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Digital Augmented Reality Flipbook Based on Local Wisdom: An Instructional Innovation to Enhance Students' Mathematical Literacy

Fitria Lestari, Noprisa*, Jeshinta Dwi Cahyani, Deni Sapto Wibowo
Mathematics Education, Universitas Muhammadiyah Lampung, Indonesia
*Correspondence E-mail: noprisa@uml.ac.id

Abstract

This research aims to develop and evaluate the effectiveness of a Flipbook Augmented Reality (AR) application based on local wisdom from Lampung in enhancing students' mathematical literacy in geometry topics. The method used is a developmental study with a design research approach, employing the 1993 Tessmer model, which consists of the preliminary, formative evaluation, and prototyping, including three parts: expert review, one-to-one, and small group, followed by the field test stage. The subject of the study was an eighth-grade student at Junior High School in Bandar Lampung. The instruments used were mathematical literacy tests and student response questionnaires. The results of expert validation indicate that the product falls into the excellent category, with a practicality level reaching 83.1%. The results of the binomial test show that more than 70% of students achieved learning mastery. The highest achievement in mathematical literacy was found in the communication indicator (88.15%). The research has proven effective in improving students' mathematical literacy. Flipbook AR can serve as a contextual learning alternative that integrates technology and local culture to meaningfully reinforce students' understanding of mathematical concepts.

Keywords: *Augmented reality, Digital flipbook, Mathematical literacy, Local wisdom*

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INTRODUCTION

In the era of the digital revolution, the development of technology and information is increasingly rapid, along with increasing human needs (Emanuele et al., 2003)Information technology is now an important component of daily life, having a significant impact on various sectors, including education, especially mathematics education in Indonesia (Harina, 2002) One of the key skills to master in the 21st century is math literacy (Rizki, 2019), which includes students' ability to reason, argue, communicate, model, and solve mathematical problems. In addition, this literacy also includes understanding mathematical symbols and the use of technology in learning. However, the results of the PISA survey show that the level of mathematical literacy of Indonesian students is still at a level that needs to be improved, as seen in Figure 1 of the results of the evaluation in recent years

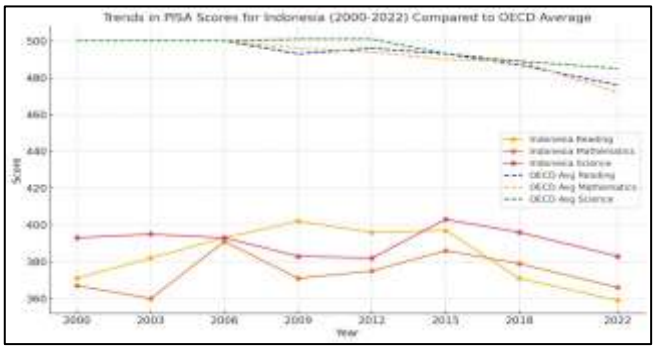

Figure 1. Indonesia PISA score comparison (2006-2022)

Indonesia's PISA average score showed a significant decline in all areas measured, namely math, reading, and science. In fact, Indonesia recorded PISA results that were below the average of the countries participating in PISA (O.E.C.D., 2023) This shows the need for improvement in teaching methods and materials (Hewi & Shaleh, 2020). This is in line with the findings obtained during the pre-survey at students of Junior High School in Bandar Lampung, based on the results of interviews with mathematics subject teachers, it was found that there are two main problems faced by students and teachers, namely (1) many students do not like mathematics, because it is considered difficult and boring. This is reflected in the data from the test results of the Minimum Competency Assessment model, which obtained the following values.

