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Development of Metaverse Learning Modules based on Local Wisdom with a Deep Learning Approach to Improve Students' Literacy Skills in Elementary Schools

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ABSTRACT

The literacy skills of elementary school students remain relatively low due to the lack of contextual and interactive learning media. This study aims to develop a metaverse-based learning module that integrates Bojonegoro local wisdom with a deeplearning approach to improve students' literacy skills. The research employed a Research and Development (R&D) method with the ADDIE model (Analysis, Design, Development, Implementation, Evaluation). The subjects were 30 third-grade elementary students in Bojonegoro. Data were collected through observation, interviews, questionnaires, and literacy tests, and analyzed both qualitatively and quantitatively. Expert validation indicated that the module is highly feasible, with media scoring 92%, language 94%, and content 95%. A small group trial (10 students) showed an improvement in literacy scores from 40% to 70%, while a large group trial (20 students) showed an increase from 45% to 85%. Student responses were very positive (86%). The N-gain result of 72.9%–81.4% indicated medium to high effectiveness. The module has proven effective in improving literacy comprehension while strengthening students' cultural identity. This research product is recommended for broader implementation in IPAS learning at elementary schools. This study developed a metaverse-based learning module integrating local wisdom and a deeplearning approach to enhance elementary students' literacy skills, proving effective in improving learning outcomes, motivation, and engagement through interactive, adaptive, and culturally contextual learning experiences."

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1. INTRODUCTION

Indonesia, with its vast land and maritime territory, possesses rich and diverse local wisdom that reflects each region's unique cultural identity. However, despite this cultural richness, literacy levels among elementary students remain relatively low due to limited access to contextual and engaging learning materials. This condition highlights the urgent need for educational innovation that not only preserves local wisdom but also integrates technology to enhance students' literacy skills through meaningful and interactive learning experiences. (Wijiningsih et al., 2017b; Ayu et al., 2019; Lyesmaya et al., 2020).

One of the key aspects of educational transformation in Indonesia is the integration of science and social studies into a single subject, Natural and Social Sciences (IPAS), which emphasizes concepts closely related to students' daily lives. This integration opens opportunities to develop local wisdom–based learning that connects academic content with students' cultural and environmental contexts. By leveraging the metaverse as an immersive digital platform, educators can transform local wisdom into interactive virtual experiences, allowing students to explore their cultural heritage while strengthening conceptual understanding and literacy skills. (Ministry of National Education, n.d.; Widyawati et al., 2021; Suttrisno et al., 2020).

One of the regions with distinctive cultural and environmental characteristics is Bojonegoro. Its rich natural and socio-cultural environment offers great potential to be integrated into learning materials that help students appreciate and preserve local wisdom. However, despite this potential, most students over 80% according to previous studies show greater interest in foreign cultures than their own. This indicates a research gap where local wisdom has not yet been optimally integrated with advanced technologies such as the metaverse and deep learning, which could create immersive, adaptive, and culturally relevant learning experiences to strengthen students' literacy and cultural identity. (Yulia et al., 2024;Lubba Kusna, 2019; Juangga et al., 2024)

Bojonegoro possesses a rich variety of local wisdom that reflects its cultural and environmental uniqueness. Traditions such as *Sedekah Bumi* (Earth Alms) express gratitude for nature's bounty, while performing arts like *Tayub* and *Sandur* embody communal harmony and respect. The distinctive *Jonegoroan Batik* patterns, inspired by teak forests and the Bengawan Solo River, symbolize the region's natural wealth. Local folktales such as *Angling Dharma* and *Mbah Joyo* convey moral and spiritual values, and sustainable forest management practices demonstrate ecological wisdom. Moreover, traditional foods like *Ledre* and *Tempe Bengawan* illustrate creativity rooted in local identity. These diverse cultural elements can be integrated into metaverse-based learning modules to provide immersive, meaningful experiences that enhance students' literacy and foster appreciation of local culture.

Based on the results of initial observations and studies, the limited understanding of students regarding Bojonegoro's local wisdom is mainly caused by the lack of innovative learning approaches implemented by teachers. To address this issue, this study aims to develop a metaverse-based learning module integrating local wisdom with a deeplearning approach to enhance students' literacy skills and cultural awareness. The novelty of this research lies in the integration of metaverse technology and artificial intelligence through deeplearning algorithms to create adaptive, immersive, and culturally contextualized learning experiences, an approach that has not yet been explored in previous studies on elementary education in Indonesia. (Yulia et al., 2022).

