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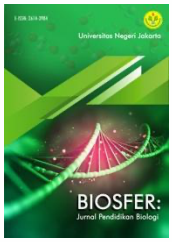

Enhancing student piety and critical reasoning through steamrel-PBL with authentic e-assessment in ecology learning

Wiwin Setiowati[1,2], Slamet Hariyadi[3*], Trapsilo Prihandono[4]

[1] Magister of Science Education, Faculty of Teacher Training and Education, University of Jember, Jember, Indonesia.
[2] Luqman Al Hakim Elementary School, Research and Development Department, AdhDhuha Foundation, Jember, Indonesia.
[3] Biology Education, Faculty of Teacher Training and Education, University of Jember, Jember, Indonesia.
[4] Physical Education, Faculty of Teacher Training and Education, University of Jember, Jember, Indonesia.

*Corresponding author: s.hariyadi.fkip@unej.ac.id

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ABSTRACT

The STEAMRel-PBL learning model equipped with authentic e-assessment is used in ecology and biodiversity learning to determine its influence on critical reasoning skills and the achievement of aspects of piety, especially students' morals towards nature. This study aims to determine the effectiveness of the STEAMRel-PBL learning model equipped with authentic e-assessment on the achievement of students' attitude of piety, especially their morals towards nature and their ability to reason critically in ecological learning. The research design carried out was a quasi-experiment of one pretest-post-test group. The research involved 30 grade VII students. Data collection techniques were carried out using pretest-post-test instruments, interviews, observations, and questionnaires. Data analysis was carried out using the N-Gain formula and calculation with a Likert scale. The results showed that the N-Gain value score showed that the STEAMRel-PBL model equipped with authentic e-assessment demonstrates significant influence in the development of students' critical reasoning. All critical reasoning indicators are on the criteria of developing as expected. The dimension of faith in fear of God Almighty is assessed using a questionnaire instrument that contains moral indicators towards nature. The results of the moral assessment of students are in the criteria of developing according to expectations, with the average student achievement being 86.88. Religious values help students reflect on God's role in His creation through science, which further strengthens their piety.

INTRODUCTION

In ecology learning, there is an opportunity to integrate scientific knowledge with religious values (Nainggolan et al., 2024). Understanding ecosystems, conservation, and responsibility for environmental sustainability can encourage students not only to think critically but also to realize the importance of God's creation (Altmeyer, 2021). Modern learning has adapted to ecological learning by prioritizing understanding through real experience and practice and providing learning experiences in schools and outdoor learning activities (Costa Neto, 2020).

Ecology learning has great potential to develop a pious attitude and critical reasoning skills (Darmawan et al., 2023). From a religious point of view, studying ecology encourages human awareness to protect and preserve the environment as a form of gratitude and responsibility (Costa Neto, 2020). The attitude of piety arises from the awareness that the entire ecosystem in nature is a mandate that must be preserved, not overexploited. By understanding ecosystems and the interactions between their components, every student is expected to appreciate God's creation more and avoid actions that can cause environmental damage because they are contrary to religious values (Nainggolan et al., 2024).

Ecology learning also stimulates critical reasoning skills because it involves analyzing cause-and-effect relationships in ecosystems (Azrai et al., 2024). Students are stimulated to identify environmental problems such as pollution and deforestation, as well as to find solutions based on scientific knowledge of those problems. This ability is important in understanding the impact of human behaviour on nature and in designing actions that favor the balance of the ecosystem (Nainggolan et al., 2024).

Ecology learning at various levels of education is often trapped in a theoretical approach that is less contextual. As a result, there is a gap between the understanding of the concept and the ability to apply it in real life (Darmawan et al., 2023). In addition, the integration of religious values in science learning, including ecology, is still not optimal (Ambarwati & Wilujeng, 2023). In practice, ecology learning often faces challenges in integrating spiritual aspects and critical reasoning skills. This causes a lack of awareness among students of the connection between natural phenomena, the greatness of God, and the use of technology in the context of learning.

Skills in the use of technology are some of the most important skills in today's educational era (Pangestuti et al., 2024). The results of research from Hadayani et al. (2020) prove that technology-based learning significantly improves learning outcomes and student motivation. However, after conducting observations and interviews with science teachers at Adh Dhuha Junior High School, the result is that most students have not used gadgets to do assignments or look for learning resources, and the application of conventional learning models is more dominant, where learning is centered on teachers and students listening. In addition to low technology use, students' critical reasoning skills are also still low, which can be seen in several ways, including (1) many students are not active in asking questions, (2) they are not enthusiastic about the learning process, and (3) most students only use gadgets to activate social media.

