ability to understand and use information effectively. Literacy initiatives can enhance academic performance (Mandrekar & Rodrigues, 2021). Pinto et al., (2024) said that literacy can be integrated with media literacy and academic literacy to create a comprehensive and efficient education system. Meanwhile, numeracy includes the ability to comprehend, apply, and interpret numerical and mathematical concepts in everyday life. Trickett et al., (2022) stated that mathematical learning takes place not only in formal classroom settings, but also during interactions, such as playing with family and friends. Furthermore, Hornburg et al., (2024) explained that numeracy consists of both language-based elements (such as general vocabulary and mathematical language) and code-based elements (including print knowledge and phonological awareness). These two abilities are crucial to equip students to face future challenges in both academic and in everyday contexts. In recent years, there has been an increase in interest in mathematics, owing to the societal effects of mathematical learning issues (Meery et al., 2020; Soares et al., 2017). LeMire et al., (2024) added that while students at all levels have significant abilities in data literacy, first-generation students (and their continuing-generation peers) might benefit from data literacy support all the way through their senior year of school.

However, based on initial observations at State Elementary School 1 Taji, Malang District, it was found that students' literacy and numeracy skills still need to be improved. Many students still have difficulties in understanding reading texts and applying basic mathematical concepts. This showed that the current learning methods have not yet optimally developed these two abilities. One of the reasons is the lack of engaging and relevant learning methods that alignt to students' needs and interests.

To address these problems, an innovative and effective learning approach is needed. Arwildayanto et al. (2023) said that elementary school teachers must be adaptive and capable of implementing a diverse range of innovative methods, technologies, and engaging instructional materials to meet current educational demands. One approach that is considered to have great potential is inquiry-based learning through learning games. Inquiry-based learning encourages students to actively engage in the learning process by seeking, investigating, and discovering independent information. Furthermore, taking part in important tasks in inquiry-based learning fosters student enthusiasm and involvement (Renninger et al., 2018). This can help students develop critical thinking skills, creativity, and problem-solving abilities, all of which contribute to improved literacy and numeracy outcomes. Kawuryan (2022) emphasized that critical thinking is one of the targeted abilities highlighted in global education systems. This is supported by Kember et al., (2000) who noted that stronger critical thinking skills improve students' reflective abilities, hence increasing their degree of assessment literacy.

Learning games are one form of innovation that can integrate the principles of inquiry-based learning. Gunawan (2019) defined inquiry as a process of obtaining and constructing knowledge through investigation. Hakim et al., (2023) described the inquiry learning model as an approach that uses problem-solving as a central component of instruction, while Derlina (2016) added that inquiry training involves students actively participating in learning by generating questions, exploring, and forming new knowledge. Learning games not only provides a fun and interactive learning experience but also allows students to learn through exploration and experimentation. The use of games in learning can also increase students' learning motivation, as they feel more interested and involved in the learning process. Rahayu et al., (2020) asserted that increased learning motivation depends heavily on students' level of engagement in the learning process. In the context of Indonesian education, literacy and numeracy are two things that are very important to be mastered by every individual, including elementary school students. Literacy and numeracy are basic skills needed to interpret information and make the right decisions in everyday life. Widayanti et al. (2022) emphasized that literacy activities have been promoted in education to foster students' interest in reading.

Nevertheless, many students in Indonesia, including those at State Elementary School Taji, still demonstrate low literacy and numeracy proficiency. This primary school is located in a rural area, in the easternmost village on the slopes of Mount Bromo, Malang Regency. In terms of infrastructure, the school faces significant challenges, including limited internet access,

inadequate educational resources, and a reliance on conventional and less engaging learning methods. The common learning paradigm made students to be less engaged because they were uninspired with the way of teaching, they felt tired, and they failed to give attention to the subject being taught (Rahayu, 2018). Therefore, innovation is needed to improve students' literacy and numeracy skills, particularly through inquiry-based learning games. Rahayu and Riska (2018) explained that games can serve as effective educational tools that benefit both teachers and students by improving knowledge in an enjoyable manner. Furthermore, Sutarti (2018) highlighted that the inquiry learning model allows students to actively participate in learning rather than passively receiving information from teachers.