Based on the initial study related to the textbooks owned by Bojonegoro students on cultural diversity materials, what was studied was the Minang tribe, a tribe that lives far from the students' environment. So this is the main factor for students, who have low knowledge, especially related to local wisdom in the Bojonegoro area. In fact, the right learning for elementary level students should start from the student's immediate environment. In this case, the material that can be raised is the local culture in Bojonegoro. (Aziz et al., 2024; Fithriyah et al., 2023)

In addition, the complex learning process makes learning broader but less in-depth. The material is often delivered superficially, eliminating essential details that help students build conceptual

understanding. As a result, students tend to memorize rather than internalize knowledge meaningfully. Teachers also face challenges in designing contextual and engaging learning materials that connect classroom content with real-life situations. This lack of depth contributes to low literacy skills and reduced student motivation. A more comprehensive and technology-driven approach is therefore required to promote deeper learning. Integrating metaverse technology can create immersive learning environments where students actively explore concepts. Combined with a deeplearning approach, this method allows personalized and adaptive learning experiences, ensuring both conceptual depth and cultural relevance. (Baniata et al., 2024)(Burhanudin et al., 2023)

One of the reasons for the lack of depth of material is the lack of supportive school facilities. In addition, the complexity of matter and the limited sense are also important aspects. There needs to be an innovation that can help students understand the material in depth and is not limited by space and time. To overcome these various problems, a teaching material in the form of technology-based modules is needed to integrate some materials that are difficult to sense in real time to improve students' literacy skills.(Wiratama & Agustin, 2021)

This research focuses on developing and examining metaverse-based learning modules integrated with local wisdom and a deeplearning approach to enhance elementary students' literacy skills, particularly in science-related content. The study evaluates both the design and classroom implementation processes to determine the module's effectiveness in improving students' conceptual understanding, cultural awareness, and engagement. Through empirical analysis, this research aims to demonstrate how the integration of metaverse technology and deeplearning algorithms can create adaptive, immersive, and contextually relevant learning environments that foster holistic literacy development.

Therefore, this study does not merely aim to conduct research but is oriented toward the development and validation of an innovative metaverse-based learning module integrated with local wisdom for elementary education. The research systematically outlines the stages of development, validation, and implementation to evaluate the module's feasibility, practicality, and effectiveness in enhancing students' literacy and cultural appreciation. Beyond producing empirical findings, this development research contributes a tangible educational product that aligns with the national agenda for digital transformation in learning. It also supports the objectives of the National Research Master Plan in the Social Affairs cluster, emphasizing educational digitalization that bridges local cultural values with 21st-century technological innovation.

The solution that can be done to increase literacy of local wisdom in Bojonegoro is to develop modules whose essence is adjusted to the wisdom and peculiarities found in the Bojonegoro area using *a deep learning approach*. In addition, this module is also equipped with visualizations that are made as if they are real so that students can understand the material more closely using Augmented Reality and Virtual Reality tools. Therefore, the development of this module is equipped with tolls/applications of Augmented Reality and Virtual Reality, which can make visualizations of materials according to their original conditions (Gupta, 2022).

The development of the Augmented Reality-based Local Wisdom Module in Science Learning in Elementary Schools is also expected to make students be able to directly experience *the vibes* of natural and socio-cultural wealth contained in the 4th grade elementary school material. To answer these problems, this study adopts a *Research and Development* (R&D) approach with *the ADDIE* (Analysis, Design, Development, Implementation, Evaluation) development model. In product development, product quality remains the main goal. This quality is maintained with expert validation activities. After the product is developed, an analysis of students' responses and literacy abilities is carried out.

The development of teaching materials based on local culture has been carried out and produced book products that are used to support thematic materials. However, this book can support learning in the 2013 curriculum. The development of other teaching materials was carried out to increase the sense of nationalism, by using historical stories in Bojonegoro. In addition, other developments were also carried out related to the value of local wisdom by raising the art of batik, but based on student

worksheets. These studies were carried out to introduce one of the existing local cultures. The development of modules that contain several local wisdom such as cultural, natural, and social holistically has not been carried out. In addition, the use of metaverse technology developments, especially AR, has also not been widely done. Therefore, the advantage of this research is the holistic integration related to cultural, natural, and social wealth in Bojonegoro based on metaverse technology.(Wijiningsih et al., 2017;Carry & Dopo, 2019;Romadhan & Suttrisno, 2021; Irawan et al., 2022).

