

Integration of High-Level Thinking Skills and Environmental Care Character by Implementing STEAM-Based Belawa Tortoise Conservation E-Supplements

Ajeng Mudaningrat^{*}, Fadhilatul Mufrihah

Faculty of Mathematics and Natural Sciences, Universitas Negeri Semarang, Sekaran,
Gunung Pati, Semarang 50229, Indonesia

^{*}Author to whom any correspondence should be addressed.

E-mail: ajengmudaningrat87@gmail.com

Abstract

Local wisdom-based learning can be meaningful learning by presenting e-learning supplements that integrate local wisdom which is expected to improve students' high-level thinking skills and environmental care character. This study aims to analyze the effectiveness of STEAM-based Belawa Tortoise conservation e-supplements in improving high-level thinking skills and environmental care character. The study was conducted at MAN 3 Buntet Pesantren Cirebon and SMAN 1 Astanajapura with 140 class X students as research subjects. This research is a quantitative research with a quasi-experimental design. The results showed that E-supplements were effective in improving critical thinking skills with an average N-Gain of 0.81 in the high category, problem-solving skills with an average N-Gain of 0.79 in the high category and environmental care character with an average N-Gain of 0.70 in the high category. Based on the development of STEAM-based Belawa Tortoise conservation e-supplement, it is stated to be effective in improving higher-order thinking skills and environmental care character.

Keywords: E-supplements; High Level Thinking Skills; Care Character

1. Introduction

Education in the 21st century requires students to possess various skills, known as 21st-century skills. Students must possess higher-order thinking skills (HOTS) to be competitive in facing the challenges of the future [1]. Higher Order Thinking Skills (HOTS) are methods or techniques that enable students to analyze, plan, design, implement, and evaluate any problem they face. HOTS skills include critical thinking and problem solving [2]. It's important for students to have critical thinking skills because they can develop careful, precise, and rational thought patterns. Critical thinking skills also enable students to choose or consider other people's opinions with their own [3]. Practicing critical thinking skills by involving real experiences will support students' ability to solve problems.

Problem-solving skills are a form of mental activity involving cognitive skills and processes, aimed at finding the right solution to a problem. Problem-solving is the highest form of learning, as it reflects a deep understanding of the rules, techniques, and content of the material being studied, particularly in biology [4].

The independent curriculum applied to class X students has two phases, namely phase E and phase F [5]. Phase E is used in class X with learning outcomes that require students to have the ability to create solutions to local, national, or global issues related to understanding biodiversity and its role, viruses and their role, biological technology innovation, ecosystem components, and interactions between components, and environmental change (Head of the Agency for Standards, Curriculum, and Educational Assessment, Ministry of Education and Culture, Research, Technology, and Higher Education, 2022). This shows that in addition to cognitive aspects, education also emphasizes character formation, especially concern for the environment as a response to the global issues of climate change and ecosystem damage.

Biology topics in Grade 10 can be connected to the environment surrounding students' schooling. The surrounding environment can be used as a learning resource. Observing, identifying, and analyzing biodiversity, ecology, and the surrounding environment can help achieve learning objectives in phase E. Approaches related to the surrounding environment include local wisdom and culture [6].

Learning based on local wisdom can be meaningful. Many environmental advantages can be used as a medium for learning based on local wisdom. Some of these include being authentic, real, and contextual, providing hands-on experiences that make information easier to understand and remember, fostering students' love for their highly beneficial local cultural wisdom, and indirectly assisting in the desired preservation efforts [7].