Based on this background, this study aims to explore and evaluate the effectiveness of using inquiry-based learning games in improving students' literacy and numeracy skills at State Elementary School Taji, Malang Regency. Through this research, it is hoped to gain a deeper understanding of how learning games can be used as effective tools to develop students' foundational skills and contribute positively to the overall quality of primary education.

This research has an urgency to overcome the challenges of education in rural areas with very limited accessibility. This game was developed to improve the numeracy and literacy abilities of third-grade elementary students in a bilingual manner. Muntolib et al., (2022) stated that in the field of science, scientific inquiry refers to the many methods used by scientists to examine the natural world and acquire scientific knowledge. In this context, the game is expected to serve as an innovative solution to overcome educational challenges by promoting wider accessibility, higher-quality education, and more engaging learning methods. Bell et al., (2023) asserted that education is widely regarded as a means of improving life opportunities, particularly for socially and economically disadvantaged populations. This inquiry-based learning game is also expected to improve students' motivation and interest in learning by incorporating elements of play and discovery. Considering the increasing influence of information technology in everyday life, it is essential for education to keep pace with these developments, particularly through the integration of basic English skills into learning, as a form of adaptation that provides relevant and inspiring learning experiences for students while serving as a model for educational innovation in similar regions.

Based on the above background, the formulation of the problem to be investigated in this study is how the development of inquiry-based bilingual games can improve the literacy and numeracy skills of students at State Elementary School Taji, Malang Regency.

METHOD

The research method used in this study is Research and Development (R&D). According to Sugiyono (2019), research methods are defined as scientific approaches to collect data for purposes. The R&D approach aims to produce new products and subsequently test their effectiveness. This study utilized the ADDIE model, which consists of five stages: Analysis, Design, Development, Implementation, and Evaluation. The detailed R&D steps are illustrated in Figure 1.

Analysis

The analysis stage included problem analysis, user needs analysis, and content analysis. Needs analysis as the first strategic step, focused on understanding the level of stduents' numeracy literacy skills, identifying the challenges faced, and assesing the available educational resources. The analysis produced data related to problems identification, learning media requirement, and content needs for the game-based learning media. A literature review of previous studies and best practices in the development of inquiry-based games was conducted at this stage.

Design

The design stage involved developing an inquiry-based bilingual numeracy literacy game design strategy as an English provision if students will choose to continue to a higher education level or not, as well as creating a learning media structure.