Despite several prior efforts to develop teaching materials incorporating local culture, most studies in Indonesia have produced text- or workbook-based products that remain aligned with the 2013 curriculum and do not utilize immersive digital technologies (Dahliani, 2010; Jusriadi et al., n.d.; Y. Sari et al., 2025; Suttrisno., 2022; Wibowo et al., 2024). Empirical studies indicate that AR/VR and metaverse technologies significantly enhance students' engagement, motivation, and conceptual understanding in science learning (Hedrick, 2022; Mitra, 2023; Pamoedji, 2017; Tan, 2022). Research on AI-driven personalization using deep learning also shows potential to adapt instruction to learners' profiles and improve learning outcomes, but most of these studies are conducted at higher education levels rather than in elementary schools (Anggriana & Dewi, 2022; Purwanto, 2022; Z. A. A. Sari et al., 2022).

Moreover, recent reviews emphasize that while AR/VR interventions are increasingly applied in education, few initiatives integrate three key elements simultaneously local wisdom, metaverse environments, and deep-learning personalization**.** Leaving a substantial gap in understanding their combined impact on literacy and cultural appreciation at the elementary level (AlGerafi, 2023; Al-Gnbri, 2022; Dewi et al., 2023; Mahartika, I., Iwan, I., Suttrisno, S., Dwinanto, A., Yulia, N. M., Andryanto, A., ... & Afrianis, 2023; Pizzolante et al., 2023; Saputra et al., 2020). Previous local studies that developed AR-based or local-wisdom teaching materials in Indonesia reported positive outcomes such as improved motivation and cultural awareness (Mahartika et al., 2023; Suttrisno et al., 2024; Yulia et al., 2024b), yet they did not produce a validated, immersive metaverse module equipped with deep-learning adaptation and tested through field implementation. This gap underlines the need for a developmental study focusing on a metaverse-based, deep-learning-enabled learning module grounded in Bojonegoro's local wisdom to empirically examine its validity, practicality, and effectiveness in improving elementary students' literacy skills.

The focus of this development is carried out with *a deep learning approach* that has not been researched in other studies. The selection of this approach is so that the material can be understood in depth, so that students' literacy skills are more optimal. Thus, the novelty of the development of this module is the use of *a Deep learning* approach in learning and metaverse integration that can give a real impression of learning materials based on AR media. The focus of this development lies in applying a deeplearning-based approach that has not been explored in previous studies on elementary education. This approach is intended to help students understand learning materials more deeply and meaningfully, thereby optimizing their literacy skills in science learning. The main objective of this study is to develop, validate, and test the effectiveness of a metaverse-based learning module integrated with local wisdom and powered by a deeplearning approach. This integration aims to produce an immersive and adaptive learning experience through augmented reality (AR) environments that reflect real-world cultural and natural contexts. The novelty of this research rests on combining metaverse immersion, local wisdom content, and deeplearning personalization within one holistic learning framework designed for elementary students.

2. METHODS

Research Design

The development design applied in this study refers to the ADDIE development model. In this study, the researcher has conducted an analysis stage, namely the analysis of learning needs both at the level of curriculum analysis and student analysis. For more details, see Figure 3 (Sulistri et al., 2020).

