Available online at: http://journal.uny.ac.id/index.php/jipi

Jurnal Inovasi Pendidikan IPA, 12 (1), 2026, 628-644

Enhancing Students' Curiosity Using e-Atlas Problem Based- Integrated with Yogyakarta's Local Wisdom on Classification Material

Muhammad Rasyid[1*], Habibatul Unayah[1], Tien Aminatun[1], Asri Widowati[1], Ibrahim Pandu Ame[2]
[1]Faculty of Mathematics and Natural Science, Universitas Negeri Yogyakarta, Yogyakarta Indonesia
[2]Science Education, The State University of Zanzibar, Zanibar, Tanzania
[*]Corresponding author. E-mail: muhammadrasyid.2023@student.uny.ac.id

Received: 20 December 2024; Revised: 3 June 2025; Accepted: 31 January 2026

Abstract: This study aimed to develop and evaluate a problem-based learning (PBL) e-Atlas integrated with Yogyakarta's local wisdom to enhance students' curiosity in biodiversity material. Curiosity is considered a critical competency in science education as it fosters deeper understanding and problem-solving skills. The e-Atlas was developed using the 4-D model (Define, Design, Develop, Disseminate). The Define stage identified the need for innovative learning media to address limited laboratory resources. The Design stage produced an interactive and contextual e-Atlas framework. During the Develop stage, the product was validated by experts and tested for readability by students. The Disseminate stage involved limited trials with ninth-grade students, The data were collected through interviews and questionnaires to maximize the research results. Validation results showed an Aiken's V index of 0.97, categorized as "very high," and the readability test indicated a 96% approval rate. Effectiveness testing with a one-group pretest-posttest design involving 30 students yielded an N-gain score of 0.71, classified as "high." A field test with control and experimental classes also showed a greater increase in curiosity among students using the e-Atlas. This study concludes that the e-Atlas is valid, practical, and effective in enhancing student curiosity through meaningful and contextual learning.
Keywords: Curiosity, e-Atlas, Local Wisdom, Problem-Based Learning.

How to Cite: Rasyid, M., Unaya, H., Aminatur, T., Widowati, A., & Ame, I. P. (2026). Enhancing Students' Curiosity Using e-Atlas Problem Based- Integrated with Yogyakarta's Local Wisdom on Classification Material. *Jurnal Inovasi Pendidikan IPA, 12*(1), 628-644. doi:https://doi.org/10.21831/jipi.v12i1.81133

INTRODUCTION

Science education at the junior high school level holds a strategic role in shaping students' scientific literacy and curiosity. These two competencies are essential in equipping learners with the ability to think critically, solve problems, and make evidence-based decisions in daily life. However, various studies and field observations reveal that student engagement in science learning remains relatively low, as indicated by their lack of motivation to inquire, explore, and understand scientific concepts deeply (Hunaepi et al., 2024; J. & K. J. Kang, 2024; Parmini et al., 2023).

One instructional approach that has been recognized as effective in enhancing student engagement and comprehension in science learning is Problem-Based Learning (PBL). This approach positions students as active participants in the learning process by involving them in solving contextual problems relevant to their everyday lives (Hmelo-Silver, 2004). Numerous studies have shown that PBL can significantly improve critical thinking skills, scientific literacy, and student curiosity (Barrows, 1996; Loyens et al., 2015). However, when PBL is implemented without incorporating local contexts, students often find it difficult to construct meaningful learning experiences(Agustini et al., 2024; J. Kang et al., 2020; J. Kang & Kim, 2020; Uyanık & Özdemir Uyanık, 2024).

An effective approach to developing curiosity is the problem-based learning model. This model facilitates hands-on learning and helps students comprehend scientific ideas and phenomena(Pasaribu et al., 2024). Problem-based learning is widely used in science education, enhancing critical thinking, improving learning outcomes, and fostering curiosity(Abdurahman et al., 2023; Amini et al., 2019; Ghani et al., 2021; Perdana et al., 2020; Safitri et al., 2023; Sari et al., 2021) (Abdurrahman, F., & Widodo, R. 2022). However, implementing problem-based learning often requires practical activities that depend on laboratory facilities, which are lacking in many schools in Indonesia. One of the significant challenges in implementing problem-based learning (PBL) is the limited availability of laboratory facilities, particularly in schools with restricted resources. The use of digital media, such as e-atlases, has been shown to be an innovative solution to address this issue. Previous research highlights that e-atlases can serve as effective learning tools to replace traditional laboratory practices. For instance, the development of an e-atlas for seed plant structures has proven to enhance students' understanding of biology concepts even in the absence of physical laboratory equipment (Carrió Llach & Llerena Bastida, 2022; Li et al., 2024). Similarly, virtual laboratories have demonstrated their potential to improve students' practical skills while overcoming the limitations of laboratory facilities. Another study emphasizes that digital atlases can increase students' learning outcomes, particularly during challenging situations such as the COVID-19 pandemic. By integrating an e-atlas enriched with Yogyakarta's local wisdom into classification learning, students can access scientifically relevant information while also understanding cultural contexts, ultimately fostering curiosity and engagement in the learning proces (Asyhari & Sifa'i, 2021; Mercy et al., 2020; Mufida & Widodo, 2021; Perdana et al., 2020; Saputra et al., 2019; Sari et al., 2021)

Alongside pedagogical approaches, advancements in educational technology have introduced innovative learning media such as the electronic atlas (e-Atlas). The concept of an atlas, originally developed by Gerardus Mercator in 1595 as a systematic collection of geographical maps, has evolved into a visual medium used across various scientific disciplines. In biology, for instance, atlases are used to present images and descriptions of organisms in a structured manner to aid identification and understanding(Gloy et al., 2022; Prasetya et al., 2024; Rahmawati & Lisdiana, 2023).

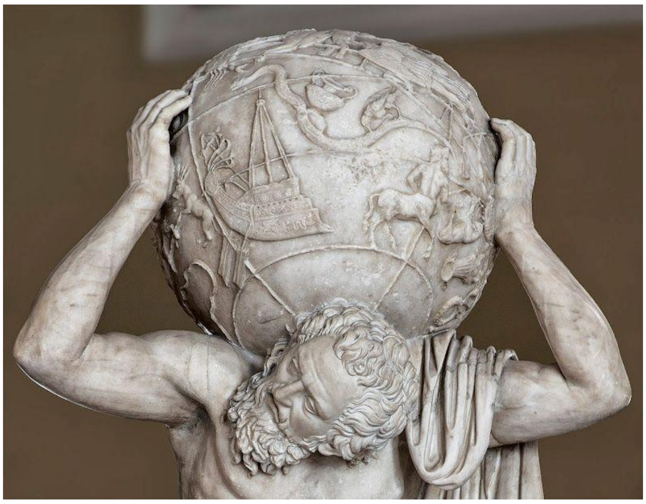

Figure 1. atlas mitologi yunani

In addition to serving as a cognitive tool, atlases play a significant role in fostering character education. Through atlas-based learning, students can access information about the anatomy biological, helping them visualize comprehensively (Oktafiyani & Widiyaningrum, 2024). Atlas in science learning not only enriches cognitive understanding but also nurtures curiosity and appreciation for the environment. Such exposure is essential in building awareness and responsibility toward sustainable practices among learners. Within the broader educational context, integrating media has been shown to improve student academic performance. For instance, classroom action research has demonstrated that using such media in social studies significantly enhances students' comprehension and academic achievements (Hunaepi et al., 2024; Pasaribu et al., 2024). These findings highlight the atlas's potential as an effective instructional tool across disciplines.