Table 1. Percentage of results of the grouping of mathematical literacy competency levels

Mathematical Literacy Competency Level	Percentage (%)
Special Intervention Is Needed	66.67 %
Basis	8.33 %
Talk	16.67 %
Proficient	8.33 %

Based on the results of mathematical literacy, it is known that students still have difficulties in formulating problems and are not able to fully apply and interpret the concepts taught. One of the main causes is the lack of experience in working on contextual problems, which results in frequent mistakes and lack of understanding of the material. (2) teachers still use visual learning media that are less varied, such as pictures and textbooks. This media seems monotonous, lacks communicative, and is difficult for students to understand. To improve students' mathematical literacy skills, both teachers and prospective teachers need to provide students with experience in solving daily problems.

The application of mathematical literacy includes the discussion of questions that measure the ability and application of technology-based learning (Dinni, 2018; M. Hasanah & Hakim, 2022; Indrawati, 2020) Research shows that math literacy can be improved through feedback, the development of Higher Order Thinking Skills (HOTS), and accustoming students to solving math literacy-based problems, such as PISA questions (Purnomo & Dafik, 2015; Sasongko et al., 2016). Therefore, students need alternative teaching materials that are more interactive to facilitate their understanding of mathematics learning In response, researchers are developing more interesting and effective learning media innovations. One of the proposed solutions is to adopt a technology-based learning approach, such as the use of interactive digital media to increase student motivation and understanding.

Flipbooks are a form of interactive digital teaching materials that present material in interesting formats, such as animations, images, audio, and videos (S. N. Hasanah et al., 2020). This information technology-based learning was developed using Flipbook Maker Pro (Andini et al., 2018) with the aim of utilizing technology in the learning process and improving mathematical literacy, which includes the ability to understand, apply, and communicate in a mathematical context. Through flipbook media, students can be more actively involved in learning, absorb information visually and interactively, and improve their understanding of mathematical concepts that are often considered difficult. With strong mathematical literacy, students can more easily access information and solve math problems through technological aids. On the other hand, Augmented Reality (AR), according to (Prasetiyo et al., 2018) Presenting virtual objects that convey information and help with daily activities. (A. Hidayat & Mujahiduddien, 2017; D. W. Hidayat et al., 2018; Wahyudi, 2014) emphasizing that AR is a technology that integrates the real world with the virtual world through electronic devices. One of the advantages of AR is its ability to display attractive visuals with three-dimensional objects that look like part of a real environment. The technology can also project 3D animation and audio to support learning materials (Pramono, 2018). The use of Augmented Reality (AR) in learning media makes it easier for students to understand the material through the visualization of 3D objects, text, images, videos, and audio displayed directly (R. Y. Endra, D. R. Agustina, 2017). Research shows that animation in learning can increase students' creativity (Salawati & Indrawati, 2015) In addition, local wisdom is an

alternative source that contains basic ideas as a guideline in daily life. Instilling knowledge about local wisdom in education is essential to maintain the preservation of natural and cultural resources (Harsojo, 2013; Maseleno et al., 2024; Noprisa et al., 2024; Nurjanah et al., 2024). According to (Mellawaty & Sudirman, 2020), The integration of local wisdom with technology has a positive impact on students' motivation, concept understanding, and attitudes. (Pamenang, 2021) adding that students have a positive perception of learning based on local wisdom, which allows them to get to know the local culture and preserve the values of that wisdom.

The integration of augmented reality (AR) with flipbooks based on local wisdom is an innovative approach to improve the educational experience by making learning more interactive and engaging. Research shows a growing interest in the development of these educational tools, which combine elements of local culture and modern technology.

Previous research related to the development of augmented reality flipbooks based on local wisdom in Bengkulu emphasized its potential in creating a more innovative learning process, especially in the Biology Education program (Apriza & Rukiah, 2023), research (Eva et al., 2023). The development of AR storybooks based on local wisdom in elementary schools also aims to prepare students for the Minimum Competency Assessment (AKM) through literacy, with results showing effectiveness and positive acceptance from students and teachers. Another study on digital flipbooks based on Kediri's local wisdom material examines figures contained in fictional stories in Grade IV Elementary School and supports the effectiveness of this tool in improving the quality of learning through validity, practicality, and effectiveness (Riska et al., 2024). The literature review shows that there has been no research on the development of augmented reality flipbooks based on local wisdom from Lampung to measure students' mathematical literacy in geometry. By incorporating the rich culture and traditions of Lampung, this research offers a relevant and contextual approach for students, while encouraging them to better understand and appreciate their cultural heritage. The importance of this approach has grown with the government's efforts to improve mathematical literacy through the Minimum Competency Assessment (AKM), which requires innovation in teaching methods that not only rely on theory but also integrate local culture to enrich students' understanding.