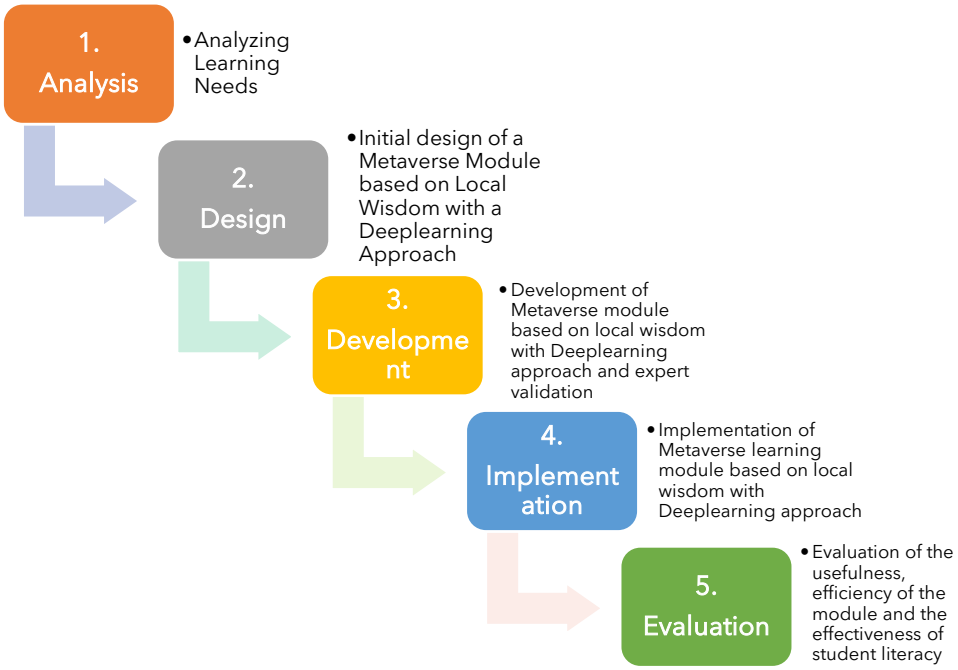

Figure 4. ADDIE Stages

The ADDIE development model includes five syntax that must be taken in developing a model, namely analysis, design, development, implementation, and evaluation. The Development Stages can be seen in Table 1.(Pornpimon et al., 2014)

Data and Data Sources

The data used in this study are qualitative and quantitative data. Qualitative data in the form of suggestions, comments, and criticisms written by sources obtained from both questionnaires and interviews. This data was obtained from experts who developed the SD/MI learning module, science learning experts, language experts, teachers, and students. Quantitative data is data obtained from questionnaire scores filled in by elementary/middle school teaching material experts, science learning experts, language experts, teachers, and students and tests, the results of student learning assessments (Last, 2022; Scott, 2020).

Data Collection Techniques

Data collection techniques were carried out by interviews, expert and teacher test questionnaires, and field trials. For interviews, points that must be asked in the interview guidelines with deep interview techniques are provided. Interviews were conducted with teachers and students. Qualification The learning module is carried out with a questionnaire given to experts/members and teachers. The expert test questionnaire contains questions about the content, language, and visualization of the Module. The practitioner test questionnaire contains questions regarding the feasibility of the module in achieving the learning objectives. After the Module was revised, the Module was piloted in SD/MI in Bojonegoro to determine the effectiveness of the Metaverse Module based *on local wisdom* with *a deep learning approach.*

Data analysis was carried out with qualitative and quantitative descriptive approaches. Qualitative descriptive analysis was carried out by processing data obtained through classroom observation and interviews with teachers. Meanwhile, quantitative data was analyzed using pre-test and post-test tests on students, student response questionnaires and validation results from media experts, linguists and material experts. Students' pretest and posttest tests are measured using the formula:

$$P = \frac{Tuntas}{\text{Jumlah Siswa}}\ X\ 100\%$$

Students' Lift Response is measured using the formula:

$$P = \frac{\text{F}}{\text{N}}\ X\ 100\%$$

Illumination:

P = Percentage F = Number of Respondents' Answers N = Maximum Number

The Effectiveness Test is measured by the formula:

$$N - gain = \frac{\text{Nilai Posttest} - \text{Nilai Pretest}}{\text{Nilai Maks} - \text{Nilai pretest}}$$

Information:

Max value: The highest score that can be obtained

For the results of the N-gain score assessment are divided into 3 categories, the following is the classification:

Table 1. N-gain classification

Percentage	Classification
N-gain > 70%	Tall
30% ≤ N-gain ≤ 70%	Keep
N-gain ≤ 30%	Low

3. FINDINGS AND DISCUSSION

The results obtained from the research have to be supported by sufficient data. The research results and the discovery must be the answers, or the research hypothesis stated previously in the introduction part.

3.1 Results

Analysis

At this stage, the researcher conducted direct observations at SDN Pacul III and MINU Unggulan Sukorejo with the aim of understanding the real conditions of the learning process that took place. This activity is in the form of needs analysis, module analysis, and learning resource analysis. The results of this stage are used as a basis for formulating the needs and direction of developing more relevant and effective learning modules.

Table 2. Stages of Analysis

Needs Analysis	Learning Module Analysis	Learning Resource Analysis
Most students have difficulty in understanding the science material, especially the metamorphosis material. This is due to the limited teaching materials, learning media used, and less varied methods.	The modules used at SDN Pacul III and MINU Unggulan Sukorejo have not fully met the principle of integration between materials, illustrations, and student activities, it is still dominated by textbooks as the only source of learning, especially in metamorphosis materials.	At SDN Pacul III and MINU Unggulan Sukorejo have provided various learning resources in print and digital form.