However, the evolution of teaching methodologies has opened pathways to maximize the benefits of atlas integration by aligning it with inquiry-based models such as Problem-Based Learning

ISSN 2406-9205 (print), ISSN 2477-4820 (online)

(PBL). PBL is a pedagogical approach that emphasizes solving real-world problems to cultivate critical and analytical thinking skills in students. This model has been proven effective in enhancing learning outcomes across cognitive, affective, and psychomotor domains (Ghani et al., 2021). The integration of atlases into PBL frameworks offers even greater advantages by contextualizing learning materials and promoting deep learning experiences (Coumans & Wark, 2024). For example, in studying classification, an atlas integrated with local wisdom provides students with detailed insights into species distribution and ecosystems within specific geographic regions. This enables learners to analyze spatial data, identify patterns, and formulate solutions to environmental challenges faced by their local communities. Such activities make learning more meaningful by connecting academic concepts with real-life applications (Suhirman & Ghazali, 2022)

Furthermore, combining atlases with the PBL model can enhance higher-order thinking skills (HOTS). Studies have shown that PBL is highly effective in developing critical thinking, problem-solving, and curiosity (Suhirman et al., 2021). The use of atlases in this context provides students with the tools to visualize complex data, fostering deeper understanding and innovative problem-solving approaches. Additionally, the integration of digital atlases aligned with PBL aligns with 21st-century learning objectives, emphasizing skills such as collaboration, communication, and creativity. By engaging students with interactive and localized content, atlases act as a bridge between traditional knowledge and modern educational demands. This synergy not only increases learning efficiency but also prepares students to address global and local challenges more effectively (Coumans & Wark, 2024).

In conclusion, the use of atlases in education, particularly within the framework of PBL, offers numerous advantages. While traditional atlas-based learning enhances content visualization and understanding, integrating it into a problem-solving approach further amplifies its impact. The ability of atlases to contextualize information, support critical thinking, and connect learners to real-world problems underscores their potential as a transformative tool in modern education. As research continues to explore innovative instructional strategies, the synergy between atlases and PBL represents a promising direction for fostering meaningful and impactful learning experiences (Azwan et al., 2019; Suhirman et al., 2021)

One of the critical challenges in science education, particularly in learning biological classification is the low level of students' curiosity. Several studies indicate that curiosity plays a vital role in enhancing students' engagement, motivation, and deeper understanding of scientific concepts (Uyanık & Özdemir Uyanık, 2024; Suhirman et al., 2021). However, research findings suggest that students' curiosity in classification learning is often low due to conventional teacher-centered approaches, lack of interactive learning resources, and minimal real-world contextualization (Ghani et al., 2021; Pasaribu et al., 2024). A lack of curiosity can significantly impact students' understanding and appreciation of biodiversity, leading to limited awareness of the ecological and cultural importance of species diversity (Mercy et al., 2020). If students do not develop an intrinsic interest in classification, they may struggle to grasp the interconnectedness of living organisms, which is essential for fostering environmental responsibility and conservation efforts (Rahmawati & Lisdiana, 2023). Therefore, innovative approaches are needed to enhance students' curiosity, making biological classification more engaging and meaningful.

One promising strategy to address this issue is integrating local wisdom into science learning. Local wisdom provides a culturally relevant framework that helps students relate scientific concepts to their everyday lives, making learning more tangible and meaningful (Amini et al., 2019; Carrió Llach & Llerena Bastida, 2022). In this study, Yogyakarta's local wisdom was chosen due to its rich biodiversity and strong cultural ties to ecological conservation. The region is known for its unique traditional knowledge in managing natural resources, such as sustainable harvesting practices of Jamur So (a wild mushroom species found under melinjo trees), which reflects the harmonious relationship between humans and nature (Suhirman & Ghazali, 2022). Incorporating these cultural elements into the learning process can provide students with a deeper understanding of classification beyond theoretical concepts, fostering both scientific literacy and environmental awareness (Prasetya et al., 2024).

By embedding local wisdom into a Problem-Based Learning (PBL) framework, students are encouraged to explore biodiversity through problem-solving activities rooted in real-life contexts. This approach not only enhances curiosity but also promotes higher-order thinking skills and engagement in science learning (Coumans & Wark, 2024; Perdana et al., 2020). Given the importance of biodiversity conservation in today's global challenges, integrating Yogyakarta's local wisdom into biological

ISSN 2406-9205 (print), ISSN 2477-4820 (online)

classification learning can serve as an effective model for contextualized science education that nurtures curiosity, critical thinking, and environmental stewardship.

e-Atlas has proven to be effective in making students more active and enthusiastic about learning. It allows students to visualize abstract concepts, improve academic achievement, and enhance motivation. When combined with actual practicum activities, e-Atlas outperforms traditional methods, offering a practical solution for schools with limited laboratory resources. To further facilitate learning, student e-atlases can be integrated with e-atlases. E-atlases guide students through active learning, containing information, instructions, and questions that support the development of procedural and theoretical understanding. Research shows that well-designed e-atlases improve learning outcomes, foster critical and creative thinking, and enhance curiosity. This study introduces a novel integration of Problem-Based Learning (PBL) and digital media (e-Atlas) with Yogyakarta's local wisdom—specifically the identification of *So* mushroom (*Scleroderma aurantium*)—to enhance students' curiosity in science learning. Unlike previous studies, which either focused on PBL or digital tools separately, this research uniquely combines both within a cultural context. The e-Atlas not only serves as an interactive learning medium but also contextualizes classification materials using local biodiversity, making science learning more meaningful, culturally relevant, and curiosity-driven for middle school students. (Kawuri et al., 2019; Perdana et al., 2020; Prasetya et al., 2024).

Classification material is particularly suitable for the development of e-Atlas-based problem-based learning e-atlas. At the junior high school level, practical activities related to classification are often limited due to a lack of equipment. e-Atlas addresses this gap by enabling students to engage in virtual experiments. Problem-based learning e-atlas integrated with e-Atlas have been shown to improve validity, practicality, and effectiveness, enhancing students' engagement and activeness. Students can easily access practicum activities by scanning QR codes on the e-atlas, promoting a seamless integration of virtual and hands-on learning.

Therefore, this study aims to develop problem-based learning e-atlas integrated with e-Atlas to enhance the curiosity of 9th-grade students in junior high schools. The integration of these tools is expected to provide an innovative solution to existing challenges in science education while fostering critical scientific competencies among students.

METHOD

This study uses the Research and Development (R&D) methodology. It follows the 4-D model, which consists of four phases: define, design, develop, and disseminate (Thiagarajan et al., 1974). The 4-D model is a development model that can be used to develop different types of learning media (Arkadiantika et al., 2020). The 4-D model is suitable for developing teaching materials based on learning objectives (Dermawan & Fahmi, 2020; Kosassy, 2019). The advantage of the 4-D model is that it does not take long because the stages are relatively not too complicated (Maydiantoro, 2019). The phases in the 4-D Model's development process are illustrated in Figure 1.