Therefore, this local wisdom-based augmented reality flipbook is an innovation that can enrich the learning experience by providing contextually and culturally relevant content, familiarizing students with solving math literacy-based problems, and leveraging technology to make education more engaging, accessible to students, and connected to the rich cultural values surrounding them.

METHOD

This research is a design research type with a development study type. The subject of the study is grade VIII students of Junior High School in Bandar Lampung, who will be taken as representative to evaluate the effectiveness of the use of digital teaching materials. The final product produced is an augmented reality flipbook based on local wisdom in Lampung to measure students' mathematical literacy skills in geometry materials. The Research Model refers to the Tessmer Model (Tessemer, 1993) with several stages that can be seen in figure 2 :

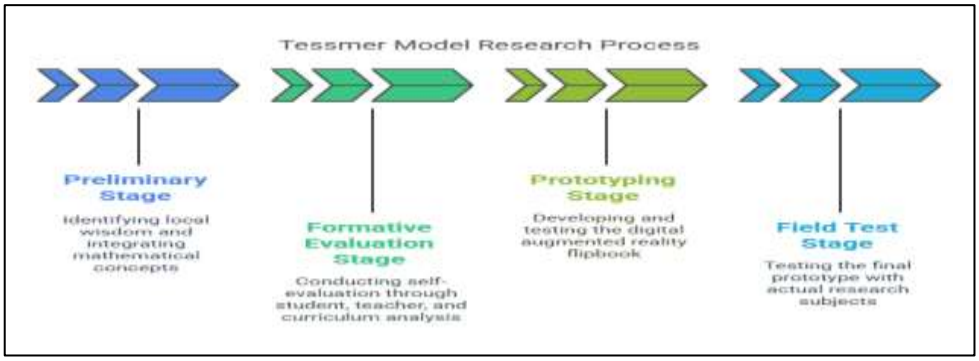

Figure 2. Research stages

Table 2. Research Sages

No	Stages	Information
1	Preliminary	a) determine the objects of local wisdom to be used, b) conduct field observations to collect data from resource persons and conduct descriptive analysis from the results of interviews and observations, c) analyze ethnographic data, and d) determine mathematical concepts and materials that will be included in the objects of local wisdom, so as to create relevance between the material and local culture
2	Formative evaluation (self Evalution)	which includes: a) analysis of students, b) analysis of teachers, c) curriculum analysis, and d) needs analysis
3	Prototyping	Expert Review: The initial product in the form of a Local Wisdom-Based Digital Augmented Reality Flipbook will be tested for feasibility through an assessment by experts to evaluate the design of the interactive teaching materials that have been created. The experts involved are experts in design and math materials. The validation results of the experts are used as the basis for the revision One-to-One: The Digital Augmented Reality Flipbook Based on Local Wisdom that has been developed is tested on two students who have studied geometry material Small Group: Revised prototypes based on the results of expert review and one-to-one tested in small groups
4	Field Test	The results of the second prototype revision were used to compile the third prototype. This prototype is then tested through field tests on the research subjects, to determine the feasibility of the product