From the results of the analysis, it can be concluded that the learning process is still not optimal in supporting students' understanding of concepts. Students have difficulty in understanding the material due to the limitations of visual media and interesting learning activities. The modules used do not fully meet the principles of integration between content, illustrations, and activities, and tend to be textual

and less interactive. In addition, the available learning resources are still limited to textbooks and worksheets, without being supported by digital media, teaching aids, or other contextual learning resources. Therefore, it is necessary to develop modules and use more varied and interactive learning resources to increase student engagement and understanding as a whole.

Design

The design stage in the development of this learning module is carried out by designing the content of the IPAS learning module of class III metamorphosis material. Some of the core items of this module can be seen in table 3.

Table 3. Module Content Design

Indicators	Information
Curriculum Content	There are learning outcomes, learning objectives, and learning objectives that will be achieved in the module.
Determination of Material	Determining the material in the science subject, namely metamorphosis material
Student Activities	This learning module contains several student activities based on Local Wisdom with a Deeplearning Approach that involves student activity
Material Visualization	The learning module is equipped with an interesting image visualization, *an augmented reality* concept that can display images in real life.
Material Exploration	Completeness of material from various sources
Module Language and Display	Languages in modules in accordance with EYD

After this design stage, the researcher develops the design results into a real form.

Development

At this stage, the product that has previously been conceptually designed begins to be realized in a form that can be tested and used according to the research objectives. The visualization can be seen in figure 1.

Cover

Curriculum Content

Select all

25

26

27

28

29

30

31

32

33

34

35

36

Select all

Module Contents

Figure 1. Module Development and Visualization

Once developed, the modules are validated by media, language, and material experts using a questionnaire. Media experts suggested adding a barcode to the *Combination of Local Wisdom with Deeplearning Approach* section for student assignments, while linguists suggested language adjustments according to the characteristics of grade III students of Elementary & MI. Based on these inputs, the module was revised, and the results were displayed in table 4.

Table 4. Development of the Science Learning Module

Indicators	Information
Curriculum Content	There are learning outcomes, learning objectives, and learning objectives that will be achieved in the module.
Determination of Material	Determining the material in the science subject, namely metamorphosis material
Student Activities	This learning module contains several student activities based on Local Wisdom with a Deeplearning Approach that involves student activity
Material Visualization	The learning module is equipped with an attractive image visualization, *an augmented reality* concept that can display images in real time and the QR ode to access the concept *of Combining Local Wisdom with a Deeplearning Approach*
Material Exploration	Completeness of material from various sources
Module Language and Display	The language in the module is in accordance with EYD and the language is appropriate for the age of the children of class III of Elementary & MI.

Implementation

At this stage, the researcher carried out a learning experiment at SDN Pacul III and MINU Unggulan Sukorejo using the Metaverse Learning Module based on Local Wisdom with a Deeplearning Approach to Improve Students' Literacy Skills in Elementary Schools. The experiment was carried out twice, namely through a small group trial and a large group trial. The research design used was a one group pretest-posttest design. Learning activities began with the implementation of a pretest to measure students' initial abilities before the application of the module. Furthermore, students follow

the learning process using the IPAS module which integrates interactive visual technology and entertainment elements, with the aim of increasing student engagement, learning motivation, and concept understanding. After the learning process is completed, students are given a posttest to measure their improvement in understanding of metamorphosis material.

Students were also asked to fill out a response questionnaire to find out their responses to the use of augmented reality-based IPAS learning modules developed based on Local Wisdom with a Deeplearning Approach. In addition, to determine the level of effectiveness of the module, an analysis was carried out using N-gain calculation to measure the increase in students' understanding after using the module.

1. Small Group Trials

The small group trial will be held on June 12, 2025 at SDN Pacul III and MINU Unggulan Sukorejo involving 20 students. This activity was carried out through pretest and posttest of the augmented reality-based IPAS module based on Local Wisdom with a Deeplearning Approach. The results are presented in table 5.

Table 5. Small Group Trial Results

Trial Design	Percentage
Pretest	40%
Posttest	70%

Based on the results of the pretest and posttest in the small group trial, it is known that there is an increase in students' understanding after using the augmented reality-based IPAS learning module based on Local Wisdom with a Deeplearning Approach to metamorphosis materials. During the pretest, the percentage of student completeness was 40%, then increased to 70% in the posttest. This 30% increase shows that the use of these modules makes a positive contribution to optimizing students' understanding.

2. Large Group Trials

The large-group trial was carried out on July 14-15, 2025 at SDN Pacul III and MINU Unggulan Sukorejo by involving students. This activity includes pretest and posttest of augmented reality-based IPAS modules based on Local Wisdom with a Deeplearning Approach. The results are presented in table 6.