ISSN 2406-9205 (print), ISSN 2477-4820 (online)

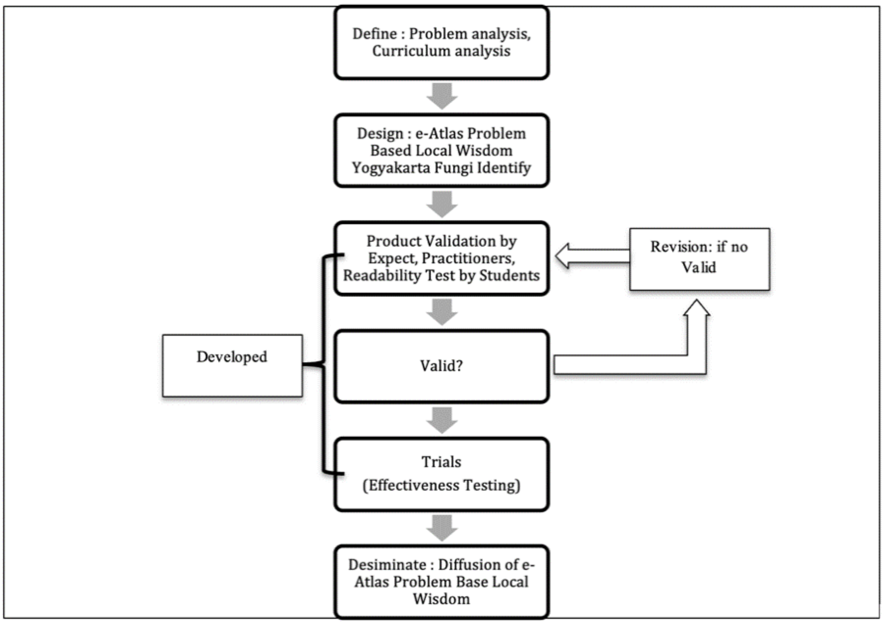

Figure 2. Research Stages with 4-D Model

The development of the e-Atlas adopts the 4-D Model, comprising four phases: Define, Design, Develop, and Disseminate. This structured methodology ensures the integration of innovative tools to address existing educational challenges while fostering curiosity among students.

Define Phase The define phase involved identifying the challenges in fostering curiosity during science education. Interviews revealed limited hands-on activities due to inadequate laboratory facilities, resulting in passive, teacher-centered learning. Curriculum analysis aligned the e-Atlas features with fostering inquiry-based learning, emphasizing engagement and curiosity development.

Design Phase In the design phase, the e-Atlas was developed using Canva and converted into an interactive PDF. The design adhered to the Problem-Based Learning (PBL) syntax: problem orientation, hypothesis formulation, data collection, analysis, and conclusion drawing. Features such as QR codes enabled students to explore virtual practicum activities, ensuring engaging and interactive experiences that cultivate curiosity.

Develop Phase This phase emphasized validation and testing to ensure the e-Atlas effectively enhances curiosity. Validators, including media and content experts, assessed its suitability using Aiken's V formula, yielding an average index of 0.97, categorized as "very high." Readability testing among students achieved a 96% approval rate, with feedback indicating that the e-Atlas successfully sparked interest and encouraged exploration. Effectiveness trials using a pre-experimental one-group pretest-posttest design revealed an N-gain score of 0.71, highlighting significant improvements in students' curiosity.

Disseminate Phase In the dissemination phase, the validated e-Atlas was introduced to schools and educators through training programs and academic publications. These efforts aimed to share the e-Atlas as a practical and effective tool for fostering curiosity, critical thinking, and active learning in science education. the validated e-Atlas was introduced to schools and educators through training programs and academic publications. These efforts aimed to share the e-Atlas as a practical and effective tool for fostering curiosity, critical thinking, and active learning in science education.

This study specifically targeted seventh-grade students at SMP IT Ibnu Abbas Yogyakarta based on several considerations. First, seventh grade is a crucial stage in secondary education where students are introduced to fundamental biological concepts, including classification. Research suggests that early exposure to interactive and inquiry-based learning at this stage can significantly influence students' long-term scientific curiosity and engagement (Pasaribu et al., 2024; Rahmawati & Lisdiana, 2023). Additionally, curiosity tends to decline with age if not actively nurtured, making early intervention essential (Ghani et al., 2021; Suhirman et al., 2021).

The choice of SMP IT Ibnu Abbas Yogyakarta was based on its educational approach and alignment with the study's objectives. The school implements a science-based curriculum but, like many other institutions, faces challenges related to limited laboratory resources. This aligns with the rationale

ISSN 2406-9205 (print), ISSN 2477-4820 (online)

for developing the e-Atlas as a digital tool to overcome constraints in conducting practical classification activities (Amini et al., 2019; Perdana et al., 2020). Furthermore, the school's location in Yogyakarta, a region rich in biodiversity and local wisdom, provided an ideal setting for integrating cultural knowledge into science education. The school's willingness to participate and its representative student population also ensured the study's findings could be applied to similar educational contexts. Through this dissemination, it is expected that the developed e-Atlas can be widely implemented in schools facing similar challenges, contributing to modernized and contextualized science education.

This study uses four validators: a media expert, a content expert, and two practitioners. Their role was to assess the validation of the developed student e-atlas. Additionally, 10 ninth-grade students participated in a readability test to evaluate the product's practicality. Field trials to assess the effectiveness of the e-atlas were conducted by randomly selecting one 7th-grade class, totalling 30 students at SMPIT Ibnu Abbas Godean, as the sample. The field-testing phase was conducted to assess the effectiveness of the problem-based learning (PBL) e-Atlas in enhancing students' curiosity. A quasi-experimental design with a control group and an experimental group was employed. A total of 60 ninth-grade students participated, divided equally into two groups: 30 students in the experimental group and 30 in the control group. Procedure Pretest: Both groups completed a pretest consisting of five multiple-choice questions designed to measure curiosity indicators, including interest in the subject matter, active participation, and exploration of information. Treatment: The experimental group used the PBL e-Atlas integrated with Yogyakarta's local wisdom for learning classification.

The e-Atlas provided interactive digital features, such as button click linked to practicum activities, and followed the structured PBL steps. The control group received conventional teacher-centered instruction using standard textbooks. Posttest: After the treatment, both groups completed the same test to evaluate changes in their curiosity levels.

Data Analysis

This research was carried out by combining experimental designs of non-uniform kelompok control with uneven kelompok control. This design consists of two groups that are not randomly selected, followed by a pretest to determine the starting condition and a posttest after completion (Vann-Hamilton, n.d.). This study is a quantitative study with two levels (K. A. Sari et al., 2017). One kelas was used as a control group (VIII-B) using the Discovery Media Module. Furthermore, another class was used as an experimental group (VIII-A) by varying the e-Atlas Learning Media in the PBL teaching model.

This study included a variety of study variables. These variables are independent, controlled, and dependent. the media modul kemdikbud model Discovery and the Media pembelajaran e-atlas model pengajaran pbl are independent variables in this study. The control variables include the classification of living areas, the number of teachers, the number of students, the length of time spent learning, and the data collection tools. Similarly, the dependent variable is curiosity.

The study was conducted at SMP IT Ibnu Abbas Yogyakarta. The purposive sampling technique is used to choose samples based on certain criteria. The sample used consisted of two classes that had different activities during the learning process, with a total of 64 students. Partisipasi dilakukan secara sukarela, bersifat rahasia, dan berdasarkan informasi yang disediakan sebelumnya. Pemilihan kelas didasarkan pada pendapat guru mata pelajaran IPA di sekolah setempat dan rata-rata skor ASPD untuk tahun 2023/2024 yang hampir sama. The composition of the number of participants used as a research sample is as follows.