The results of the document study analysis show that the Belawa Tortoise is one of the local cultivation wisdoms in Cirebon Regency which is included in the Appendix II category of CITES (Convention on International Trade in Endangered Species of Wild Fauna and Flora, 2010) and is included in the vulnerable category in the Red Data Book. The Belawa community considers the Belawa Tortoise as their pride animal. According to the Decree of the Regent of KDH Level II Cirebon No. 522.51 / SK.29 / PEREK / 1993, the Belawa Tortoise is recognized as a typical animal of Cirebon Regency [8]. However, the tortoise population in Belawa Village is dwindling due to a mass death in 2010, which nearly wiped out the entire population of 2,000, leaving only 13 remaining. This was due to an outbreak of fungal and bacterial diseases that attacked the tortoises, prompting the local government to capture the tortoises in Belawa Village to be bred at the Belawa tourist attraction [9]. The potential of local wisdom in the form of the Belawa Tortoise tourism conservation area is a good learning resource to achieve the demands of the Phase E curriculum for Biology subjects.

Local wisdom in the form of Belawa tortoise conservation, used in biology lessons, will foster an attitude of environmental stewardship. If students consistently cultivate this attitude, it will develop into a character that cares about the environment. Character is a person's personality traits and morals that shape how they think, behave, and act [10]. The character of caring for the environment is very important because the good or bad condition of an environment is also determined based on the good or bad character of caring for the environment of humans towards their environment [11].

The results of limited interviews with teachers showed that students' indifference towards the environment was because teachers had not yet utilized it as a learning resource, so students were less concerned about these conservation efforts. This research is supported by an analysis of the teaching materials used in grade X of SMAN 1 Lemahabang, namely the Science-Biology Package for the Independent Curriculum written by Imaningtyas and Sagita in 2022 on material ecosystems. The material presented is still general and does not include examples of ecosystem conditions relevant to the participants' daily lives. The learning materials do not directly teach concepts, are too text-heavy, and lack rich images.

The latest learning in the Independent Curriculum emphasizes learning with a STEAM (science, technology, engineering, art, and mathematics) approach. STEAM-based learning stimulates students' curiosity and motivation in higher-order thinking skills, including problem-solving, collaboration, independent learning, project-based learning, challenge-based learning, and research [12]. This STEAM approach is very effective in achieving learning objectives that are appropriate to the context of independent learning and has the potential to improve the quality of education in Indonesia [13].

Based on the results of an analysis of articles using Google Scholar on learning with local issues at the high school level over the past five years, 4,460 articles were obtained, 39% of which used the STEAM approach. Therefore, a combination of learning that emphasizes local wisdom and the STEAM approach is necessary.

To help students understand their environment and critically assess the current state of the Belawa Tortoise ecosystem, a STEAM-based supplement to the Belawa Tortoise conservation curriculum is needed. To facilitate student access, the supplement is presented digitally as an e-supplement. An e-supplement is a paperless learning material designed as a digital file that can be accessed through various electronic media [14].

This study aims to analyze the effectiveness of the STEAM-based Belawa Tortoise conservation e-supplement in improving higher-order thinking skills and environmental care character. With this e-supplement, students are expected to develop critical thinking skills regarding the potential dangers and impacts of not conserving the Belawa Tortoise. Furthermore, they are expected to develop problem-solving skills by providing solutions to environmental issues they face, and foster a caring attitude toward the environment.

2. Methodology

This research is a quantitative research. The subjects of the research were 140 students of MAN 3 Buntet Pesantren Cirebon and SMAN 1 Astanajapura. Class X.1 of MAN 3 Buntet Pesantren Cirebon and SMAN 1 Astanajapura were

used as Experimental classes and class X.7 students of MAN 3 Buntet Pesantren Cirebon and class X.2 of SMAN 1 Astanajapura were used as control classes in implementing STEAM-Based Belawa Tortoise Conservation e-supplement. This research was conducted using a quasi-Experimental method. The pre-experimental method design used was a one group pre-test design [15]. In this research design, the class groups were given an initial test (pre-test), then the experimental group was given special treatment in the form of the use of e-supplements in their learning process. After the learning activities, the class groups were tested with the same test as the final test (post-test). The results of the initial test with the final test totaling 25 questions in the class groups were tested for differences. A significant difference between the initial and final tests in the experimental group indicates the effect of the treatment given. The student assessment instruments designed are pre-test and post-test questions in the form of AKM which have been tested for validity using validity and reliability tests as well as environmental care character using a questionnaire sheet.