Table 6. Results of Large Group Trials

Trial Design	Percentage
Pretest	45%
Posttest	85%

Based on the results of the pretest and posttest in the large group trial, there was an increase in students' understanding after using the augmented reality-based IPAS learning module based on Local Wisdom with a Deeplearning Approach to metamorphosis materials. The percentage of completeness increased from 45% in the pretest to 85% in the posttest. This 40% increase shows that the use of these modules makes a positive contribution to optimizing students' understanding.

3. Student Response Questionnaire

From the application of this science learning module, positive responses were obtained from grade III students of SDN Pacul III and MINU Unggulan Sukorejo. The students' responses can be seen in table 7.

Table 7. Student Response Survey Results

Trial	Percentage	Category
Small Group Trials	88%	Very Positive
Large Group Trials	85,6%	Very Positive

4. Effectiveness Test

The results of the analysis of N-gain pre-test and post-test students are as follows in the small group test and the large group test as follows:

Table 8. N-Gain Results

Trial	N-Gain	Category
Small Group Trials	72,9%	Keep
Large Group Trials	81,4%	Tall

Based on the N-gain results with the criteria used, this module is included in the "High" effectiveness criterion.

3.2 Discussion

The development in this study is in the form of *an augmented reality* (AR)-based IPAS learning module, which is designed based on Local Wisdom with a Deep Learning Approach. This module allows students to access material visualizations in the form of three-dimensional through cellphone devices, making the learning process more interesting, interactive, and not boring. This research uses the Research and development (R&D) method. The development model used uses the ADDIE model. The ADDIE model is one of the R&D development models.

The initial stage in the development process of the IPAS learning module is the analysis stage At this stage, it includes the analysis of student needs, analysis of the learning modules that have been used, and analysis of the availability and utilization of learning resources. Needs analysis is carried out to find out the actual conditions of learning and students' needs for appropriate learning media. Based on the results of the analysis of the needs of grade III students of SDN Pacul III and MINU Unggulan Sukorejo, it was found that most students had difficulties in understanding science material, especially on the topic of metamorphosis. This is due to the limited teaching materials, learning media used and less varied methods. Students said that they tend to feel bored with one-way learning and hope for more interesting and interactive media. stated that the use of monotonous teaching media can weaken students' motivation to learn, thus having an impact on low understanding of the material being taught. Therefore, innovation and variety in teaching materials, media and learning methods are needed to increase the effectiveness of IPAS learning.(Nabilah, 2024)

In addition, students show interest in digital media that can be accessed through cellphone devices, especially if accompanied by interesting visualizations. The study found that the use of cellphones in learning science class V increased attention, interest in learning, and understanding of the material for students of SDN 28/1V Jambi. The use of cellphones is categorized as providing a more fun and effective learning environment Therefore, it is necessary to develop innovative and fun learning modules to increase student involvement and understanding in the learning process.(Private, Chiquita Azura, Noviyanti, 2025)

The results of the analysis of the learning module show that social studies learning in schools is still dominated by textbooks as the only source of learning. Teachers generally use the conventional approach, which is to explain the material verbally while pointing to the pictures in the book without the support of media or varied methods. Research by By revealed that many teachers do not understand learning planning in depth, even though this is important so that books are not the only hand. As a result, learning becomes monotonous and less interesting, so students experience boredom and difficulty understanding the material, especially abstract concepts such as metamorphosis. In fact, IPAS

material covers topics that are concrete and contextual, such as living things, the environment, and natural phenomena, which should be conveyed with a concrete and interesting approach. When the delivery of material is not tailored to the cognitive development characteristics of elementary school students, their understanding tends to be limited to the visual aspects contained in textbooks. This condition confirms the need for the development of innovative and fun learning modules, capable of visualizing abstract concepts in real life. This kind of module is expected to increase the effectiveness of learning and help students understand IPAS material in a more in-depth and meaningful way (Nursyahida, Siti Fadhila, Nurhaliza, 2024).

The results of the analysis of learning resources show that SDN Pacul III and MINU Unggulan Sukorejo have provided various learning resources in print and digital form. In terms of printed teaching materials, there is a Student Worksheet Book (LKS) for grades I to VI. The books are arranged based on grade level and adjusted to the level of cognitive development of students, so as to help students understand the material gradually and in a structured manner. In addition, there are also books Teacher guidelines that contain learning guides, material delivery strategies, and learning outcome indicators, which can help teachers in managing learning systematically and in a directed manner.