Participation was voluntary, confidential, and based on prior informed consent. The selection of classes was based on the opinions of science subject teachers at the local school and the average ASPD scores for the 2023/2024 academic year, which were nearly identical. An expert lecturer verified and assessed the test prior to its usage (content validity and construct validity). Content validation evaluates the instrument's appropriateness to the material being measured. Five specialists carried out the test and gave the equipment to be rated. The assessment results were then computed using the Aiken Index. Construct validation was used to evaluate the quality of each question on the test. This was accomplished by administering questions to 32 class IX students who had acquired coursework on the human digestive system. The Pearson Product Moment Correlation method was then applied to the test findings. Additionally, the Cronbach Alpha (α) formula was used to assess the test's reliability.

ISSN 2406-9205 (print), ISSN 2477-4820 (online)

The data analysis approach employed was precondition testing and hypothesis testing. The precondition test determined if the data had a normal and homogenous distribution. The normality test was performed using the Shapiro-Wilk approach. The homogeneity test was conducted using the Levene Statistics test algorithm. The data was judged normal and homogenous if the significance value above the probability value (Sig > 0.05). The following tests included the t-test and the n-gain test. The independent sample t-test was used to demonstrate disparities in student average outcomes. In the t-test, Sig (2-tailed) <0.05 indicated rejection of H0 and acceptance of H1. Meanwhile, if Sig (2-tailed) > 0.05, H0 was approved whereas H1 was denied. The N- Gain test was used to assess students' progress following therapy by examining the size of the growth in critical thinking abilities (Utami, 2019).

The pretest and posttest scores were analyzed using t-test was carried out with the help of Microsoft Excel and SPSS to calculate the N-gain scores, measuring the improvement in curiosity. Statistical analysis using a t-test revealed a significant difference between the two groups, confirming the effectiveness of the e-Atlas in fostering curiosity. The results were categorized as high, medium, or low based on the N-gain criteria.

The experimental group showed a significant improvement in curiosity with an average N-gain score of 0.72, categorized as "high." In contrast, the control group achieved an average N-gain score of 0.45, categorized as "medium." Statistical analysis using a t-test revealed a significant difference between the two groups, confirming the effectiveness of the e-Atlas in fostering curiosity. The validation sheet and student responses related to the readability test used a 4- point Likert scale, as shown in Table 1.

Table 1. Linkert Scale Criteria

Criteria	Score
Very good	4
Good	3
Less	2
Very less	1

To measure the validity of the e-atlas so that it is suitable for use, namely using the Aikens' V, it can be seen in equation 1:

$$V_{aiken} = \frac{\sum s}{[n(c-1)]}$$

information:

S = r - lo

V = Aiken validity index

C= highest validity rating number

n = number of validators

Lo= lowest validity rating

r = number given by the validator

Table 1. Aiken's V Validity Criteria

Aiken V index	Criteria
$0.8 < V \leq 1$	Very High
$0.6 < V \leq 0.8$	High
$0.4 < V \leq 0.6$	Medium
$0.2 < V \leq 0.4$	Low
$0.0 < V \leq 0.2$	Very Low

(Rahmat et al., 2024)

The readability test questionnaire was analysed by calculating the average assessment score

ISSN 2406-9205 (print), ISSN 2477-4820 (online)

given to ten 9th-grade students. The average score of all aspects of the assessment was calculated using Equation 2.

$$P = \frac{n}{N} \times 100\%$$

Information:

P = percentage of readability
n = score obtained
N = max score

The average score will later be converted into a qualitative value based on the score conversion guidelines in Table 3, which includes five scales.

Table 2. Readability Test Score Conversion

Readability Test (%)	Category	Information
>80	Very good	Unrevised
70 – 80	Good	Unrevised
60 – 69	Enough	Revised
50 – 59	Less	Revised
<50	Very less	Revised

(Pratiwi et al., 2014)

The research type is pre-experimental, using a one-group pretest- posttest design, as illustrated in Table 4.

Table 3. Research Design

Control Class	O_1	X_1	T_1
Experimental Class	O_2	X_2	T_2

The research was carried out using a pretest with varied treatments in each class, followed by a posttest to assess students' critical thinking ability. The collected data was then examined to see whether the results were consistent with the research objectives. The study design used is detailed in the table below (Sugiyono, 2010).

Data was collected by administering 20 questions based on Student's Curiosity in the pretest and posttest. These questions were then analyzed using MS Excel and SPSS to obtain the gain score and determine the impact of atlas on improving students' curiosity. The atlas focuses on classification materials. Table 5 outlines the various aspects of Student's Curiosity.

Table 4. The various aspects of Student's Curiosity

No	Aspect	Indicator
1	Interest in the subject matter	• Interested in the material taught by the teacher. • Initiative to ask and answer questions about the material being studied.
2	Enthusiastic and actively involved in the learning process	• Creation of an active learning atmosphere between teachers and students • Students listen and pay attention to the teacher's explanation during the lesson
3	Conducting information exploration	• Creation of an active learning atmosphere between teachers and students • Students listen and pay attention to the teacher's explanation during the lesson

ISSN 2406-9205 (print), ISSN 2477-4820 (online)

To see the product's effectiveness in improving curiosity, looking for the gain value using Formula 3 is necessary gain score suitable for cognitive, non-cognitive curiosity.

$$N - gain = \frac{S_{Posttest} - S_{Pretest}}{S_{Maximum} - S_{Pretest}}$$

The N-gain results are categorised into three groups, as shown in Table 6 (Saputri & Tirtoni, 2022).

Table 5. N-Gain Value Criteria

Nilai	Kriteria
N-gain > 0.7	High
0.3 < N-gain ≤ 0.7	Medium
N-gain ≤ 0.3	Low

RESULT AND DISCUSSION

The first stage in this research is to define. Several activities are carried out at this stage, including analyzing student and teacher problems. Information was obtained through interviews that practicum activities were rarely carried out in this material because of the lack of laboratory facilities and equipment, so learning was only textual and measured cognitive achievements. Learning activities use direct learning that is still teacher-centered and has not yet utilized e-atlas simulation, which is integrated into student e-atlas. The next activity, curriculum analysis, namely the material used, is adjusted to the features of the e-atlas simulation, analyzing how well the content aligns with intended educational results and goals. e-atlas is adjusted to the stages of the problem base.

“Jamur so” or “Jamur melinjo” is a type of wild mushroom that grows naturally under melinjo (Gnetum gnemon) trees, commonly found in Gunung Kidul, Yogyakarta. This mushroom is renowned for its distinct flavor and seasonal growth, particularly during the rainy season. It is widely consumed by the local community, forming an integral part of their traditional diet and culinary practices. Beyond its culinary uses, jamur so melinjo holds ecological and cultural significance within the local community. It is harvested sustainably by locals, reflecting their harmonious relationship with nature and their understanding of biodiversity preservation.

When the mushroom begins to grow to the size of a handful and appears fresh yellow, the local people of Gunung Kidul engage in a practice called "ngurungi" where the mushroom is covered using a bamboo woven basket known as a "tumbu" at figure 2. Scientifically, covering the mushroom with a tumbu helps maintain optimal humidity and protects it from external contaminants, ensuring better growth and quality. This practice reflects their harmonious relationship with nature and their understanding of biodiversity preservation.

Figure 3. Tumbu used for ngurungi

The second stage is design. At this stage, the e-atlas is designed in the Canva app and then converted to glide apss, as you can see in the initial view of the e-atlas in Figure 3.