The main challenge in achieving the goal of character education, in addition to the use of technology, is to create a balance between the achievement of cognitive competence and character building, including the strengthening of religious values. Facing the existing challenges, an innovative learning model is needed that can integrate aspects of STEAM (Sofia et al., 2020), religious values, and environmental concerns. A learning model that aligns with the STEAM approach is problem-based (Suradika et al., 2023). The integration of STEAM, PBL, and religious aspects can be accommodated in the STEAMRel-PBL model.

STEAMRel-PBL (STEAM-Religion-Problem-Based Learning) is a learning model that integrates the STEAM approach with religious values in learning. The integration of STEAMRel-PBL is based on the belief that the development of science and technology needs to run in harmony with religious and ethical values. The concept of STEAMRel originated from the concept of STEM, which is an integration of science, technology, engineering, and mathematics (Asiyah et al., 2023). The STEAMRel-PBL model has the potential to develop students' positive attitudes and critical reasoning skills simultaneously. The learning model is a means for students to create ideas through thinking and exploration activities in solving problems based on six integrated disciplines. The learning model is a means for students to create ideas through thinking and exploration activities in solving problems based on six integrated disciplines (Erduran et al., 2022). The integration of religious values is also needed to build students' character. Religious values can also be integrated into the material as knowledge to stimulate students' curiosity and higher-order thinking skills (Irma et al., 2023).

The STEAMRel-PBL learning model allows for good learning practices in teaching STEM content (Agustina et al., 2020). STEM requires teamwork and strong technology skills (Wahono et al., 2022). PBL provides opportunities for students to work in groups, develop communication skills, and use technology to solve complex problems (Ali, 2019). Learning that integrates religion in STEAM can shape students who are not only academically intelligent but also socially and morally responsible (Al-Zahrani & Aly, 2019). Students will be sensitive to global issues such as climate change, social injustice, and sustainable technological innovation. Religion often encourages reflection and critical thinking about human life (Aulia et al., 2020). When integrated in STEAM and PBL, the results can strengthen students' ability to think critically and analytically and develop critical-reasoned solutions to complex problems (Suryadi et al., 2023). The application of this model in classroom learning can increase student involvement in learning so that students are more motivated to learn. Also, it encourages the mastery of critical reasoning skills, creativity, communication, collaboration, technological literacy, and helps shape the character of students with faith, piety, and noble character. However, the implementation of this model takes a lot of time, so it is more effective if it is equipped with e-authentic assessment (Irma et al., 2023).

E-authentic assessments allow for more comprehensive and efficient measurement of student competencies. In the context of ecological learning, e-authentic assessments can help measure not only knowledge but also students' attitudes and skills in dealing with environmental issues. The assessment method factor is very important to create quality graduates who are ready to face the real world. E-authentic assessments allow for more comprehensive and efficient measurement of student competencies (Gomez-del Rio & Rodriguez, 2022). Authentic assessment is considered to be the most effective assessment method to achieve this. Authentic assessments aim to evaluate students' proficiency by having them perform real-life tasks (Irma et al., 2023). Based on these objectives, authentic assessment has the advantage of providing a true picture of students' learning conditions, providing more information about students' strengths, weaknesses, needs, and interests, which can help in adjusting teaching towards improving learning activities. What's more, authentic assessment is considered a better and more tangible approach to assessment. This approach associates learning with real-life situations and is quite complex (Esa, 2024). Authentic assessment can be done web-based so that students get feedback faster and the learning process becomes more efficient and effective when applied to many students (Ambarwati & Wilujeng, 2023). Based on these things, this study aims to determine the effectiveness of the STEAMRel-PBL learning model equipped with authentic e-assessment on the achievement of students' attitude of piety, especially their morals towards nature, and their ability to reason critically in ecological learning.

METHODS

Research Design

This study uses a pre-experimental design in the form of a one-group pretest-posttest design, as explained by Sugiyono (2019). In this design, data were taken from one group that was given a pretest to measure the initial condition, followed by the treatment or implementation of the learning model, and ended with a final test (posttest) to evaluate the learning outcomes. The difference between the results of the pretest and post-test was thought to reflect the effect of the treatment.

Population and Samples

The sample of this research was selected by purposive sampling, students from an Islamic religion-based school. This study was conducted on grade VII students of SMPS Adh Dhuha Jember for the 2023-2024 academic year. The number of participants in this study was 30 students with an age range of 12-13 years and all females. Students have a moderate average cognitive ability when viewed from the learning outcomes of students before the research was carried out. The subject matter presented was ecology and biodiversity.