The indicators measured are critical thinking skills include interpretation, analysis, evaluation, explanation, and self-regulation but self-regulation indicators are not used in this study because this study measures students' cognitive and self-regulation indicators are assessed to measure students' affective [16]. Indicators of problem-solving include identifying problems, asking questions and explaining several strategies, providing reasons for the strategies used and evaluating the influence of the strategies used [17]. Indicators of environmental care character including knowledge, concern and attitude [18].

The data analysis technique used for the pre-test and post-test questions to assess the effectiveness of the STEAM-based Belawa Tortoise conservation e-supplement using prerequisite tests, namely the normality test and homogeneity test, followed by a comparative test with the t-test and the N-Gain test assisted by the SPSS 23 statistical analysis application. The environmental care character using a questionnaire was analyzed using a Likert scale and then tabulated using the categorization of bad, less, good or very good, while the interview results were described according to the findings obtained.

3. Results and Discussion

The application of STEAM-based Belawa Tortoise conservation e-supplement to higher-order thinking skills is focused on the aspects of critical thinking and problem-solving skills. This research was conducted in two schools, namely MAN 3 Buntet Pesantren Cirebon and SMAN 1 Astanajapura, each with two classes, namely the experimental class and the control class. In analyzing the effectiveness of the application of this e-supplement, it was combined between the Experimental class at MAN 3 Buntet Pesantren Cirebon and SMAN 1 Astanajapura as well as the control class with 70 samples each. The effectiveness of the application of e-supplement to grade X SMA students can be measured based on students' understanding of the material taught.

The Effectiveness of Implementing STEAM-Based Belawa Tortoise Conservation e-supplement on Critical Thinking Skills of Grade X Senior High School Students

The STEAM-based Belawa Tortoise Conservation e-supplement improved the critical thinking skills of 10th-grade high school students, as demonstrated by the N-Gain value and t-test. The results of the N-Gain calculation can be seen in Table 1.

Table 1. N-Gain Value of Students' Critical Thinking Skills.

No	Variable	N-Gain Control Class		N-Gain Experimental Class	
		Score	Criteria	Score	Criteria
1.	Analysis	0,63	Medium	0,79	High
2.	Explanation	0,65	Medium	0,73	High
3.	Evaluation	0,66	Medium	0,73	High
4.	Interpretation	0,68*	Medium	0,93*	High
5.	Inference	0,41	Low	0,87	High
Average		0,60	Medium	0,81	High

(*)Indicates the highest N-Gain value on the indicator of students' critical thinking skills.

Based on the results of the N-Gain analysis, it was found that the highest indicator of students' critical thinking skills was in interpretation in both the experimental and control classes. The N-Gain value in the experimental class was 0.93 with high criteria and the control class was 0.68 with medium criteria. The lowest indicator in the experimental class was explanation and evaluation with an N-Gain value of 0.73 having high criteria, but in the control class was inference with an N-Gain value of 0.41 having low criteria.

The highest improvement in students' critical thinking skills is found in the interpretation indicator, namely students are able to group and interpret data using their understanding and then interpret it using their own language. Grouping in this case students are able to group biotic and abiotic components according to niche in the food chain and interpreting data in this case students are able to read and describe graphs regarding the swimming behavior of Belawa Tortoises. In

the interpretation indicator, students can understand and communicate various situations, experiences, data, events, beliefs, standards, procedures, or criteria [16]. In the interpretation indicator students are asked to provide an explanation and understanding of the concept or meaning displayed in the question [19].

The lowest performance indicators were found in the explanation and evaluation indicators in the experimental class and the inference indicator in the control class. This indicates that students in the experimental class struggled to explain or present logical arguments for each question. In the explanation indicator, students were required to select a statement that describes the interaction between the abiotic components seen in the image and to explain how to care for the decomposer population. Questions containing explanatory indicators require students to provide reasons that can be considered based on the results obtained [19]. Questions with explanation indicator is that students are required to have the ability to determine and provide logical reasons based on findings [20]. Questions with explanation indicators ask students to be better able to state and justify reasoning based on conceptual, methodological, criteriological, evidential and contextual considerations that underlie the results [16].