Figure 4. e-atlas Initial View

At this stage, students learn activities on the e-atlas that follow the structured steps of the problem base, including orientation, problem formulation, data collection, data analysis, and conclusions. The student e-atlas are also integrated with the E-atlas simulation, where students only scan the QR Code on the e-atlas, which is directly connected to the E-atlas simulation in the classification experiments. Students immediately carried out practicum activities on their respective smartphones. For more details, see Figure 3.

Figure 5. Learning Activities Based Local Wisdom

The Problem-Based Learning (PBL) syntax in this study is reflected through a series of structured stages that guide students in exploring classification concepts integrated with Yogyakarta's local wisdom. The stages are designed to foster curiosity, while making learning contextual and meaningful. These stages, supported by the e-Atlas as a learning tool, include Problem Orientation At the beginning, students are introduced to real-world problems related to classification in the context of Yogyakarta. These problems are carefully designed to be relevant to students' surroundings and aligned with the local cultural and ecological context. Using the e-Atlas, students explore scenarios involving the region's unique flora and fauna, sparking curiosity and engagement.

ISSN 2406-9205 (print), ISSN 2477-4820 (online)

Problem Exploration and Hypothesis Formation, In this phase, students work in groups to analyze the problem and identify key questions. They utilize the e-Atlas to gather initial data and insights about classification. This tool provides rich, localized information, helping students generate hypotheses and predictions about the problem at hand. Data Collection and Investigation, Students delve deeper into the problem by conducting investigations using data and resources provided in the e-Atlas. This stage emphasizes active learning, as students are encouraged to seek patterns, interpret data, and connect their findings to the broader ecological and cultural context of Yogyakarta. The digital format of the e-Atlas allows for interactive exploration, enhancing engagement and understanding. Data Analysis and Conclusion Drawing In this stage, students collaboratively analyze their findings and synthesize conclusions. They use the e-Atlas to validate their hypotheses, cross-referencing their results with the data on Yogyakarta's classification. This stage fosters critical thinking as students evaluate evidence and draw meaningful conclusions. Solution Presentation and Reflection in the final phase, students present their findings and proposed solutions to their peers and teachers. This phase involves reflective discussion, where students assess their learning process, revisit their understanding, and connect it to real-world implications. The integration of local wisdom ensures that solutions are culturally and ecologically relevant. Through these syntactic stages, the PBL model encourages students to engage deeply with the material, develop 21st-century skills, and cultivate a sense of environmental and cultural stewardship. The e-Atlas serves as a pivotal tool in this process, bridging the gap between theoretical knowledge and practical application within a local context.

Figure 4 shows learning activities following the Problem based model structure of data analysis and conclusions.

Figure 6. Data Analysis and Conclusion Activity

The figure presented in this article illustrates a critical stage in the implementation of the e-Atlas, which is based on Problem-Based Learning (PBL) and integrated with Yogyakarta's local wisdom. This stage, referred to as data analysis and conclusion drawing, showcases students actively engaged in collaborative discussions while utilizing the e-Atlas to process information related to classification materials. The e-Atlas serves as an innovative learning medium designed to connect students with the unique classification and cultural heritage of Yogyakarta.

In this stage, students use the e-Atlas to analyze and interpret data as a foundation for solving problems or answering questions related to classification. This activity not only facilitates their understanding of scientific concepts but also promotes critical, creative, and analytical thinking. The

ISSN 2406-9205 (print), ISSN 2477-4820 (online)

figure demonstrates how students interact with the digital learning tool to link empirical data with real-world phenomena, such as the diversity of flora and fauna native to Yogyakarta.

Furthermore, the activity highlights the core values of collaboration and group discussion inherent in the PBL approach. Students exchange ideas, evaluate data, and collaboratively draw conclusions to address the given challenges. This process effectively integrates 21st-century skills, such as teamwork, communication, and problem-solving, which are essential for preparing students to navigate global challenges.

The use of the e-Atlas as a learning aid exemplifies innovation in science education, making the learning experience more interactive and contextual. This digital resource has undergone rigorous validation by experts in media, content, and practice to ensure its relevance and suitability for students' educational needs. By incorporating Yogyakarta's local wisdom, the e-Atlas not only functions as a learning tool but also as a means to instill cultural and environmental awareness in students.

Overall, the figure reflects the synergy between technology, problem-based learning methodologies, and local wisdom in creating a meaningful learning experience. The data analysis and conclusion-drawing stage, as depicted, emphasizes that learning extends beyond mere information transfer. It empowers students to become independent, critical learners. By leveraging technology such as the e-Atlas, the learning process is adapted to meet the needs of modern students while maintaining a connection to local contexts.

The third stage is development. During this stage, the designed e-atlas need to be validated by validators. E-atlas are validated by whatever validators are available, namely media experts, content experts, and 2 practitioners. The validation results from the validators are shown in Table 7.

Table 7. The validation results

ISSN 2406-9205 (print), ISSN 2477-4820 (online)

Assessed Aspects	Validator				Index	Category
	Media expert	**Content expert**	**Practitioners 1**	**Practitioners 2**		
Eligibility Content: Suitability of material with learning outcomes and objectives	4	4	4	4	1	Very High
Accuracy of the material	4	3	4	4	0.92	Very High
Encourage students' curiosity	4	4	4	4	0.92	Very High
Eligibility of Serving:	3	4	4	4	0.92	Very High
Serving support	4	4	4	4	1	Very High
Presentation of learning	3	4	4	4	0.92	Very High
Conformance with problem base models	4	4	4	4	1	Very High
Compatibility with improve Science literacy and curiosity	4	3	4	4	0.92	Very High
e-atlas simulation integration:						
Suitability of e-atlas simulations to materials	4	4	3	4	0.92	Very High
Ease of use of E-atlas simulations	4	4	4	4	1	Very High
Contribution of E-atlas simulation to concept understanding	4	4	4	4	1	Very High
Language Qualifications: Straightforward and communicative	4	4	4	4	1	Very High
Dialogical and interactive	4	4	4	4	1	Very High
Suitability with student development	4	4	4	4	1	Very High
Conformity with language rules	4	4	4	4	1	Very High
Average Aikens' V index	58	58	59	60	0.97	Very High

Table 7 is the validation result of the e-atlas developed. The validators consisted of 4 people, namely media experts, material experts, and two practitioners who were science teachers. The validation results with Aikens' V averaged 0.97 for all aspects and indicators with a very high category, showing that the E-atlas simulation integrated problem base- based e-atlas is feasible for science learning. After the validator validates this e-atlas, ten students who have been selected test it for readability. The results of the readability test are shown in Table 8.

Table 8. The results of the readability test

Acpects	Indicators	Scores obtained	Readability (%)	Category

ISSN 2406-9205 (print), ISSN 2477-4820 (online)

Ease of use	Easy-to-use e-atlas in the learning process	38	95	Very good
	Instructions for using the e-atlas are clear and easy to understand.	37	93	Very good
	The steps of activities in a e-atlas are easy to follow	40	100	Very good
	The language used is simple and easy to understand.	38	95	Very good
	The layout and design of the e-atlas are interesting and not confusing	37	93	Very good
Time-effectiveness, benefits, and problem base learning models	The allocation of time provided is by learning.	38	95	Very good
	E-atlas helps streamline learning time.	37	93	Very good
	E-atlas helps students understand concepts	39	98	Very good
	E-atlas encourages students to learn science literacy	35	88	Very good
	E-atlas helps students improve their curiosity.	37	93	Very good
E-atlas simulation integration	E-atlas simulation is easy to integrate into the learning	40	100	Very good
	E-atlas simulation helps visualize abstract concepts	39	98	Very good
	E-atlas simulation increases students' science literacy and curiosity	40	100	Very good
	Instructions for using E-atlas simulation are clear and easy to follow	38	95	Very good
	E-atlas simulation helps us understand the concept of matter.	39	98	Very good
	E-atlas simulation supports data collection activities.	38	95	Very good
Average readability test results		**38**	**95**	**Very good**

Table 8 shows the readability test results for ten grade 9 students. The average percentage of the readability test assessment for all aspects was 96%, with the category of very good without revision. This means that E-atlas simulation-integrated problem base-based student e-atlas are practically used in science learning in junior high school students.