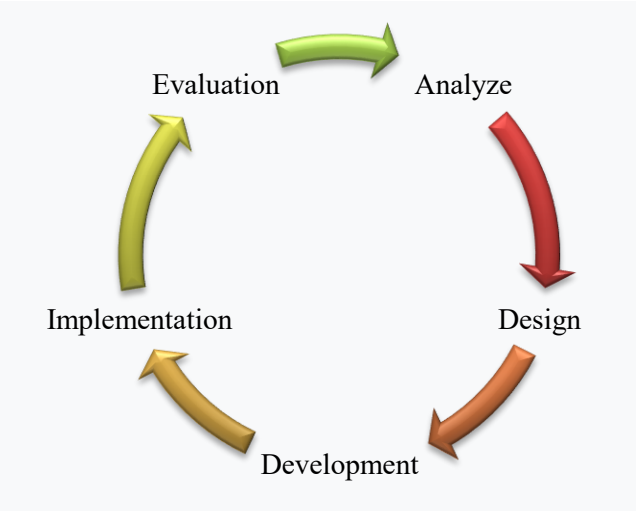

Figure 1. ADDIE Method

Development

At the development stage, instructional materials are developed according to the syllabus, lesson plans, material preparation, and evaluation using inquiry-based games to measure the validity and response of research subjects. In this content development, literacy and numeracy materials are made interesting and relevant for elementary school students. At this stage, media and material experts provided suggestions and opinions about the game as an inquiry-based bilingual learning media. Assessment of data and suggestions from media and material experts were used as improvements to the development of this learning media. Assessment from media and material experts was done by filling out a questionnaire consisting of four Likert-scale options: Strongly Agree (SA= 4), Agree (A= 3), Disagree (D= 2), and Strongly Disagree (SD= 1) (See Table 1 dan Table 2).

Table 1. Aspects of media expert assessment

No	Assessment Aspect	Indicator
1.	Media efficiency	The learning media presented is appropriate for the age of the students.
		The learning media is packaged with an attractive board design.
		Learning media is easy to use.
		Learning media uses appropriate language.
2.	Aesthetics	Learning about media uses clear images.
		The learning media uses interesting color and image composition.
		The design of the learning media display is interesting and motivates students.
		Harmony of color selection for learning media.
3.	Design Appropriateness	Appropriateness of learning media design with the game concept
		Accuracy of color selection, background and writing.
		Appropriateness of learning media layout
		Learning media has appropriate design quality

Implementation

At the implementation stage, the learning program is implemented by applying specific learning that uses learning media and learning modules related to literacy and numeracy problems.

Evaluation

At the evaluation stage, the effectiveness of the bilingual numeracy literacy game was examined to determine whether it successfully addressed the learning challenges faced by elementary students. Evaluation also aimed to measure improvements in students' literacy and numeracy skills.

Data was collected through questionnaires completed by media experts, material experts, and students. The results were analyzed quantitatively using descriptive statistics and presented as percentage scores of eligibilities. After calculating the average, the quantitative results were converted into qualitative categories, Very Good, Good, Fair, and Poor, based on Arikunto's (2010) conversion scale. The quantitative data conversion values are shown in Table 4.

Table 2. Aspects of material expert assessment

No	Assessment Aspect	Indicator
1.	Content	The game is in accordance with the core competencies and basic competencies.
		The games developed are in accordance with the learning objectives.
		The material is presented in accordance with the characteristics of elementary school students.
		The material can add insight to students.
2.	Language	Learning media uses language that is easy for students to understand.
		Learning media uses good language rules.
		The language used in the learning media is delivered coherently.
		The language in the learning media has a variety of new vocabulary and is relevant to the understanding of elementary school students.
3.	Learning Strategy	Learning media makes it easy for students to understand the material.
		Learning media makes it easy for students to use learning media.
		Learning media helps students to easily remember the material.
		Learning media stimulates students' curiosity and motivation.

In addition to the media and material experts' questionnaires, table 3 showed the student assessment aspect to see the practicality of the developed media.

Table 3. Aspects of student assessment

No.	Assessment Aspect	Indicator
1.	Display	The media display is attractive.
		Images and writings in the media are clear.
		Instructions for learning media are easy to understand.
		The use of language is easy to understand.
2.	Learning Strategy	Media motivates students.
		Students find it easy to use learning media.
		Learning media helps to understand the material.
		Learning media increases students' knowledge.

Table 4. Conversion of quantitative values

No.	Category	Percentage
1	Very good	76%-100%
2	Good	51%-75%
3	Fair	26%-50%
4	Poor	0%-25%

FINDINGS AND DISCUSSION

Findings

This inquiry-based bilingual learning media development produced data in the form of Analyses, Design, Development, Implementation, and Evaluation. The results achieved at each stage are as follows.

