



Development of STEAM-Based Belawa Tortoise Conservation E-Supplement to Improve Higher Order Thinking Skills in High School Ecosystem Material

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Abstract

Using local potential as teaching materials is an effort to meet the learning outcomes of class X biology subjects. This research aims to develop a STEAM-based Belawa Tortoise conservation e-supplement to improve higher-order thinking skills in high school ecosystem materials. This research is a Research and Development research using the ADDIE model. The ADDIE development model is composed of the analyze, design, development, implementation and evaluation stages, but is limited to the implementation stage, namely small-scale tests. The small-scale test was conducted on 10 students of grade XI MAN 3 Buntet Pesantren Cirebon. The results showed that STEAM-based Belawa Tortoise conservation e-supplements have characteristics that there are local wisdom offerings with conservation content, virtual tours equipped with representative pictures and videos, STEAM-based student activities. E-supplements are valid and feasible to use based on the assessment of material experts and media experts with small-scale test results having an average of 94.6 with excellent criteria and unrevised qualifications. Based on the research, it can be concluded that the STEAM-based Belawa Tortoise conservation e-supplement is declared feasible, potentially to improve the higher-order thinking skills of high school learners.

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INTRODUCTION

Freedom of learning is a breakthrough policy launched by Education Minister Nadiem Makarim (Hutabarat *et al.*, 2022). In class X, the phase used is phase E with the learning outcomes of biology subjects, students are required to have the ability to create solutions to problems based on local issues related to understanding the diversity of living things, ecosystem components, and interactions between components and environmental changes (Head of the Education Standard, Curriculum, and Assessment Agency, Ministry of Education and Culture of Research and Technology, 2022).

One of the local issues in the form of cultivation wisdom in the Cirebon Regency area is the Belawa Tortoise. Belawa tortoises are included in the CITES Appendix II category (Convention on International Trade in Endangered Species of Wild Fauna and Flora 2010) and are classified in the vulnerable category in the Red Data Book. For the Belawa people, the Belawa Tortoise is a characteristic animal that is the pride of the Belawa people. The Regional Government of Cirebon Regency has issued a Decree of the Regent of KDH Level II Cirebon No.522.51 / SK.29 / PEREK / 1993 which states that the Belawa Tortoise is a typical animal of the Cirebon region (Dewi & Priyadi, 2019). However, the existence of tortoises in Belawa Village is declining, one of which is due to mass deaths caused by a disease outbreak in the form of fungi and bacteria in 2010 which almost wiped out all tortoises in Belawa Village and left 13 out of approximately 2000 (Sari *et al.*, 2022). The potential of local wisdom in the form of a Belawa Tortoise tourism conservation area is a good learning resource to achieve the demands of the phase E curriculum for Biology subjects.

The latest learning in the Independent Curriculum is to raise learning with a STEAM approach (science, technology, engineering, art, mathematic). The STEAM approach is a transformation from the STEM approach combined with "arts". The addition of arts is intended to foster the creativity and art of students. STEM is the main foothold in the learning process while the media used is only an instrument to support the implementation of STEM. Learning with the STEAM approach aims to make it easier for students to understand the concept of material, be able to apply the material in everyday life, and be able to explore the potential that exists in them (Fikri Nurhidayat & Asikin, 2021). Thus, a combination of learning is needed by raising local wisdom and the STEAM approach.

To meet the learning outcomes phase E requires higher order thinking skills. Higher order thinking skills are thought processes that require learners to manipulate existing information and ideas in a certain way to solve a problem at hand and create something new (Musdalifah *et al.*, 2020). Higher order thinking skills are skills that make learners tend to use logic rather than just remembering and memorizing material, so that learners will master concepts and be able to solve more complex problems (Amalia & Hadi, 2020). Indicators of higher order thinking skills include students being able to think critically and solve problems.

Critical thinking is the ability to think reflectively that focuses on decision-making patterns about what should be believed, must be done and can be accounted for that produce interpretation, analysis, evaluation and inference, as well as exposure using evidence, concepts, methodologies, criteria, or contextual considerations that are the basis for decision making (Ennis, 2011); (Facione, 2011). Critical thinking is a higher-order thinking skill that has the potential to increase learners' critical analytical power. The best effort to develop critical thinking skills that can be done is by linking learning materials with students' real experiences in the daily environment (Susilawati *et al.*, 2020). Practicing critical thinking skills by involving real experience will support students' ability to solve problems.

Problem-solving skills are the main goal in learning because problem solving is a cognitive activity involved in the learning process and these skills are related to aspects of knowledge, thinking skills, and reasoning abilities. Problem-solving skills are needed to build reasoning based on observations and data, namely to test hypotheses, solve complex problems, represent mathematical equations by connecting results before testing hypotheses and after testing hypotheses, and be able to work in teams well (Fitriyani *et al.*, 2019).

Based on a survey using questionnaires that have been conducted on grade X.7 students at MAN 3 Buntet Pesantren Cirebon as many as 35 students, it can be said that 48.6% of students do not know that the Belawa Tortoise is included in the Appendix II category of CITES (Convention on International Trade in Endangered Species of Wild Fauna and Flora 2010) and is classified in the vulnerable category in the Red Data Book. 51.4% of students did not know that the Belawa Tortoise is an endemic animal of Cirebon Regency, 48.6% of students felt that the Belawa Tortoise did not need to be conserved.