Instrument

Instruments used in this study include instruments in the form of teaching modules, pretest-posttest questions, student worksheets, observation sheets for learning implementation, and student questionnaires. Teaching modules and student worksheets have a level of validity in the very valid category. Pretest and post-test questions are made different but with the same category and level of difficulty. This is in accordance with the Mastery Learning theory by Bloom, which emphasizes the

importance of continuous evaluation to measure student development. Pretest-posttest questions have a level of validity in the valid category. Student questionnaires have a high level of validity in the very valid category.

Procedure

Before testing the effectiveness of the learning model, validation is carried out first. Validation was carried out by 3 validators, 2 of whom are experts, and 1 person is a user validator who is a science teacher. When the validator states that the learning model and the device used are valid, an effectiveness test is carried out. The steps taken in the effectiveness test are at the beginning of the meeting, students' knowledge related to ecological and biodiversity materials is assessed in the pretest, and continued with learning using the STEAMRel-PBL learning model equipped with authentic e-assessment, and at the end of the learning, students are again assessed in the posttest. In this study, only one sample group served as a control group and an experimental group. This design is used to compare students' progress after learning using the STEAMRel-PBL learning model. The pretest and posttest questions consist of 5 multiple-choice questions and 5 essay questions that contain moral indicators towards nature and critical reasoning. During the learning, observations were made to assess students' critical reasoning skills based on the indicators. The achievement of the dimension of fearing God, the moral element towards nature, was measured through a student questionnaire distributed at the end of learning. The indicators used can be seen in Table 1.

Table 1.
Indicators of the Dimension of Piety of Moral Elements Towards Nature and Critical Reasoning

P3 Dimension	Indicators
Faith in fear of God Almighty, noble character	Identify the cause-and-effect relationships between various natural phenomena or cosmic events that are God's creations.
	Understanding that the universe is carefully governed by God, and that every event or phenomenon has a cause that can be traced.
	Analyze causal relationships in depth, including the influence and consequences of any interaction between God's creations.
	Apply their knowledge of the concept of cause and effect in a real-life context.
Critical Reasoning	Ask a question.
	Identifying, clarifying information and ideas.
	Analyze and evaluate.
	Reflecting and evaluating one's own thought.

(Source: Ministry of Education and Culture, 2022)

Data Analysis Techniques

The validation results were analyzed using the percentage (Sari et al., 2020), which is then converted into quantitative data with criteria according to Table 2. If the validation result reaches 70.01%, the product is declared valid and will be continued with an effectiveness test. The validity percentage is calculated using the following formula and the criteria according to Sugiyono (2019). The pretest-posttest question instruments were also tested empirically. The results of the empirical test show that the calculation >r table. The magnitude of the average calculation with a significance of 5% is 0.601 greater than the Table, which is at 0.306. So, it can be said that the components of the pretest and posttest questions are valid**.** Data analysis from the effectiveness test was carried out using a descriptive qualitative approach. Data was obtained by analyzing students' pretest and posttest scores and then calculating the index of acquisition. The results of the index are converted into quantitative. Quantitative data were analyzed using the N-gain formula and criteria according to Hake (1998). The STEAMRel-PBL learning model equipped with authentic e-assessment is said to be effective if student learning outcomes increase with an average N-gain of $0.3 \leq N-gain < 0.7$ in the medium category. Meanwhile, learning can be said to be successful if the individual learning outcomes of students reach a score of 75. The achievement of the dimension of faith in fear of God Almighty is assessed using the questionnaire given to students, and the achievement of the student's critical reasoning dimension is assessed through observation during the learning process. Everyone is given a score index according to indicators of morality towards nature and critical reasoning. The achievement is said to develop according to expectations if the total score obtained is > 75.

RESULTS AND DISCUSSION

The validity of this model is tested through a validation process by education experts, especially in the STEM field. According to Sugiyono (2019), the validity of a learning model can be measured through expert validation, where experts in the field of education assess the components of the learning model based on their conformity with theory, learning objectives, and practical implementation. This validation aims to ensure that the learning model is feasible to use and can achieve the desired results.

The validation process is carried out is a tiered validation, namely draft 1 is validated by validator 1 and gets feedback. The revision process is carried out through a consultation stage with validator1. After the revision is made, it is then validated by validator 2. The corrections and feedback obtained are used as the basis for the second revision process. The validation process by validator 2 resulted in a valid learning model and suggestions for slight improvements to the teaching module. The results of the second revision were used in the trial process and validated by validator 3 and resulted in a valid learning model that can be used without revision. The results of expert validation of the module can be seen in Table 2.