Analysis

At the problem analysis, user needs analysis, and content analysis stages, the following results were obtained: 1) Problem analysis as the first strategic step aimed at understanding the students' level of numeracy literacy skills, the challenges they faced, and the available educational

resources. The analysis produced data to identify research problems, determine the need for games as learning media, and outline the necessary content for game development. 2) The user needs analysis identified students' cognitive characteristics in the form of cognitive development. The data showed that students were mostly aged between 9 and 10 years. Based on Piaget's theory, this age corresponds to the concrete operational stage, which is characterized by the development of logical thinking abilities, although limited to physical objects. At this stage, children can discuss the material that has been delivered to them. 3) The content analysis identified earning materials for third-grade mathematics, which included basic mathematical concepts such as addition, subtraction, multiplication, and division, as well as understanding of numbers, shapes, and patterns that are packaged in everyday situations to increase teaching effectiveness and student engagement in mathematics learning.

Design

At the design stage, data were obtained through planning of teaching material development as follows 1) The preparation of materials was based on the third-grade mathematics syllabus by reviewing core and basic competencies to select learning materials aligned with information, ideas, values, procedures, time allocation, and indicators. 2) Development of teaching and learning scenarios. 3) Selection of teaching material competencies. 4) Development of learning tools based on subject competencies. 5) Learning materials consisting of addition, subtraction, multiplication, division, as well as understanding numbers, shapes, and patterns packaged in inquiry-based and bilingual approaches in real-life contexts.

Development

At the development stage, the learning media was designed in accordance with the subject matter, namely mathematics for third grade elementary students, using a bilingual inquiry-based approach. The resulting product was a numeracy literacy board game called E-Lens (Exploring Literacy, Numeracy, Math, and English). The E-Lens board consisted of 36 boxes, including 32 boxes containing nominal values, 3 reward card boxes, and 1 start box. The game also featured 32 question cards, 10 reward cards, and 10 punishment cards. Initial trials were conducted with a small group of students to ensure that the learning media functioned as intended. The E-Lens game was then validated by media and material experts for assessment and feedback using a validation recapitulation sheet. Furthermore, the learning media is revised based on expert advice and tested on students as users on a larger scale.

Implementation

The implementation stage of the research aimed at implementing the design of teaching materials that have been developed in actual classroom settings. During this stage, the design of bilingual inquiry-based learning media was developed and applied to actual teaching conditions. The developed materials were delivered according to the learning plan, followed by an initial evaluation to provide feedback on the application of learning media development in the next teaching material. The main objectives in this implementation stage were to guide students to achieve learning objectives, solve problems they faced in the learning process, and ensure measurable improvement in their abilities at the end of learning.

A large-scale trial was also conducted on a group of students to validate the effectiveness of the media in real-life conditions and to identify potential issues undetected during development. Media and material experts participated in this validation process, ensuring that the media performed effectively in practice. The results of the recapitulation carried out by media experts are shown in Table 5.

Table 5. Recapitulation of media expert validation

Validator	Assessment Results of Each Aspect			Average Percentage of Media Experts
	1	2	3	
Media Expert	75%	81,25%	81,25%	79,20%

The results of the media expert validation show that the eligibility percentage of the E-Lens learning media was 79.2%. Based on the eligibility category in table 4, 79.2% is in the range of 76%-100%, this showed that the E-Lens learning media is in the very good category.

In addition to validating learning media, media expert provided suggestions including the use of bright colors and attractive graphics to maintain the elementary students' attention and interest, choosing relevant and engaging themes such as reading or counting characters, and adding visual guides that explain game rules to support independent play. They also suggested using durable, child-safe materials and designing an appropriately sized board for easy use by students.

The assessment data from material experts is carried out in the same way as media expert, consisting of four Likert-scale options. The recapitulation of the material expert validation is shown in Table 6.