From the aspect of digital media, the school has facilitated technology-based learning through Smart TVs available in every class. This media is used to broadcast learning materials in visual and audio formats, such as educational videos or multimedia presentations, so as to make the learning process more interesting and easy to understand, especially for abstract or complex materials. Research at MI Tasywirul Afkar Gresik shows that the use of Smart TVs to display videos and presentations increases students' interest in learning because the content is attractive and interactive. In addition, the school is also equipped with projectors that teachers use to convey material to make it more interactive and communicative. Internet network facilities (WiFi) are also available in the school environment and can be accessed by teachers and students. This allows the integration of learning with digital media, such as learning videos, online learning resources, and educational applications based on gadgets. The availability of this digital infrastructure has great potential to support the development of more innovative and interactive learning resources.(Ilmiyah, Nailin Najahatul, Muslih, 2024)

The second stage in this study is the design stage. The design stage in the development of this learning module is carried out by formulating Learning Outcomes (CP), setting Learning Objectives (TP), compiling Learning Objectives (ATP) Flows, selecting appropriate subject matter, and designing the concept of augmented reality-based science learning modules based on Local Wisdom with a Deeplearning Approach.

The third stage in this study is the development stage. The development stage is carried out by referring to the research procedures that have been set. At this stage, the product that has previously been conceptually designed begins to be realized in a form that can be tested and used according to the research objectives. The development of this learning module uses the Canva platform, assemblr studio, wordwall and bookwidgets which provide metamorphosis materials, CP, TP, ATP, ready-to-use 3D objects, and based on Local Wisdom with a Deeplearning Approach, thus facilitating the learning process interactively.

One of the great things about Canva is that it provides a variety of elements that make the design more attractive and fun. According to research, Canva makes it easy to create engaging and interactive visual content through a rich selection of templates and design elements, increasing students' creativity, motivation, and understanding in the learning process. For the advantage of using assemblr studio is the ease of generating QR codes, which allows students to access 3D objects through mobile devices. According to the conclusion, Assemblr Edu's interactive media is "feasible and valid" and significantly improves students' science literacy, thanks to the ability to display 3D objects triggered through QR codes. Through this technology, students can observe the stages of metamorphosis such as eggs, larvae, pupae nymphs, and adult animals visually and interactively, so that the understanding of the material becomes more in-depth and fun. Meanwhile, the advantage of wordwall and bookwidgets is that it

makes it easier for researchers to create problems, and of course increases students' motivation to learn so that learning becomes more effective and fun.(Aryanto Nur, 2024; Nurul Mahruzah Yulia, Darul, Dinar Putri, Liana, 2024)

The use of augmented *reality-based IPAS learning modules* based on Local Wisdom with a Deeplearning Approach also makes it easier for educators to deliver metamorphosis material. Students showed high enthusiasm in participating in learning because of the visualization of interesting objects and also learning while playing. Augmented *Reality* (AR)-based learning offers an interactive and contextual learning experience, where learning objects can be visualized directly in a real environment. This approach allows students to actively interact with the teaching material through simulation and self-exploration.

According to the theory of constructivism put forward by Jean Piaget (1936 in), the learning process is not a passive activity that involves only the reception of information, but rather an active process in which individuals independently build their knowledge through direct experience. Even though educators play a role in conveying concepts or information, true understanding must still be constructed by students themselves through activities such as observing, feeling, and exploring. Therefore, effective learning demands active cognitive engagement as well as direct interaction with the learning environment.(Ahmad Suryadi, Muljono Damopolii, 2022)

In addition, based on Local Wisdom with a Deeplearning Approach, it aims to create a comfortable environment and motivate students to achieve optimal learning outcomes. In the Self-Determination Theory (SDT) developed by Deci and Ryan (2023) in . This theory explains that students' motivation to learn will grow optimally if three basic psychological needs are met, namely: Autonomy, Competence, and Connectedness. When all three needs are met, students tend to show stronger intrinsic motivation. The combination of Local Wisdom with the(Ryan, 2023) *Deeplearning* Approach provides space for children to learn in the way they like, feel capable (competent) and enjoy the process.