Table 2.
Teaching Module Validation Results

Aspects	Validator Assessment (%)			Percentage (%)	Total (%)	Interpretation
	V1	V2	V3			
General Information Module	69.64	85.71	100.00	85.12	87.39	Very valid
Core Components	72.62	83.23	100.00	85.38		
Attachment	100.00	75.00	100.00	91.67		

Based on the validation results in Table 2, the teaching module developed has a total score of 87.39, so it is in the very valid category.

Table 3.
Results of Validation of the Learning Model Guidebook

Assessed Aspects	Validator Assessment (%)			Percentage (%)	Total (%)	Interpretation
Learning theory that is the foundation	75.00	75.00	100.00	83.33	84.03	Valid
Concept of student character	75.00	75.00	100.00	83.33		
Structure of the Learning Model	71.67	78.33	100.00	83.33		
Language Eligibility	66.67	91,67	100.00	86.11		

Based on the validation results in Table 3, the learning model guidebook developed obtained a score of 84.03 and was in the valid category. The results of expert validation of the pretest-posttest questions used in the study can be seen in Table 4.

Table 4.
Validation Results of Pretest and Posttest Questions

Assessed Aspects	Validator Assessment(%)			Percentage (%)	Total (%)	Interpretation
	V1	V2	V3			
Content Eligibility	78.13	78.13	100.00	85.42	84.03	Valid
Appearance	75.00	75.00	100.00	83.33		
Language Eligibility	50.00	100.00	100.00	83.33		

Based on the validation results in Table 9, the pretest and posttest questions used in the study obtained a score of 84.03, so that they were in the valid category. The results of expert validation of the student questionnaire used in the study can be seen in Table 5.

Table 5.
Student Questionnaire Validation Results

Assessed Aspects	Validator Assessment (%)			Percentage (%)	Total (%)	Interpretation
	V1	V2	V3			
Relevance	82.14	92.86	100.00	91,67	90.63	Valid
Language Eligibility	68.75	100.00	100.00	89.58		

Based on the results of the validation in Table 5, the student questionnaire to measure the dimension of morality towards nature as part of piety to God Almighty used in the research is in the very valid category. The analysis of students' pretest and posttest scores can be seen in Table 6.

Table 6.
N-Gain Calculation Results of the STREAMRel-PBL Learning Model

Indicator	Pretest	Post-test	N-Gain	Interpretation
STEAMRel-PBL	33.73	79.00	0.70	High

Based on the results of the pretest and posttest given to students, it was found that there was a significant improvement in students' cognitive learning outcomes. The average score of the student pretest was 33.73, while the average score of the student posttest increased to 79. This shows that the application of the STEAMRel-PBL learning model equipped with authentic e-assessment has a positive influence on students' understanding, or it can also be said that the STEAMRel-PBL learning model equipped with authentic e-assessment is effective in improving student learning outcomes and students' critical reasoning skills. The average N-Gain yield belongs to the high category. Based on the calculation of N-Gain, 60% of students are in the high category, 40% of students are in the middle category, and no students are in the low category. In the aspect of piety towards God Almighty, especially morality towards nature, students show good development. This can be seen from the results of questionnaires and observations that show students' awareness of associating religious values in problem solving. The results of the student questionnaire in this aspect in full can be seen in the results of the analysis of the student questionnaire can be seen in Table 7.

Table 7.
Results of Student Questionnaire Analysis of the Moral Dimension to Nature

Indicator	Average	Interpretation
Identify cause-and-effect relationships between various natural phenomena or cosmic events that are God's creations.	87.83	Grow as expected
Understanding that the universe is carefully governed by God, and that every event or phenomenon has a cause that can be traced.	89.33	Grow as expected
Analyze causal relationships in depth, including the influence and consequences of any interaction between God's creations.	82.17	Grow as expected
Apply their knowledge of the concept of cause and effect in a real-life context.	88.17	Grow as expected