Based on the answers of students in the control class to the pretest and posttest questions containing inference indicators, information was obtained that the Belawa Tortoise conservation e-supplement had not optimally formed inference abilities in students' critical thinking skills because students were asked to conclude data based on the stimulus questions. Concluding is a cognitive level C5 which includes indicators of high-level thinking skills so that students in the control class found it difficult to conclude data and make hypotheses based on the data presented.

The analysis indicators presented in the questions are analyzing the role of abiotic components in the ecosystem based on the image, analyzing the comparison of body size between juvenile and juvenile tortoises based on the image, analyzing the number of eggs that failed to hatch based on the data and analyzing the number of eggs produced by adult tortoises based on the data. In the analysis indicators, students are asked to find the relationship between ideas, statements, and concepts. The indicators of this analysis include questions that ask students to make a plan to solve a problem or use concepts they already understand to solve it [19]. Questions with analysis indicators involve examining ideas, collecting opinions, and analyzing opinions [20]. Analytical indicators require students to understand the inferential relationships between statements, questions, concepts, descriptions, or other forms of representation to express beliefs, judgments, experiences, reasons, information, or opinions. Questions with analytical indicators develop critical thinking skills in problem-solving [16]. The goal is for students to be able to make connections between statements, questions, and concepts in the given questions. A t-test was also conducted to analyze the significance of critical thinking skills before and after using the STEAM-based Belawa Tortoise Conservation e-supplement, as presented in Table 2.

Table 2. Results of the t-test of students' critical thinking skills.

Data	T-Test
Sig. (2-tailed)	0,000
t Table	7,187
Conclusions	0,000<0,05

Table 2 shows that the Experimental group has a p-value from the t-test of $0.000 < 0.05$ and the calculated $t >$ from the t Table, namely $7.187 > 1.960$, so 'Ha' is accepted and H_0 is rejected, so it is said that the STEAM-based Belawa Tortoise conservation e-supplement is effective in improving the critical thinking skills of high school students. Critical thinking is essential for someone to face challenges in their life. Critical thinking allows someone to change, modify, or improve the way they think so they can act better. People who have reasoning skills are known as critical thinkers. A person can use their reasoning in situations where their reasoning shapes their thinking [19].

The Effectiveness of Implementing STEAM-Based Belawa Tortoise Conservation e-supplement on Problem-Solving Skills of Grade X Senior High School Students

The effectiveness of implementing a STEAM-based Belawa Tortoise conservation e-supplement on the problem-solving skills of 10th-grade high school students was determined based on the N-gain value and t-test. The results of the N-gain calculation can be seen in Table 3.

Table 3. N-Gain Results of Students' Problem-Solving Skills.

No	Variable	N-Gain Control Class		N-Gain Experimental Class	
		Score	Criteria	Score	Criteria
1.	Identifying the problem	0,59	Medium	0,82	High
2.	Justifying the strategy used	0,57	Medium	0,78	High

No	Variable	N-Gain Control Class		N-Gain Experimental Class	
		Score	Criteria	Score	Criteria
3.	Evaluating the impact of the strategy used	0,63	Medium	0,67	Medium
4.	Asking questions and explaining	0,71*	High	0,89*	High
Average		0,62	Medium	0,79	High

(*) Indicates the highest N-Gain value on the student problem solving indicator.

The problem-solving skill indicators presented in the questions are based on Brookhart & Nitko, (2011). The highest achievement in both the experimental and control classes was in asking questions and explaining, namely students were assessed as being able to explain changes in one member of the food chain that can affect the entire ecosystem based on the Belawa Tortoise food chain image, explain solutions for preventing tortoises from being easily attacked by fungus, explain students' opinions on efforts to revive dead spots at the Belawa Tortoise tourist attraction. This indicator requires students to solve problems, create solutions, and express their opinions and suggestions about the problem. This indicator encourages students to search for or recall previously solved problems and to identify patterns or rules for developing solution procedures [21].