To see the effectiveness of the student e-atlas developed, a trial was carried out on 30 students in one class of the 9th grade, with a design model, namely one group pretest-postest design. Seeing the effectiveness of the e-atlas developed to improve students' Student’s Curiosity with N-gain. The results of the effectiveness of the e-atlas developed to improve Student’s Curiosity can be seen in Figure 5.

ISSN 2406-9205 (print), ISSN 2477-4820 (online)

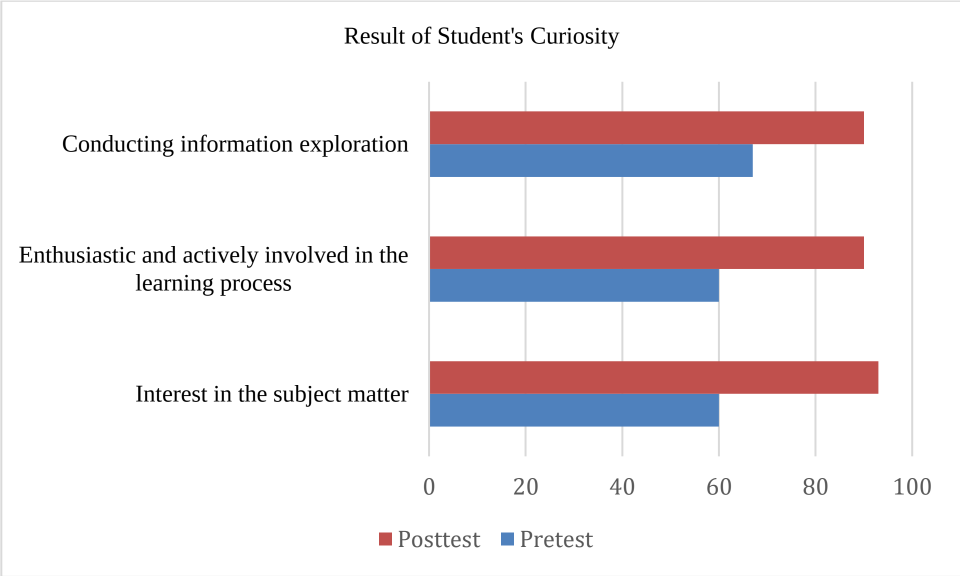

Figure 5. Pretest Posttest Scores Student's Curiosity

The e-atlas' effectiveness in enhancing Student's Curiosity can be evaluated using N-gain. Table 9 displays the N-gain values for each indicator of Student's Curiosity.

Table 9. N-Gain Score for Each Indicator of Student's Curiosity

Aspects	Pretest	Posttest	N-gain	Criteria
Interest in the subject matter	60	93	0.83	High
Enthusiastic and actively involved in the learning process.	60	90	0.75	High
Conducting information exploration	67	90	0.7	Medium
Average N-gain			**0.71**	**High**

Table 10 presents the N-gain scores for science process skill indicators. The results demonstrate that the developed e-atlas effectively enhance Student's Curiosity. This is evidenced by the average N-gain of 0.71 for Student's Curiosity, which falls into the high category. Consequently, the e-atlas is an effective tool in science education for improving students' Student's Curiosity.

Aspect	Pretest	Posttest	N-gain	Criteria
Observing	60	93	0.83	High
Quality Questions	70	87	0.57	Medium
Interest in New Things	60	90	0.75	High
Persistence	67	90	0.70	Medium
Creativity	57	87	0.70	Medium
Average N-gain	-	-	**0.71**	**High**

The final phase is dissemination. After the product's validation, readability, and effectiveness tests, the next stage is disseminating e-atlas-based problem base integrated with E-atlas simulation to schools that need them. These e-atlas can be employed in scientific education to enhance students' abilities in conducting scientific procedures. The next activity is to make scientific papers related to the products developed. This research shows that E-atlas simulation integrated problem base-based e-atlas are feasible, practical, and effective for improving Student's Curiosity(Jayanti et al., 2024). There is

ISSN 2406-9205 (print), ISSN 2477-4820 (online)

previous research which improves Student's Curiosity, such as guided problem base-based e-atlas (Anisah & Nasrudin, 2023), using module-based problem base (Yusra et al., 2021), using e-atlas with assisted e-atlas (Arifullah et al., 2020), using E-atlas to learn science (Haryadi & Pujiastuti, 2020), using e-atlas-based guided problem base integrated E-atlas (Chotimah et al., 2023).

The discussion in this study needs to be aligned more explicitly with its main objective, which is to enhance students' curiosity through a Problem-Based Learning (PBL)-based e-Atlas integrated with Yogyakarta's local wisdom. Curiosity is a fundamental aspect of science learning that encourages students to actively explore scientific concepts and develop a deeper understanding (Ghani et al., 2021; Suhirman et al., 2021; Uyanık & Özdemir Uyanık, 2024). However, the previous discussion did not explicitly connect curiosity with the study results. Therefore, it is crucial to emphasize how the developed e-Atlas fosters curiosity based on the established indicators.

Curiosity in this study was measured using three main indicators: interest in the subject matter, active participation in the learning process, and information exploration. The findings indicate that using the PBL-based e-Atlas significantly improved students' curiosity, with an average N-gain score of 0.71, categorized as high. This improvement suggests that the e-Atlas not only serves as an innovative learning medium but also effectively engages students in understanding classification concepts more deeply (Abdurahman et al., 2023; Coumans & Wark, 2024; Pasaribu et al., 2024).

PBL is structured to stimulate students' curiosity from the initial learning stages. In the problem-orientation phase, students were introduced to real-world phenomena relevant to their daily lives, such as Jamur So mushrooms growing under melinjo trees in Yogyakarta. This phenomenon not only captured students' attention but also encouraged them to explore further into mushroom classification and the ecological factors influencing its growth (Amini et al., 2019; Carrió Llach & Llerena Bastida, 2022; Perdana et al., 2020). Integrating local wisdom into learning provides a more meaningful and contextualized experience, further stimulating students' curiosity.

Additionally, during the exploration and hypothesis formation phase, students were given opportunities to discuss classification concepts based on the information available in the e-Atlas. Interactive features, such as QR codes linked to virtual experiment simulations, allowed students to independently explore information without being constrained by limited laboratory facilities. This process strengthened students' active participation in learning, as reflected in the increase in the "active participation" indicator, which had an N-gain score of 0.75 (Mercy et al., 2020; Safitri et al., 2023; Sari et al., 2021).

Another curiosity indicator, information exploration, also showed an increase, with an N-gain score of 0.70. This indicates that students using the e-Atlas were more proactive in seeking additional information to solve problems posed in the PBL framework. The e-Atlas provided an opportunity for students to understand the connection between scientific and cultural aspects, allowing them to grasp biological classification not only in an academic context but also in their daily lives (Ghani et al., 2021; Rahmawati & Lisdiana, 2023; Suhirman & Ghazali, 2022).