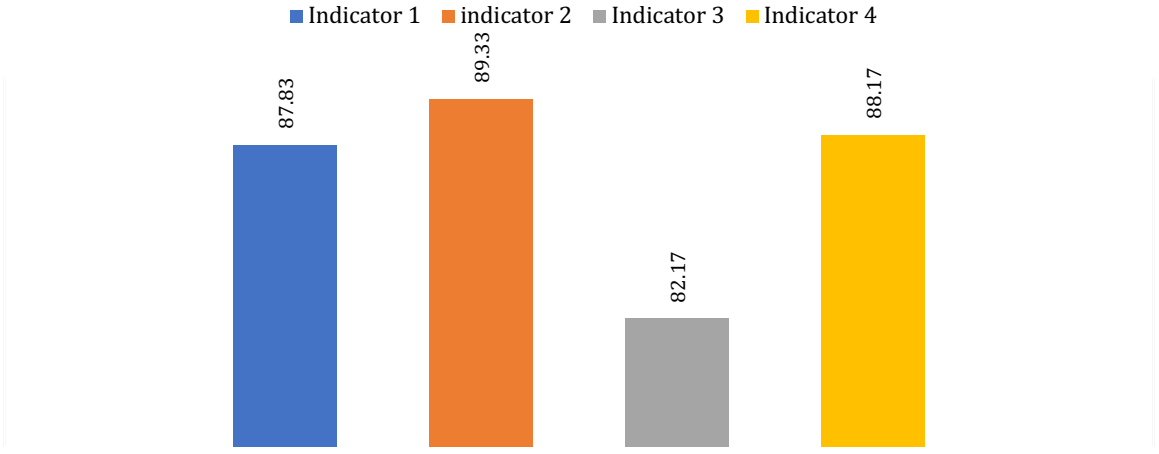

Figure 1. Students' Moral Dimension to Nature Achievement

Based on Table 7, it shows that the development of the Pancasila student profile that students have in the moral element towards nature for phase D students develops according to expectations. Observation of students' activities to measure their critical reasoning skills is done by assessing the quality of the questions they write before learning begins and observing whether students find answers to those questions during the learning process. Assessment is also carried out by observing the learning process, analyzing the results of assignments on student worksheets (LKPD), and in group discussions, observing how students identify problems, analyze information, and propose solutions based on STEAM principles and religious. Each aspect is assessed using a scale of 1 to 4, and the total score obtained will reflect the level of students' critical reasoning skills. Each student's score is given based on the critical reasoning assessment rubric. The results of the final analysis of critical reasoning skills can be seen in Table 8.

Table 8.
Results of Analysis of Students' Critical Reasoning Achievement

Indicator	Average	Interpretation
Ask a question.	84.17	Grow as expected
Identifying, clarifying information and ideas.	79.17	Grow as expected
Analyze and evaluate.	78.33	Grow as expected
Reflecting on evaluating one's own thoughts.	80.00	Grow as expected