The stages of the research are described in table 2 The research instrument consisted of a student mathematical literacy test and a questionnaire of student responses to learning. The mathematical literacy test instrument consists of 5 questions containing mathematical digital literacy indicators. The digital math literacy indicator refers to the *Association of American Colleges and Universities* (AAC&U) (Rafianti et al., 2018) which breaks down mathematical literacy into six indicators,1) interpretation; 2) representation; 3) calculations; 4) assumptions; 5) application/analysis; and 6) communication. The test instrument that has been prepared is then validated by experts to see the suitability of the material and the readability of the questions. The test instrument in this study is to evaluate the effectiveness of the Flipbook Digital Augmented Reality teaching materials based on Local Wisdom which was developed based on the Minimum Completeness Criteria (KKM), as well as to assess students' understanding of the material taught. The data obtained was then analyzed using binomial tests with the help of the SPSS application version 26. Response questionnaire instruments Response questionnaires from students and teachers are collected through questionnaires as a measurement instrument

RESULTS AND DISCUSSION

This study aims to design a Local Wisdom-Based Digital Augmented Reality flipbook that focuses on students' mathematical literacy skills in geometry materials through the following steps:

Preliminary

In the preliminary stage, the study also involved a pre-survey at Junior High School in Bandar Lampung through interviews with mathematics teachers, which revealed two main problems faced by students and teachers. First, many students do not like mathematics because it is considered boring, and the difficulty of students in formulating problems and applying the concepts taught is due to their lack of experience in working on contextual problems. Second, teachers still use limited learning media, such as pictures and textbooks, which seem monotonous, lack of communication, and are difficult for students to understand**.** After

analyzing the needs data, the next step is to conduct a literature review to better understand the way students think by referring to learning theories and previous research results.

Formative Evaluation

At this stage, it is necessary to analyze problems based on pre-survey data a) analysis of students, b) analysis of teachers, c) curriculum analysis, and d) needs analysis. Therefore, it is necessary to develop Local Wisdom-Based Digital Augmented Reality flipbook teaching materials with an attractive design to increase students' interest in learning the material. This interactive flipbook prototype was created using the Professional Flip PDF application and is equipped with Augmented Reality based on local wisdom. In its development, this flipbook includes contextual problems, ranging from the delivery of material to practice questions. At the beginning, a guide is provided on the instructions found in the flipbook. The characters and issues raised are based on the culture of Lampung. This flipbook consists of two parts, namely material on building limas and prisms. Figure 3 shows the initial draft or first prototype of the flipbook that has been made:

Figure 3. AR flipbook teaching materials

After carrying out the design process, the researcher evaluated the AR flipbook by being validated by expert judgment of media and materials. Validators are given a questionnaire containing grids and assessment sheets. The results of the validation of the subject matter experts are shown in Table 3.

Table 3. Categories of material expert validation results

Component	Average	Rating Categories
Content Eligibility Aspects	4,50	Excellent
Language Aspects	4,50	Excellent
Serving Aspect	4,75	Excellent
Graphic Aspects	4,50	Excellent

Based on the score as listed in Table 3, there are several suggestions given by validators to be used by Augmented Reality in order to provide a more detailed description of mathematical concepts. The results of the revision are shown in Figure 4.

Figure 4. before and after revision

The results of comments and suggestions at the self-evaluation stage are used as a guide to make revisions, which are then continued to the one-to-one stage.

One-to-one

At this stage, trials are carried out to see the practicality of the product. This practicality is to find out the level of readability, understanding, and interest of students in the product. The one-to-one trial was carried out on 2 students. The results obtained at this stage. Some students find it difficult to navigate, especially in understanding the interactive buttons on the flipbook. This shows that the instructions for use or navigation guide in the product are not clear enough, so students have difficulty operating the media optimally. So that repairs are carried out at this stage. After the revision is carried out, the Small Group stage (prototype 3) is continued.

Small Group

The small group stage of the small group test is a product trial stage based on the results of expert review, and one-to-one trials are carried out on 5 students with high, medium, and low ability. This activity can be seen in Figure 5

Figure 5. Small group stage

In this small group stage, students test the practicality of flipbooks. The test results show that most students can easily operate flipbooks. However, students with low abilities still struggle to navigate the interactive buttons and understand the instructions for use. This highlights the need to simplify the navigation guide to make it more accessible for all students.