Table 6. Recapitulation of material expert validation

Validator	Assessment Results of Each Aspect			Average Percentage of Material Experts
	1	2	3	
Material Expert	81,25%	75%	75%	77%

The results of the material expert assessment indicate that the eligibility percentage was 77%, categorized as very suitable for use. Suggestions from material experts included incorporating literacy and numeracy questions such as reading comprehension, number recognition, and basic operations with open-ended questions to promote critical thinking. They also emphasized using age-appropriate language, avoiding overly complex terms, and integrating everyday story elements to make the learning experience more engaging. Additionally, experts recommended focusing on essential basic concepts and designing the game to foster collaboration and social interaction among students through group discussions and teamwork.

Evaluation

Evaluation is a process to see whether the developed learning media met the intended objectives. This evaluation is the final stage in the ADDIE research design model. In this phase, it evaluates the implementation of bilingual inquiry-based mathematics learning media. Evaluation is carried out with the stages of evaluating student learning outcomes and student responses. The data is intended to improve the learning media to make it more effective and efficient.

In the development of E-Lens learning media, Exploring Literacy, Numeracy, Math, and English to improve students' literacy and numeracy skills based on bilingual inquiry is carried out in groups, for example one group consisting of two until four students. The display of the E-Lens game board is depicted in Figure 2.

The picture shows the numeracy literacy board consisting of 36 boxes, divided into 32 boxes with nominal money, 3 reward card boxes, 1 start box. The game is printed with a size of 3 meters x 3 meters, allowing students to participate physically as pawns in the game. Each box has a money value, helping students learn about currency units (ones, tens, and hundreds). The teacher acted as the "banker." The game began with each group rolling the dice, with the group that rolled the highest number starting first. Figure 3 shows the students' enthusiasm when they tried out the E-Lens. Figure 3 showed the enthusiasm of the students when they tried out the E-Lens.

Then, each group selected a leader to represent them on the board. When the game order has been determined, the group leader rolled the dice to start the game. The number on the dice determines how many boxes the group leader must pass. When the group leader has stopped at the intended box, the group leader must take 1 question card in the middle and give the card to the teacher to be guided to solve the problem and start the discussion. If the group can answer, then the group will receive a sum of money according to the nominal stated on the game box. If the group cannot answer then, it will not get the nominal money and must take 1 punishment card. If the group can answer the question three times in a row, the group will get 1 reward card.

Figure 2. E-Lens Game Board

Figure 3. Enthusiasm Students Tried E-Lens

Figure 4 shows the example of the front and back view of the question card on the E-Lens. This game was designed with the aim of being an educational tool to improve the numeracy literacy skills of elementary school students based on bilingual inquiry. When the teacher asks questions, she includes open-ended questions to encourage children to think critically and explore different solutions. On the front of the card, there is an English math question sentence with Bahasa Indonesia translations on the back to support bilingual learning. Figure 5 is an example of the money that students will receive if they successfully answer the questions in each box. The money used is in units, tens, and hundreds.

If a group of students can answer the question three times in a row or the student stops at the reward box, the student will take a reward card containing a bonus. An example of a reward card is shown in Figure 6.

Figure 6 shows one example of a reward card. Each reward card contained messages in both English and Indonesian, such as: “You found a treasure chest! Collect 50 bonus points.” Meanwhile, an example of punishment is depicted in Figure 7.