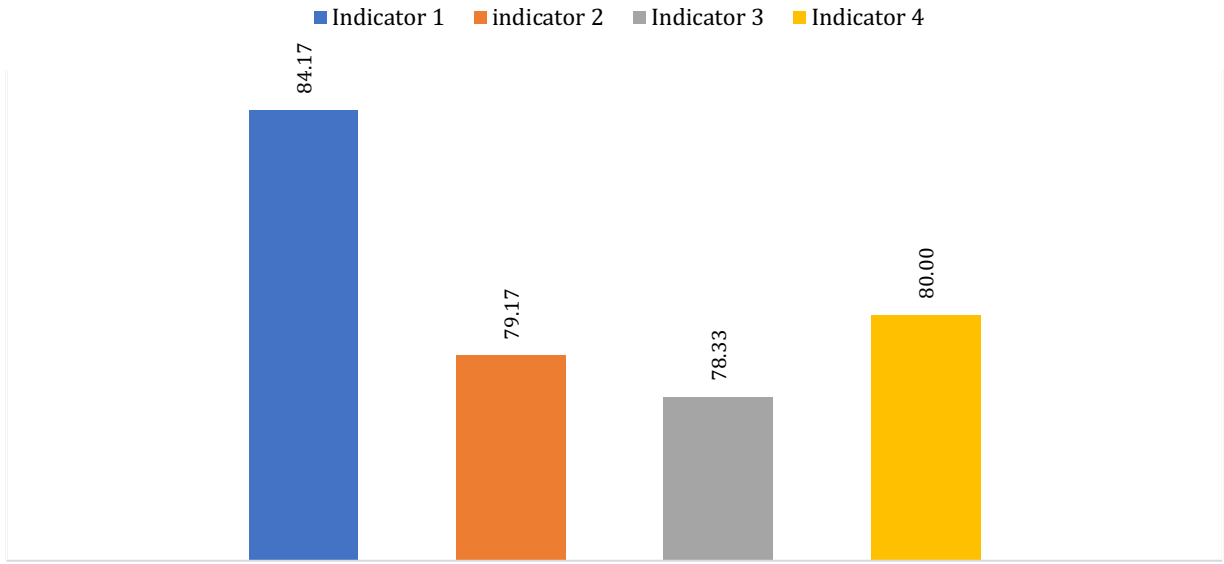

Figure 2. Students' Critical Reasoning Achievement

The results of the effectiveness test conducted on the STEAMRel-PBL learning model are equipped with authentic e-assessments in line with the results of Utomo et al. (2020) research that the STEAM approach helps students become problem solvers with integrated thinking; thinking by considering different perspectives will encourage students to think holistically and pay attention to their culture. This means that students become more understanding of the problems they face and work collaboratively to face the challenges of daily life in the future. In the research of Agustina et al. (2020), it was found that this approach can improve students' systems thinking skills. This learning educates students to work together and respect the role of each member in the group.

The effectiveness of this model is shown through a significant improvement in student learning outcomes, especially in the aspect of critical reasoning and religious attitudes in this study, which are moral towards nature (Jelita & Mazlan, 2023). Slavin (2006) stated that the effectiveness of the learning model can be seen from its impact on student learning outcomes. An effective learning model can improve learning outcomes, both in terms of knowledge, skills, and attitudes. The effectiveness of the model can also be measured by the ability of the model to maintain student interest during the learning process. The results of the effectiveness test conducted on the STEAMRel-PBL learning model are

complemented by authentic e-assessments in line with the results of research by Irma, et al. (2023) and Aulia, et al. (2020) that this approach helps students solve problems with integrated thinking, thinking by considering different perspectives stimulates students to solve problems by paying attention to many aspects. This means that students will think holistically.

The stages in this learning model accommodate indicators of critical reasoning. The learning began by providing problems in the form of water pollution and the difficulty of obtaining water suitable for consumption and purification that occurred in several areas through videos that were shown. During the video screening, the teacher guides the students by giving a verbal narrative. This is in accordance with the results of Ilesanmi's (2023) research that video viewing causes an increase in questions in students when they try to understand the content of the material in the video. The focus of the chosen problem is how to get clean water through the filtration of dirty or polluted water. During the video screening, students can write down the questions they have on a piece of scrap paper and paste them on the reading corner provided. Students begin to engage in the problem-solving process by looking for alternative ways to purify water. Students searched for the necessary information in groups regarding the water requirements that can be used to purify water from several hadiths and the requirements for water that is suitable for drinking according to health considerations.

The use of media in the form of learning videos adjusts the characteristics of students who have an audiovisual learning style and supports the effectiveness of the learning model (Ilesanmi, 2023). This follows the opinion of Reigeluth (1999), who stated that the effectiveness of the learning model also depends on the suitability of the model to the characteristics of students, such as the level of initial knowledge, learning style, and individual needs. A good learning model can be adapted for different types of students to meet diverse learning needs (Al-Zahrani & Aly, 2019). Meanwhile, Plomp (2007) emphasizes that technology can support learning through the use of digital platforms, interactive software, and visual aids that can improve student understanding and enable more flexible learning.

Before designing, students identify the materials that can be used for water purification, their respective properties, and their functions so that they can deconstruct the sequence of materials used in water purification. At this stage, students engage in intensive group discussions to identify and clarify the ideas they have acquired. This process develops one of the indicators of critical reasoning. This is in accordance with the results of research by Shanta & Wells (2020) that design-based learning activities have been proven to improve analytical thinking and problem-solving skills in students. Design activities significantly improve students' ability to identify and clarify problems by encouraging critical thinking, creativity, and practical skills (Smith et al., 2022).

The next step is for students to make a prototype of a water purification device according to the design agreed upon by their group. The prototypes made by each group are relatively similar in terms of the materials used, and the variation is found in the order of the arrangement of the materials they use. This prototype is assessed by peer assessment and self-assessment. The goal is to compare their work with other groups so as to motivate students to produce better products. After that, each group can revise the prototype they created. Finally, students are invited to reflect on the process of making products and their benefits for the environment. Students can also look back at their questions and ask questions that they have not been able to find answers to in the learning process. At the end of the entire learning process, student learning outcomes are assessed with posttest question instruments. The implementation of the posttest at the end of learning ensures that students have received all the materials needed for evaluation. This provides accurate data on learning effectiveness and student achievement (Magdalena et al., 2020).