Field Test

Field Trials are conducted with students, who are given questionnaires with results presented in Table 4. To see the mathematical literacy ability of students towards the material, an evaluation was carried out. Figure 6

Table 4. Student response questionnaire results

Aspects	Percentage	Criterion
Format	81.3 %	Very Practical
Relevance	83.2 %	Very Practical
Benefit	82.2 %	Very Practical
Interest	85,.7 %	Very Practical

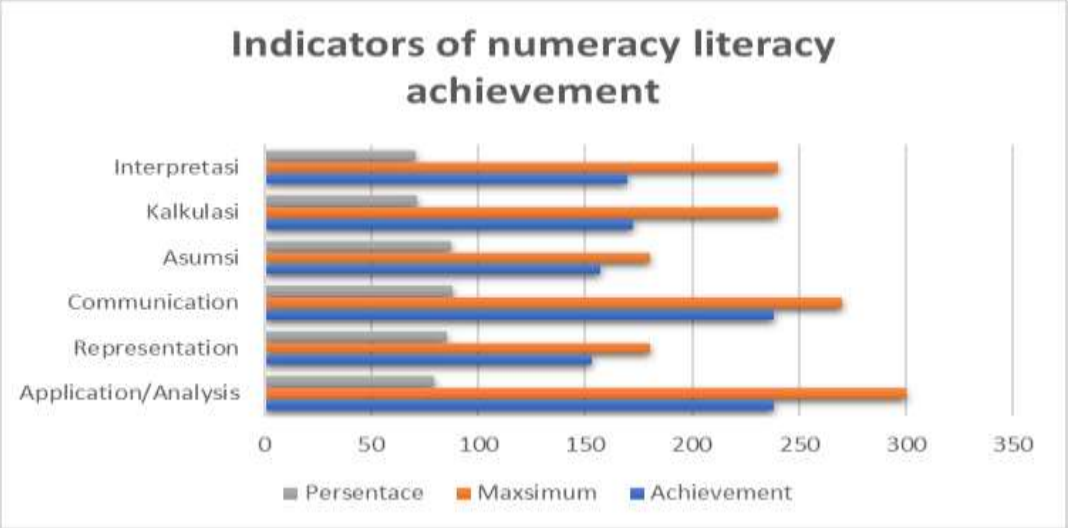

Figure 6. Results of achievement analysis of students' mathematical literacy indicators

Based on the post-test results, the indicator with the highest achievement was communication, with a percentage of 88.15%. This shows that students are very capable of conveying ideas, explaining the steps of completion, and expressing mathematical arguments well. The indicators of assumption (87.22%) and representation (85.00%) also showed good achievement, which means that students are quite capable of understanding the situation, taking appropriate assumptions, and converting information into the form of charts, tables, or mathematical drawings. Meanwhile, the application/analysis indicator obtained a score of 238 with a percentage (79.33%), indicating that some students are starting to be able to relate mathematical concepts to real life. On the other hand, the lowest achievement was seen in the indicators of interpretation (70.83%) and calculation (71.67%). This indicates that there are students who still have difficulty in making calculations correctly and in interpreting the meaning of the calculation results or data presented. Students with low scores are generally only able to participate in visual and contextual activities through the AR feature, but still have difficulty in solving problems that require precision calculation and the ability to understand the meaning of mathematical data. This difficulty is likely due to low basic numeracy skills as well as lack of practice in analyzing data. In addition, students who are passive and less actively involved in learning tend to show weak performance on calculation and interpretation indicators. This finding strengthens the view of (Maralova Bakyt Omiralievna, 2024; Nurani et al., 2020; Septiyaningrum et al., 2024) that students' activeness in learning has a great influence on the development of mathematical literacy skills, especially in aspects that require in-depth analysis and understanding. Data were analyzed using a binomial test with the application of SPSS 26.