Beyond the quantitative results, qualitative aspects of this study also demonstrated the effectiveness of the e-Atlas in fostering curiosity. The readability test results showed that the e-Atlas had a high level of practicality, with a score of 96%, indicating that students found it user-friendly and engaging. Positive student responses further reinforced the findings that this medium was not only visually appealing but also enhanced engagement and motivation in learning (Gloy et al., 2022; Prasetya et al., 2024; Wisnuputri et al., 2023).

Based on these findings, it can be concluded that the PBL-based e-Atlas integrated with Yogyakarta's local wisdom is an effective innovation for increasing students' curiosity. Through a problem-oriented approach and the contextualized and interactive presentation of information, this tool encourages students to actively ask questions, engage in discussions, and explore scientific concepts more deeply. Therefore, the implementation of this e-Atlas has the potential to be widely adopted in science education, especially in schools with limited laboratory facilities (Hunaepi et al., 2024; Pasaribu et al., 2024; Suhirman et al., 2021).

This research aligns with prior findings demonstrating that e-atlas integrated by E-atlas simulations effectively improve scientific problem base abilities (Novebrini et al., 2021; Rizki et al., 2022; Zulimah et al., 2018; Payudi et al., 2017), improve critical thinking skills (Rahmat et al., 2024), enhance educational achievements (Mahtari et al., 2020), E-atlas- assisted e-atlas with STEM models enhance critical thinking skills (Agustina & Dwikoranto, 2021; Fitriyah & Madlazim, 2021, Rasyid et al., n.d.)), improve concept understanding (Wisnuputri et al., 2023), improve problem-solving skills (Kamila et al., 2021).

In addition, E-atlas also encourages active learning and problem base and helps students develop problem-solving skills (Perkins et al., 2015; Sari et al., 2022). E-atlas implementation can enrich educational experiences by providing visual aids, practical demonstrations, and graphical representations (Nur Khilafah, 2023; Nur, 2023; Rasyid et al., n.d.)(Makransky et al., 2019). In E-atlas, a visual display and interaction between students and the concepts being taught can help students develop an understanding (Price et al., 2018). E-atlas simulations are technological tools that enable students to visualise complex ideas, facilitating easier understanding and potentially boosting both academic performance and learning enthusiasm (Ganasen & Shamuganathan, 2017; Banda & Nzabahimana, 2023), as well as help teachers facilitate learning and contribute to learning (Peffer et al., 2015; Özcan et al., 2020), physics learning using E-atlas simulation can improve high-order thinking skills (Yusuf & Widyaningsih, 2019), learning using E-atlas assisted by a scaffolding approach can increase activity Learning (Eveline et al., 2019)

CONCLUSION

This study successfully developed and evaluated a Problem-Based Learning (PBL) e-Atlas integrated with Yogyakarta’s local wisdom as an innovative tool to enhance students’ curiosity in learning classification material. Using the 4-D development model (Define, Design, Develop, Disseminate), the e-Atlas was validated, tested for readability, and assessed for effectiveness.

The validation phase involved four experts (media expert, content expert, and two practitioners), achieving an Aiken’s V index of 0.97, which falls under the "very high" category, demonstrating the e-Atlas's suitability in content accuracy, interactivity, and alignment with PBL principles. The readability test, involving 10 ninth-grade students, yielded a 96% approval rate, categorized as "very good," indicating the e-Atlas was user-friendly, engaging, and practical for science learning without requiring revisions.

The effectiveness test was conducted through a quasi-experimental design, involving 60 ninth-grade students divided into experimental and control groups. The experimental group used the PBL e-Atlas with interactive digital features, including virtual practicum activities, while the control group received conventional textbook-based instruction. The findings revealed a significant improvement in curiosity levels in the experimental group, with an average N-gain score of 0.72 ("high" category), compared to 0.45 ("medium" category) in the control group. Statistical analysis confirmed a significant difference between the two groups, validating the e-Atlas’s effectiveness in fostering curiosity through active learning and cultural contextualization.

The integration of Yogyakarta’s local wisdom in the e-Atlas provided meaningful and contextualized learning experiences. By aligning the e-Atlas with PBL principles, students were actively engaged in critical thinking, problem-solving, and collaborative learning, further enhancing their curiosity and environmental awareness. The tool not only addressed the challenges of limited laboratory facilities in Indonesian schools but also served as a bridge between theoretical knowledge and real-world applications, promoting 21st-century skills.

REFERENCE

Abdurahman, A., Asfahani, A., Sudarwati, N., Warwer, F., & Asrijal, A. (2023). The influence of problem-based learning model on students’ learning outcomes. *International Journal of Trends in Mathematics Education Research*, *6*(3), 247–255. https://doi.org/10.33122/ijtmer.v6i3.226

Agustini, R., Meilanie, R. S. M., & Pujiastuti, S. I. (2024). Enhancing Critical Thinking and Curiosity in Early Childhood Through Inquiry-Based Science Learning. *Aulad: Journal on Early Childhood*, *7*(3), 734–743. https://doi.org/10.31004/aulad.v7i3.780

Amini, R., Setiawan, B., Fitria, Y., & Ningsih, Y. (2019). The difference of students learning outcomes using the project-based learning and problem-based learning model in terms of self-efficacy. *Journal of Physics: Conference Series*, *1387*(1). https://doi.org/10.1088/1742-6596/1387/1/012082

ISSN 2406-9205 (print), ISSN 2477-4820 (online)

Asyhari, A., & Sifa'i, M. (2021). Problem-Based Learning to Improve Problem-Solving Skill: Is it Effective Enough? *Indonesian Journal of Science and Mathematics Education*, *4*(1), 78–88. https://doi.org/10.24042/ijsme.v4i1.8674

Azwan, A., Magfirah, I., Chairul, M., Umanailo, B., Malmia, W., Makatita, S. H., Lisaholit, S., Tinggapi, H., & Chairul, M. (2019). Problem-Based Learning As An Effort To Improve Student Learning Outcomes. *Article in International Journal of Scientific & Technology Research*, *146*, 606. www.ijstr.org

Carrió Llach, M., & Llerena Bastida, M. (2022). Exploring innovative strategies in problem based learning to contribute to sustainable development: a case study. *International Journal of Sustainability in Higher Education*, *24*(9), 159–177. https://doi.org/10.1108/IJSHE-07-2021-0296

Coumans, J. V. F., & Wark, S. (2024). Impact of Problem-Based Learning Coaching and Neuroeducation in the Development of 21st Century Lifelong Learners. *Mind, Brain, and Education*, *18*(1), 35–42. https://doi.org/10.1111/mbe.12406

Ghani, A. S. A., Rahim, A. F. A., Yusoff, M. S. B., & Hadie, S. N. H. (2021). Effective Learning Behavior in Problem-Based Learning: a Scoping Review. In *Medical Science Educator* (Vol. 31, Issue 3, pp. 1199–1211). Springer. https://doi.org/10.1007/s40670-021-01292-0

Gloy, K., Weyhe, P., Nerenz, E., Kaluschke, M., Uslar, V., Zachmann, G., & Weyhe, D. (2022). Immersive Anatomy Atlas: Learning Factual Medical Knowledge in a Virtual Reality Environment. *Anatomical Sciences Education*, *15*(2), 360–368. https://doi.org/10.1002/ase.2095

Hunaepi, H., Suma, I. K., & Subagia, I. W. (2024). Curiosity in Science Learning: A Systematic Literature Review. *International Journal of Essential Competencies in Education*, *3*(1), 77–105. https://doi.org/10.36312/ijece.v3i1.1918

Jayanti, M. I., Umar, U., & Syarifuddin, S. (2024). Global Issues and Research Trends On Science Learning Based On The Scopus Database From 2019 To 2023: A Bibliometric Analysis. *Jurnal Inovasi Pendidikan IPA*, *10*(2), 135–149. https://doi.org/10.21831/jipi.v10i2.72068

Kang, J. & K. J. (2024). Exploring the predictiveness of curiosity and interest in science learning in and after class. *Journal of Research in Science Teaching, Wiley Online Library*, *61*(8), 1821–1857.