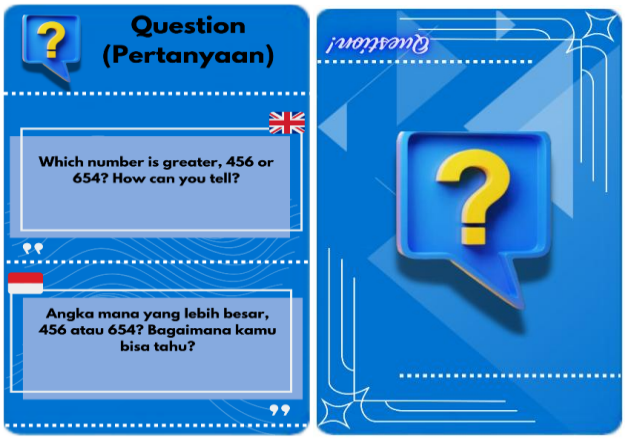

Figure 4. Front View of Question Cards and Back View of Question Cards

Figure 5. E-Lens Money

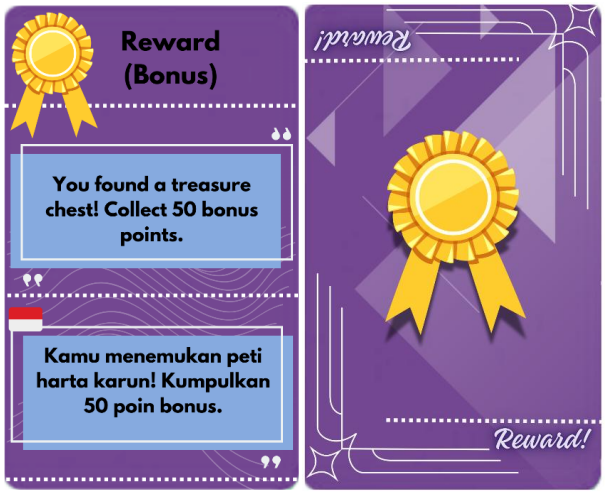

Figure 6. Front View and Back View of the Reward Card

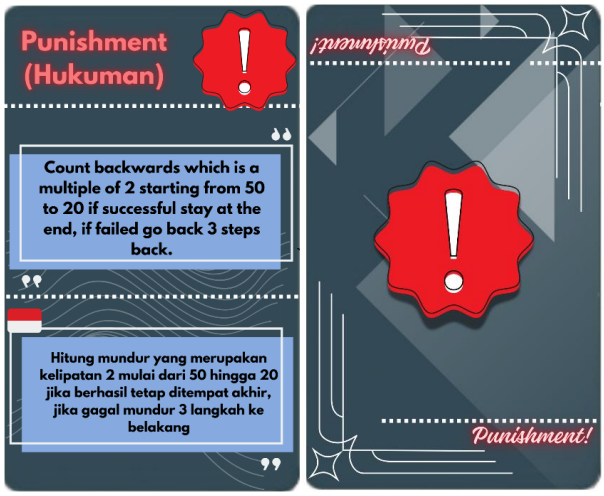

Figure 7. Front View and Back View of the Reward Card

The punishment cards contain math questions; one example is that students are asked to count backwards from 50 to 20. If successful, students can stay in place; if not, they moved back three boxes, as written on the punishment card.

Discussion

The learning media developed is entitled E-Lens, Exploring Literacy, Numeracy, Math, and English. The purpose of developing this bilingual inquiry-based learning media is to serve as an educational tool that enhances literacy and numeracy among third-grade elementary school students, making it easier for them to overcome difficulties in comprehending reading texts and applying basic mathematical concepts. Previous research by Tyas et al., (2022) on the implementation of literacy and numeracy through the smart apps creator (SAC) learning media in elementary school students showed that SAC helped teachers in analyzing students' literacy and numeracy skills more effectively. In this study, many teachers had not yet found solutions beyond using printed books to practice literacy and numeracy skills, and SAC provided an alternative approach to address this limitation. Other studies have also focused on the development of ICT-based literacy and numeracy instruments. Mulyadi and Nursetyo (2022) developed ICT-based literacy and numeracy assessment instruments designed to serve as practice materials and preparation tools for national assessments. Similarly, Mulyani (2022) found that educational game–based learning media developed using Microsoft PowerPoint 2010 were valid and feasible for classroom use. In addition, Izzatin et al. (2022) emphasized that the use of higher-order thinking skills (HOTS) questions contributes to improving students' numeracy literacy, while Kirom and Aini (2023) reported that inquiry-based educational games were valid, practical, and effective in enhancing elementary students' literacy and numeracy abilities.