Based on students' answers to the pretest and posttest questions containing the questioning and explanation indicators, it was found that the Belawa Tortoise Conservation e-supplement can develop the ability to ask questions and explain problems in problem-solving skills because students are asked to create solutions and explain several opinions based on the problems they face. Students are also trained to try to find or recall previously solved problems that are similar to the problem to be solved or to find similar solution patterns.

The lowest problem-solving skill indicator was in the experimental class, namely evaluating the influence of the strategy used, and in the control class, namely providing a rationale for the strategy used. This indicator was lowest because in the experimental class, students were trained to create solutions that could increase the percentage of successful egg hatching and analyze the feasibility of the pond used for raising Belawa tortoises, including the reasons. In the indicator analyzing the impact of the strategy used, there is a cognitive process that includes analyzing and evaluating whether the procedures applied and the results obtained are correct, or whether the procedures can be generalized [22].

Based on students' answers to the pretest and posttest questions containing indicators for evaluating the influence of the strategies used, information was obtained that the Belawa Tortoise Conservation e-supplement had not fully developed the ability to evaluate the influence of strategies used on problem-solving skills because students lacked self-confidence and involved high cognitive processes such as analyzing and evaluating the correctness of established procedures.

The lowest indicators in the control class were providing reasons for the strategies used because students were trained to provide solutions that could reduce the negative impacts of excessive pesticide use, providing solutions to the phenomenon of ecosystem imbalance based on the Belawa Tortoise food chain image, providing students' opinions on whether it is permissible for someone to keep Belawa Tortoises independently, and providing platform suggestions for promoting the Belawa Tortoise tourist attraction. Providing a rationale for the strategy used is included in the planning stage. Students plan the theory to be used and provide a rationale for it [23].

Based on students' answers to the pretest and posttest questions containing the indicator of providing a rationale for the strategy used, it is known that the Belawa Tortoise Conservation e-supplement has not fully developed the ability to provide a rationale for the strategy used in problem-solving skills. This indicator falls within the stages of forming a plan/developing the theory to be used and the rationale for using solutions to the phenomenon of ecosystem imbalance, and proposing a media platform for promoting the Belawa Tortoise.

The indicator identifies the problem presented in the question, which is an illustration of the problem. Then, students determine the animal causing the problem and that it must be removed. Then, they are presented with data on the size of the Belawa Tortoise pond. Then, they calculate its population density, analyze the relationship between the number of visitors to the Belawa Tortoise tourist attraction and the ability to ensure the survival of the Belawa Tortoise. They analyze the conservation status of the Belawa Tortoise, which is an endangered and protected animal, and the need for conservation efforts. Students are trained to understand problems. Activities that can be carried out at this stage include asking what is known (data), what is not yet known (asked), whether the information is sufficient, what conditions (requirements) must be met, and conveying the original problem in a form that is easier to understand (can be solved) [21]. In the indicator of understanding the problem, students must read the questions carefully so that they can understand the meaning of the stimulus given [23]. Based on students' answers to the pretest and posttest questions containing indicators for problem identification, it is known that the Belawa Tortoise Conservation e-supplement can develop problem identification skills in problem-solving skills. This is because students are trained in the content and evaluation of Chapter 3 within the e-supplement, thus fostering problem identification skills. The results of the t-test analysis are presented in Table 4.

Table 4. t-Test Results for Students' Problem-Solving Skills.

Data	T test
Sig. (2-tailed)	0,000
t Table	5,198
Conclusion	0,000<0,05

Table 4 shows that the STEAM-based Belawa Tortoise Conservation e-supplement is effective in improving high school students' problem-solving skills. The experimental group has a p-value from the t-test of $0.000 < 0.05$ and a calculated t-value $>$ from the t-table of $5.198 > 1.960$. Therefore, H_a is accepted and H_0 is rejected.