Kang, J., & Kim, J. (2020). 과학 학습에서 유발되는 과학상태호기심 및 과학상태불안 수준에 따른 학습효과 Learning Effects According to the Level of Science State Curiosity and Science State Anxiety Evoked in Science Learning. *Journal of the Korean Association for Science Education Journal Homepage: Www.Koreascience.Org Journal of the Korean Association for Science Education*, *41*(3), 2021. https://doi.org/10.14697/jkase.2021.41.3.221

Kang, J., Yoo, P., & Kim, J. (2020). 과학 상태호기심 및 과학 상태불안 측정도구 개발 The Development of Instruments for the Measuring Science State Curiosity and Anxiety in Science Learning. *Journal of the Korean Association for Science Education Journal Homepage: Www.Koreascience.Org Journal of the Korean Association for Science Education*, *40*(5), 2020. https://doi.org/10.14697/jkase.2020.40.5.485

Kawuri, M. Y. R. T., Ishafit, I., & Fayanto, S. (2019). Efforts To Improve The Learning Activity And Learning Outcomes Of Physics Students With Using A Problem-Based Learning Model. *IJIS Edu : Indonesian Journal of Integrated Science Education*, *1*(2). https://doi.org/10.29300/ijisedu.v1i2.1957

Li, W. W., Zhao, L. J., Liu, W., Zhu, L., Li, P., Zhao, G. Y., & Zhu, Y. Y. (2024). Study on shear performance of discontinuous PBL connectors with double holes. *Alexandria Engineering Journal*, *88*, 45–57. https://doi.org/10.1016/j.aej.2024.01.006

Mercy, A., Lapuz, E., & Fulgencio, M. N. (2020). Improving the Critical Thinking Skills of Secondary School Students using Problem-Based Learning. In *International Journal of Academic Multidisciplinary Research* (Vol. 4, Issue 1). https://ssrn.com/abstract=3543211

Mufida, A. Al, & Widodo, A. (2021). Analisis kedalaman dan keterkaitan antar konsep pada pembelajaran IPA di masa pandemi. *Jurnal Inovasi Pendidikan IPA*, *7*(2). https://doi.org/10.21831/jipi.v7i2.40887

ISSN 2406-9205 (print), ISSN 2477-4820 (online)

Nur Khilafah, Mr. (2023). *KARAKTERISTIK MORFOLOGI JAMUR SO (Scleroderma aurantium)*. *2*(2), 55–62. www.FUNGIKINGDOM.net.

Nur, M. R. (2023). PENGARUH MEDIA PEMBELAJARAN E-ATLAS DENGAN MOTIVASI BELAJAR SISWA SMA. *Jurnal Edukasi Biologi*, *9*(2), 128–135. https://doi.org/10.21831/edubio.v9i2.19277

Oktafiyani, A., & Widiyaningrum, P. (2024). Development of E-Atlas Anatomy of the Vertebrate Digestive System as a Teaching Material Supplement to Improve Student Learning Outcomes. *Journal of Biology Education*, *13*(3), 265–272. http://journal.unnes.ac.id/sju/index.php/ujbe

Parmini, N. P., Ida Bagus Rai Putra, Mukhamdanah, Ida Ayu Putu Aridawati, & I Wayan Sudiartha. (2023). 21st Century Skills and Information Literacy in Indonesian Language and Literature Education Study Program. *Mimbar Ilmu*, *28*(1), 83–95. https://doi.org/10.23887/mi.v28i1.59441

Pasaribu, A. R., Siregar, L. Y. S., & Hasibuan, N. A. P. (2024). Integrating Problem-Based Learning and Visual Media to Spark Science Curiosity in Fifth Graders. *Journal of Educational Management and Learning*, *2*(2), 57–63. https://doi.org/10.60084/jeml.v2i2.200

Perdana, R., Jumadi, J., Rosana, D., & Riwayani, R. (2020). The online laboratory simulation with concept mapping and problem based learning (Ols-cmpbl): Is it effective in improving students' digital literacy skills? *Cakrawala Pendidikan*, *39*(2), 382–394. https://doi.org/10.21831/cp.v39i2.31491

Prasetya, S. P., Hidayati, A., Farid, J. A., Listari, T., Ardiansyah, R., & Chanthoeurn, D. (2024). Development of Augmented Reality Atlas Volcano Series Media in Social Sciences Learning. *TEM Journal*, *13*(4), 3125–3136. https://doi.org/10.18421/TEM134-47

Rahmawati, A., & Lisdiana. (2023). Development of Basic Tissue Histology Atlas to Improve Student Motivation and Learning Outcomes on Animal Tissue Structure Materials in High School. *Journal of Biology Education*, *12*(2), 230–239. http://journal.unnes.ac.id/sju/index.php/ujbe

Rasyid, M., Unayah, H., Kuswanto, H., Aminatun, T., Sulistiyawati, S., & Bog, K. J. (n.d.). *A Systematic Review of Pedagogical Models to Enhance Students' Critical Thinking in Physics Learning*. *25*(3), 1444–1467. https://doi.org/10.23960/jpmipa/v25i3.pp1444-1467

Safitri, R., Hadi, S., & Widiasih, W. (2023). Effect of the Problem Based Learning Model on the Students Motivation and Learning Outcomes. *Jurnal Penelitian Pendidikan IPA*, *9*(9), 7310–7316. https://doi.org/10.29303/jppipa.v9i9.4772

Saputra, M. D., Joyoatmojo, S., Wardani, D. K., & Sangka, K. B. (2019). Developing Critical-Thinking Skills through the Collaboration of Jigsaw Model with Problem-Based Learning Model. In *International Journal of Instruction* (Vol. 12, Issue 1). www.e-iji.net

Sari, Y. I., Sumarmi, Utomo, D. H., & Astina, I. K. (2021). The Effect of Problem Based Learning on Problem Solving and Scientific Writing Skills. *International Journal of Instruction*, *14*(2), 11–26. https://doi.org/10.29333/iji.2021.1422a

Suhirman, S., & Ghazali, I. (2022). Exploring Students' Critical Thinking and Curiosity: A Study on Problem-Based Learning with Character Development and Naturalist Intelligence. *International Journal of Essential Competencies in Education*, *1*(2), 95–107. https://doi.org/10.36312/ijece.v1i2.1317

Suhirman, S., Prayogi, S., & Asy'ari, M. (2021). Problem-Based Learning with Character-Emphasis and Naturalist Intelligence: Examining Students Critical Thinking and Curiosity. *International Journal of Instruction*, *14*(2), 217–232. https://doi.org/10.29333/iji.2021.14213a

Uyanık, G., & Özdemir Uyanık, R. (2024). Effect of the quantum learning model on attitude, anxiety, curiosity, academic achievement and retention in science course. *Education Mind*. https://doi.org/10.58583/EM.3.3.3

ISSN 2406-9205 (print), ISSN 2477-4820 (online)