The result of the posttest shows that the STEAMRel-PBL learning model has a high effect on students' critical reasoning ability and students' morals towards nature. Pretest and posttest questions are made slightly different but with the same level of difficulty as the expectation of knowledge that students have during the learning process develops and increases. This is in accordance with mastery learning by Benjamin S. Bloom, which emphasizes the importance of using continuous evaluation to measure student learning progress. Pretests are designed to identify the initial level of student comprehension, while posttests are used to assess the extent to which learning has progressed. These two tests must have a balanced level of difficulty for the results to be validly compared (Ilesanmi, 2023).

During the learning process, students can identify problems, analyze information, and propose solutions based on religious values taught through the STEAMRel approach. This improvement in critical reasoning skills is in line with the learning objectives of the independent curriculum, which emphasizes the formation of student character known as the Pancasila Student Profile (Mariatul

Kibtiyah, 2022). In terms of religious attitudes, students who engage in this model show improvement in their understanding of religious values and the application of moral principles in daily life (Mukminin et al., 2023).

This learning model combines various disciplines in STEAMRel, which helps students understand concepts in a more in-depth and applicable way. When combined with religious values, students not only develop technical knowledge but also understand how the science relates to spiritual and ethical values (Aulia et al., 2020). Integrated religious values help students reflect on God's role in His creation through science, further strengthening their piety. Student learning outcomes can be improved because students are involved in learning that is relevant to their daily lives and supported by religious perspectives, so that students' understanding is more meaningful.

PBL itself encourages students to practice identifying problems, collecting information, analyzing data, and formulating solutions (Suradika et al., 2023). This process requires high reasoning skills, where students are required to evaluate various alternatives, predict outcomes, and construct logical arguments. When solving contextual and complex problems, students learn to think independently, relying not only on memorization but also on the ability to understand, evaluate, and apply information. This can improve his critical reasoning skills (Sari et al., 2020).

In this study, students are faced with the context of problems related to ethics, morals, and spirituality. They were invited to reflect on how the solutions they came up with could be in line with religious teachings. Through the environmental issues raised, students can reflect on the responsibility of humans as caliphs on earth based on their religious teachings (Esa, 2024). This makes them more aware of the moral impact of every action they take, as well as increasing piety to the Creator. Students are led to understand that the knowledge they get is also a means to get closer to God Almighty (Asiyah et al., 2023).

The e-authentic assessments used allow for a more comprehensive evaluation as they focus not only on the result but also on the thought processes and skills that students develop during learning (Anderson, 2003). By using digital technology, teachers can provide feedback more quickly and in detail (Pangestuti et al., 2024). Students can instantly understand which parts need to be improved and improve their learning outcomes. This type of assessment can also increase transparency because learning outcome data is recorded automatically, making it easier for teachers to monitor the progress of each student (Irma et al., 2023).

Pancasila Student Profile is a character and competency that must be possessed by Indonesian students (Aini et al., 2024). Through the application of the 6 dimensions of the Pancasila student profile, namely faith and devotion to God Almighty, global diversity, independence, cooperation, critical reasoning, and creativity, it is hoped that Indonesian students will become intelligent and characterful individuals and be able to face global challenges and in still Pancasila values consistently and finally be able to realize a prosperous and dignified national life (Mulyani et al., 2023). The Pancasila student profile development strategy is carried out through integration in formal education activities through intracurricular, co-curricular, and extracurricular. The Pancasila student profile emphasizes character building through collaborative decision-making and critical thinking, as demonstrated in the high school environment (Rahmawati et al., 2023).

The dimensions of faith, fear of God Almighty, and noble character measured in this study are limited only to the moral element towards nature. The ecology and biodiversity material selected follows the moral indicators towards nature that have been set by the Ministry of Education and Culture. There are 4 indicators used to measure the moral dimension of nature, which is adjusted to the achievement of phase D, namely 1) identifying the cause-and-effect relationship between various natural phenomena or cosmic events that are God's creation, 2) understanding that this universe is carefully regulated by God and that each event or phenomenon has a traceable cause, 3) analyze causal relationships in depth, including the influence and consequences of any interaction between God's creations, and 4) apply their knowledge of the concept of causality in real-life contexts (Aini et al., 2024). The average student score in all indicators was in the developing category, as expected. The development of this dimension is due to the STEAMRel-PBL learning model providing a holistic approach to developing the dimension of faith and fear of God Almighty, especially in the element of morality towards nature. In the ecology and biodiversity material, this model helps students see nature as God's creation that must be grateful and protected. Students learn to solve real problems related to the environment.