Compared to conventional teaching materials, the STEAM-based Belawa Tortoise Conservation e-supplement encourages active student engagement. The e-supplement makes students more independent and strives to find solutions. Students will also gain a better understanding of the subject matter, improve their critical thinking skills, search, analyze, communicate, and conclude and answer problems [24].

The STEAM-based Belawa Tortoise Conservation e-supplement can help students solve problems using everything they know and external circumstances. Students must participate in the thinking process when solving problems. They must not only recall previously acquired information but also process and integrate it to find solutions to problems [25].

The theory of meaningful learning emphasizes the importance of associating experiences, specific phenomena, and all the facts students learn with previously learned concepts. This way, learning becomes more meaningful, and students are able to apply the concepts they learn in different situations [24].

The Effectiveness of Implementing the STEAM-Based Belawa Tortoise Conservation e-supplement on the Environmental Care Character of High School Classes

The effectiveness of the implementation of the STEAM-based Belawa Tortoise conservation e-supplement on the environmental care character was obtained based on the results of the survey. The effectiveness of the implementation of the e-supplement based on the results of the questionnaire on the environmental care character of grade X high school students was determined by the N-gain value. The following are the results of the N-Gain analysis of the environmental care character presented in Table 5.

Table 5. N-Gain results of students' environmental care character.

No	Environmentally Caring Character Aspects	Indicator	N-Gain Control Class		N-Gain Experimental Class	
			Score	Criteria	Score	Criteria
1.	<i>Knowledge</i>	Understanding Biodiversity in Indonesia	0,72*	High	0,80*	High
		Understanding protected flora and fauna species and their conservation status according to the IUCN	0,70	High	0,75	High
2.	<i>Awareness</i>	Understanding the importance of caring for and preserving biodiversity	0,66	Medium	0,69	Medium
3.	<i>Attitude</i>	Understanding concern for biodiversity conservation	0,42	Medium	0,51	Medium
Average			0,62	Medium	0,70	High

(*) Indicates the highest N-Gain value on the environmental care character indicator of students.

A t-test was also conducted to analyze the significance of the STEAM-based Belawa Tortoise Conservation e-supplement on students' environmental awareness, as presented in Table 6.

Table 6. Results of the t-test for environmental care character.

Data	T-Test
Sig. (2-tailed)	0,001
t Table	3,241
Conclusion	0,001<0,05

In the experimental group, Table 4.14 shows that the p-value of the t-test is $0.001 < 0.05$ and the calculated t-value is $3.241 > 1.960$, so " H_a is accepted and H_0 is rejected." Thus, the STEAM-based Belawa Tortoise conservation supplement is effective in increasing environmental awareness in high school students.

Based on the results of the student questionnaire, it was able to foster environmental awareness in students. This is evident in several aspects of the STEAM-based Belawa Tortoise conservation e-supplement: the material presented in the e-supplement regarding the application of endangered animals near students, introducing their conservation status and

efforts students can make to preserve them, and the complete management methods for managing Belawa Tortoise breeding are included in the e-supplement, thus fostering environmental awareness. Using teaching materials has helped students develop environmental stewardship in their daily activities, both at school and at home. The questionnaire results indicate a positive environmental stewardship in students. However, the questionnaire measurements were only administered twice, before and after the e-supplement implementation. This study's measurements were not significant enough, as character development must be measured consistently. The lack of environmental stewardship in students is due to the limited timeframe of the study, which was only conducted over one month, making it impossible to develop a truly environmentally conscious character in students. Improved character development in students can occur if activities specifically designed to instill character are carried out repeatedly or continuously [26]. Consistent behavioral habits can shape character. When activities designed to instill character are carried out repeatedly or continuously, students' character development can improve [27].

4. Conclusion

The STEAM-based Belawa Tortoise Conservation e-supplement was effective in improving critical thinking skills with an average N-Gain of 0.81, categorized as high, problem-solving skills with an average N-Gain of 0.79, categorized as high, and environmental awareness with an average N-Gain of 0.70, categorized as high.

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