This learning module has been validated by experts, namely media experts, linguists, and material experts. The validation results show that the augmented reality-based IPAS learning module based on Local Wisdom with a Deeplearning Approach is stated to be very feasible and can be tested in learning, especially in Natural and Social Sciences (IPAS) subjects with a focus on metamorphosis material. Validation from experts showed the following results: media experts in the second stage gave a score of 92% (category "very feasible"), linguists in the second stage gave a score of 94% (category "very feasible"), and material experts gave a score of 94.2% (category "very feasible"). Although there are aspects that need to be improved, in general the modules are declared suitable for use in the learning process. This study also refers to previous studies, such as research by Wahyuningsih, which showed that the validation of subject matter experts reached 96% (the very practical category), the validation of linguists 90% (the "very valid" category), and the results of the students' test effective criteria obtained 91% (the "very effective" category). The results of the study stated that the teaching materials were feasible to be applied and went through good trials.

The fourth stage in this study is the implementation stage. At this stage, the researcher conducted a learning experiment at MI AI Ulum Kabalan using a Metaverse Learning Module based on Local Wisdom with a Deeplearning Approach to Improve Students' Literacy Skills in Elementary Schools. The results of the small group trial showed a significant optimization of understanding in student learning outcomes. In the initial test (pre-test), the percentage of completeness of students' scores is 40%, while in the final test (post-test) it increases to 70%. An increase of 30%. While the results of the large group trial showed the initial test (pre-test), the percentage of student completeness was 45%, while in the final test (post-test) it increased to 85%. This increase of 40% shows that the augmented reality-based IPAS Learning Module based on Local Wisdom with a Deeplearning Approach makes a positive contribution to optimizing student understanding.

Based on the results of the questionnaire, student responses to the small group test showed a percentage of 88% with the category "very positive. Then in the large group test, the student response questionnaire showed a percentage of 85.6% with the category "very positive. From the results of the

student response questionnaire, it can be concluded that the augmented reality-based IPAS learning module based on Local Wisdom with a Deeplearning Approach is very effective in applying it to learning.

Based on the results of the module effectiveness test using the N-gain small group test, an assessment score was obtained with an average score of 75.9 and a percentage of 72.9%. Based on the criteria used, this module is included in the "Medium" effectiveness criteria. Meanwhile, the results of the N-gain large group test were obtained with an assessment score of 81.4%. Based on the criteria used, this module is included in the "High" effectiveness criterion.

This research also refers to a study conducted by Njulvia Rahayu Ningsih. The results of the material validation in the study obtained a score of 82.1% which was categorized as "very feasible", Furthermore, validation by linguists in the second stage showed an increase with a score of 94.5%, also included in the "very feasible" category. However, the results of validation by media experts in the second stage obtained a score of 47.7%, which is in the category of "quite feasible" 59 Based on the study, it can be concluded that augmented reality-based teaching materials have the potential to attract students' attention and are suitable for use in the learning process, although they still need improvement in terms of the visual media used.

The results of this study are in line with the constructivist theories of Piaget and Vygotsky, which emphasize the importance of hands-on experience in the formation of knowledge. In addition, in accordance with Deci & Ryan's Self-Determination Theory, students' motivation to learn increases due to the fulfillment of the needs of autonomy, competence, and connectedness.

Thus, this research confirms that the metaverse can be a new immersive learning space, while local wisdom makes the material relevant and meaningful. The integration of deeplearning adds an adaptive dimension that helps students improve literacy both in terms of reading, writing, and understanding the local cultural context. The integration of deeplearning in the learning module puts this research in a superior position compared to previous studies. Deeplearning allows the system to recognize students' learning patterns, customize the material, and provide a personalized experience that is rarely found in basic education research in Indonesia. This advantage is in line with the global trend of artificial intelligence-based education that drives learning efficiency and effectiveness.

This research has strategic value because it successfully combines three important aspects: cutting-edge technology (metaverse), cultural identity (local wisdom), and pedagogical innovation (deep learning). The synergy of the three presents a new contribution to the literacy of elementary school students who not only focus on reading and writing skills, but also on contextual understanding rooted in local culture. This makes this research superior to previous research which tends to be partial, both in terms of technology and content.

4. CONCLUSION

Metaverse learning modules based on local wisdom with a deeplearning approach have proven to be effective in improving the literacy skills of elementary school students. This module provides an interactive, personalized, and contextual learning experience by integrating the local culture of Bojonegoro. This research contributes novelty in the development of digital technology-based teaching materials that are relevant to the Independent Curriculum. The final product of this module is worthy of publication and registered Intellectual Property Rights. This study developed a metaverse-based learning module integrating local wisdom and a deeplearning approach to enhance elementary students' literacy skills, proving effective in improving learning outcomes, motivation, and engagement through interactive, adaptive, and culturally contextual learning experiences.

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