The STEAMRel-PBL learning model encourages students to develop critical awareness of the

impact of human actions on nature. Students are invited to analyze environmental problems from the perspective of religion and science. Students are encouraged to understand that preserving nature is not only an ecological obligation but also a spiritual obligation (Nainggolan et al., 2024). By combining religious understanding with natural science, this model can foster an attitude of love for the environment based on faith in God Almighty (Costa Neto, 2020). The learning model is designed not only to improve the understanding of concepts, but also the students' critical reasoning skills. There are 4 indicators used to measure the critical reasoning dimension, namely 1) asking questions, 2) identifying, clarifying information and ideas, 3) analyzing and evaluating, and 4) reflecting and evaluating one's thoughts (Hikamah et al., 2024) All indicators show that students' critical reasoning skills are developing as expected.

The development of students' critical reasoning skills is possible because this learning model encourages students to play an active role in the learning process through real problem-solving involving science, technology, engineering, and aspects of religious morality (Rahmawati et al., 2023). In this context, critical reasoning skills develop because students are invited to analyze, evaluate, and solve problems by considering a variety of perspectives, including moral and spiritual perspectives. They are faced with a problem that not only has one correct answer but requires in-depth analysis and consideration of various factors (Rumtini et al., 2022). In this process, students are challenged to identify problems, gather information, and evaluate possible solutions from a scientific point of view. The integration of religious aspects in the STEAMRel-PBL learning model expands the thinking paradigm of students. They are not only asked to analyze problems from the point of view of science or technology, but also from the point of view of religious values. This presents a challenge to consider the moral and spiritual implications of any solution they offer. This learning model also emphasizes collaboration, where students work in groups. Students are exposed to a variety of different views and opinions, which requires them to listen, evaluate, and provide logical arguments (Al-Zahrani & Aly, 2019). In this process, critical reasoning skills are honed because students must be able to communicate their thoughts and accept opinions from other perspectives. Reflection, which is an important part of this learning model, provides space for students to evaluate their learning process. They reflect on the decisions taken, the difficulties faced, and the solutions implemented. In this process, they can improve their thinking process so that their critical reasoning skills can continue to develop.

This study succeeded in proving the effectiveness of the STEAMRel-PBL learning model equipped with authentic e-assessment but is only limited to Islamic religion-based schools, so the results cannot be fully generalized. This creates a gap in understanding how this model can be implemented more broadly in different types of schools, including in rural areas or in schools with limited resources. On the other hand, although there are some studies on STEAM and PBL in general, research that specializes in the integration of STEAM and religion in the context of character education is still limited (Asiyah et al., 2023). This research was also conducted in a relatively short period of time, which may not be enough to see the long-term impact of the implementation of this model on character education. Long-term research is needed to understand the effects of this learning model in more depth.

The results of this research show that the STEAMRel-PBL learning model with e-authentic assessment has the potential to be applied in the national curriculum, especially in strengthening the character dimension of students as stated in the Pancasila Student Profile. In the context of public schools, the application of this model can have positive implications for character-based learning by emphasizing the relationship between science and human responsibility in maintaining the balance of nature. This is in line with the concept of character-based education, which aims to create students who are not only intellectually intelligent but also have ethical awareness and social responsibility. In addition, the role of technology in this learning model is very significant, especially in supporting digital-based assessments (e-authentic assessment), which allows for a more comprehensive and efficient evaluation of the learning process. The use of digital platforms not only helps to measure students' academic and moral achievements more objectively but also encourages the use of technology in the learning process more optimally. Therefore, the combination of the STEAM approach, the integration of religious values, and the use of technology can be an innovative strategy in improving the quality of education at various school levels.

Further research can expand the scope of the research by involving more schools and diverse characteristics, both urban and rural, to obtain a more comprehensive picture. Future research can also be conducted over a longer period to explore the long-term impact of the application of STEAMRel-PBL on the formation of students' character and whether those characters persist in their lives after

completing formal education. This is supported by what Gall et al (2003) state that diversity in research subjects is important to improve the reliability and generalization of results (Ambarwati & Wilujeng, 2023). Thus, research in diverse schools ensures that the STEAMRel-PBL learning model is relevant to a wider population.

CONCLUSION

The STEAMRel-PBL learning model is equipped with an e-authentic assessment that is effective in developing the critical reasoning dimension and the dimension of fearing God Almighty, the moral element towards nature for students' Islamic religion-based schools. The average value of N-gain, indicating the effectiveness of the use of learning models, is high. Students' critical reasoning skills on ecological and environmental diversity materials developed as expected. The attitude of piety, especially morality towards nature, also develops according to expectations. Further research can expand the scope of the research by involving more schools and diverse characteristics, both urban and rural, to obtain a more comprehensive picture.

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