It is known that the Sig value is 0.35 with a significance level of 0.05. Because the Sig value < 0.05, H_1 was accepted or the percentage of learning completeness of students who used Augmented reality flipbooks based on local skills was more than 70%. This success shows that the integration of local culture-based content and interactive technology can create a more

contextual, engaging, and meaningful learning experience.

These findings are in line with the results of previous research such as by (Apriza & Rukiah, 2023; Caridade, 2023; Estapa & Nadolny, 2015; Eva et al., 2023) showing that the use of technology-based media such as AR and flipbooks can increase student engagement and understanding in mathematics learning. In addition, research by (Faiz et al., 2020; Fajrie et al., 2024; Riska et al., 2024) also confirms that the integration of local wisdom in learning media has a positive impact on student motivation and attitudes. The study corroborates these findings with evidence that more than 70% of students achieve learning completion based on binomial tests, and students respond very positively to aspects of the product's format, relevance, benefits, and interest. Thus, this AR flipbook based on local wisdom is not only an innovation in terms of media, but also a bridge between technology and local wisdom to strengthen 21st century learning achievements, especially mathematical literacy. This approach brings the subject matter closer to students' daily lives and strengthens cultural identity, while increasing the attractiveness and effectiveness of the learning process.

CONCLUSION

This research shows that Digital Augmented Reality (AR) Flipbooks based on local wisdom in Lampung enhance students' mathematical literacy, especially in geometry. The media combines local culture and AR technology, making the material engaging and easy to understand. Expert validation rated the product as "very good," and students rated it highly for practicality, relevance, and interest (average 83.1%). Trials revealed improvements in student understanding, with over 70% achieving learning completion. Communication (88.15%) had the highest achievement, followed by assumptions (87.22%) and representation (85%). However, interpretation (70.83%) and calculation (71.67%) showed lower achievement. Limitations include the study being confined to one topic (geometry) and one school. Some students struggled with navigation, suggesting a need for better interactive design and guides. Future research should expand to other math topics and schools with diverse backgrounds, and consider adding features like gamification and adaptive assessments to improve engagement and effectiveness.

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BIOGRAPHIES OF AUTHORS

Fitria Lestari, M.Pd. is a lecturer in the Mathematics Education Department, Faculty of Education and Teacher Training, Universitas Muhammadiyah Lampung. Her research focuses on mathematics education, Realistic Mathematics Education (RME), Scaffolding in education, mathematical communication, problem-based learning, critical thinking, STEM education, and literacy. Affiliation: Mathematics Education Department, Faculty of Education and Teacher Training, Universitas Muhammadiyah Lampung, Lampung, Indonesia. Phone: (+62) 89655554860 E-mail: fitria_lestari@uml.ac.id

Noprisa, M.Sc is a lecturer in the Mathematics Education Department, Faculty of Education and Teacher Training, Universitas Muhammadiyah Lampung, Her research focuses interest His research focuses on mathematics education, Applied Mathematics, Modeling Mathematics, ethnomathematics. Affiliation: Mathematics Education Department, Faculty of Education and Teacher Training, Universitas Muhammadiyah Lampung, Lampung, Indonesia Phone: +6285379867770 Email: noprisa@uml.ac.id

Jeshinta Dwi Cahyani is a student of the Mathematics Education Program Universitas Muhammadiyah, Lampung, Indonesia Her research focuses interest is problem solving, understanding concepts mathematics, mathematical communication. Affiliation: Mathematics Education Department, Faculty of Education and Teacher Training, Universitas Muhammadiyah, Lampung, Indonesia Phone: +628973646678 Email: jeshinta2001@gmail.com

Deni Sapto Wibowo is a student of the Mathematics Education Program Universitas Muhammadiyah, Lampung, Indonesia. His research focuses interest is problem solving, understanding concepts mathematics, mathematical communication. Affiliation: Mathematics Education Department, Faculty of Education and Teacher Training, Universitas Muhammadiyah, Lampung, Indonesia Phone: +6283177158078 Email: denisw0912@gmail.com