In a literature review on the numeracy literacy of elementary students, Nastiti and Dwiyanti (2022) revealed that declining literacy levels are partly due to students' preference for digital entertainment and games over reading books. The lack of numeracy literacy, on the other hand, stems from teachers' limited practice in providing literacy- and numeracy-oriented exercises. These findings were supported by Utami et al. (2023), who found that students' overall numeracy literacy levels remain low.

Based on the findings of previous studies, it can be concluded that the low level of students' numeracy literacy necessitates the development of innovative learning media to enhance these skills. The novelty of this study lies in the integration of an inquiry-based approach as an innovative solution that promotes active student engagement and deeper conceptual understanding. Moreover, the E-Lens game is bilingual, using both English and Indonesian, and the development process follows a research and development (R&D) method validated by media and material experts before classroom implementation. The use of such learning media can foster social interaction and collaboration among students, enabling them to share knowledge, discuss concepts, and apply literacy and numeracy skills in a game-based context. This is supported by Garwan et al. (2023), who found that educational board games such as Monopoly can create enjoyable learning environments that encourage active engagement and spontaneous language use. Likewise, Widayanti & Rahayu (2018) highlighted that learning through games increases student motivation and interest compared to conventional instruction.

In this study, both media and material experts assessed the E-Lens learning media using three main aspects and twelve indicators. The media expert evaluation covered media efficiency, aesthetics, and design suitability, with respective scores of 75%, 81.25%, and 81.25%. From these results, an average percentage of 79.2% was obtained so that the E-Lens game board was categorized as very feasible to use. Meanwhile, the material expert evaluation included content, language, and learning strategy aspects, scoring 81.25%, 75%, and 75%. Of the three aspects, the average percentage is 77%. If converted, this percentage is included in the very feasible category. The validation results from both experts confirmed that the E-Lens bilingual inquiry-based board game is highly suitable as instructional media for elementary-level learning. This is also supported by the assessment conducted by students covered appearance and learning strategy aspects, yielded an average score of 84.37%, indicating strong feasibility and positive reception among learners.

The results of the validation assessment of media experts, material experts, and trials conducted by students show that the E-Lens (Exploring Literacy, Numeracy, Math, and English) bilingual inquiry-based board game is highly feasible and effective for use as a learning tool in teaching mathematics through English. The learning media motivated students to improve their literacy and numeracy skills.

CONCLUSION

Based on the research method carried out using the ADDIE model, which consists of Analysis, Design, Development, Implementation, and Evaluation, this study successfully developed inquiry-based numeracy literacy learning media for third-grade students. The inquiry-based approach implemented through the ADDIE method effectively enhanced students' understanding of numeracy concepts. Students demonstrated significant progress in comprehending and applying basic mathematical concepts such as addition, subtraction, and recognizing shapes and patterns. At the design stage of the ADDIE model, engaging and relevant learning activities were successfully created according to students' developmental needs. The inquiry-based tasks encouraged students to explore and discover mathematical concepts actively, thereby increasing their motivation and engagement in the learning process. This is supported by the results of the student questionnaire on the appearance and strategy of the learning media, which obtained a score of 84.37%.

The learning media was also validated by media and material experts. The media experts' assessment yielded an average score of 79.2%, categorizing the E-Lens board game as highly feasible for use. Meanwhile, the material experts' evaluation produced an average score of 77%, which, when converted, also falls within the highly feasible category. These validation results confirm that the bilingual inquiry-based E-Lens board game is suitable for use as a numeracy learning medium at the elementary level.

This study demonstrates that the inquiry-based ADDIE approach is both relevant and applicable within the context of elementary education. The use of this approach not only improves students' numeracy abilities but also enhances their critical thinking and problem-solving skills. Overall, the findings indicate that combining the ADDIE model with an inquiry-based approach is an effective strategy for improving numeracy literacy among third-grade students. This method provides an interactive, engaging, and meaningful learning experience, which is crucial for the development of foundational numeracy skills at the early stages of education.

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