This research is supported by an analysis of

teaching materials used at SMAN 1 Lemahabang class X, namely the Science-Biology Curriculum Merdeka Package Book written by Irnaningtyas & Sagita (2022) ecosystem material. The teaching materials presented are still in general and do not discuss details about the application of examples of ecosystem conditions that are close to the lives of students. The teaching materials do not directly teach about concepts, too much writing and lack rich images.

Efforts that can be made as a solution so that students can recognize their environment and can criticize the condition of the Belawa Tortoise ecosystem problems, it is necessary to present a STEAM-based Belawa Tortoise conservation learning supplement. To make it easier for students to access these supplements, they are presented in digital form with e-supplements. E-supplements are teaching materials that do not use paper raw materials, but digital files that can be accessed on various electronic media. The advantage of teaching material supplements is that they can stand alone without the main teaching materials because they are accompanied by instructions for use in them (Nukila *et al.*, 2022).

Based on the explanation in the background above, this study aims to develop a STEAM-based Belawa Tortoise conservation e-supplement to improve critical thinking and problem-solving skills of grade X high school students. With the presence of this e-supplement, students are expected to understand the ecosystem, have critical thinking skills about the potentials that cause harm if the Belawa Tortoise is not conserved and its impact. Then, students are expected to have problem-solving skills by providing solutions to problems in the surrounding environment faced.

METHOD

This research is an RnD (Research and Development) research using the ADDIE development model. The ADDIE development model consists of the analyze, design, development, implementation and evaluation stages, but is limited to the implementation stage, namely small-scale tests. The small-scale test was conducted on 10 students of grade XI MAN 3 Buntet Pesantren Cirebon.

At the analysis stage, it involves the process of collecting information by analyzing the need for the development of teaching materials in learning objectives. Needs analysis was carried out by conducting interviews with MAN 3 Buntet Pesantren Cirebon teachers to obtain data on what

is needed in learning on ecosystem materials. Then, conduct material analysis related to literature studies of materials contained in class X high school biology package books on Ecosystems and conduct Learning Outcomes analysis for phase E, namely students are required to create solutions to problems in the environment. However, the teaching materials available do not discuss local issues. So the solution obtained is to create teaching materials in the form of STEAM-based Belawa Tortoise conservation e-supplements.

The design phase includes several plans for the development of STEAM-Based Belawa Tortoise conservation e-supplements. The contents of the e-supplement to be developed are the cover, foreword, table of contents, curriculum on ecosystem sub-materials, STEAM aspects, material on the ecosystem in general then management of Belawa Tortoise management as a conservation effort, assignments in the form of infographic making projects and there are essay tests, bibliography and developer profiles. Data was collected using observation techniques at the Belawa Tortoise attraction and documented in the form of photos and videos.

The development stage is carried out the development of STEAM-based Belawa Tortoise conservation e-supplements based on the results of analysis and design. Then, validation was carried out to see the quality of feasibility before trials by media experts, material experts and biology teachers. Media experts and material experts are two lecturers who are competent in media development and environmental conservation. Biology teachers who validated the e-supplement were three teachers from MAN 3 Buntet Pesantren Cirebon and SMAN 1 Lemahabang. The validated data was analyzed using the V'Aiken method. Aiken's V coefficient criterion used if the achievement level is large from 0.6 to 1.0 ($>0.6-1.0$) then it is categorized as valid, if the achievement level is small from 0.6 (<0.6) then it is declared invalid (Irman & Waskito, 2020). The results of the validation analysis and expert input are then used as improvement material for design revisions.

The implementation phase was carried out on a small scale trial aimed at improving the quality of e-supplements as teaching materials in learning activities. The small-scale trial phase used 10 students of grade XI MIPA 5 from MAN 3 Buntet Pesantren Cirebon. Data analysis using the scoring results of questionnaire sheets using Likert scale. The data were analyzed based on a recapitulation of the distribution of questionnaires with tabulation, analysis and conclusions.

The evaluation phase is carried out in each

of the previous four stages for revision needs. The evaluations carried out are 1) validation by experts, 2) small-scale trials, and 3) large-scale trials by learners. Evaluation is also carried out at the final stage of product development to determine the practicality and effectiveness of the product developed.

RESULT AND DISCUSSION

Characteristics of STEAM-Based Belawa Tortoise Conservation E-Supplement

STEAM-based Belawa Tortoise conservation e-supplement is a teaching supplement that is packaged digitally with examples of real conservation applications in local wisdom in Cirebon Regency, namely the endangered animal Belawa Tortoise with STEAM-based. This e-supplement has characteristics that distinguish it from other teaching materials, namely containing conservation and environmental care content presented with virtual tours in the form of videos and images equipped with STEAM-based student activities.

The STEAM-based Belawa Tortoise conservation e-supplement contains general ecosystem content and conservation content. Ecosystem content in general consists of understanding ecosystems, ecosystem components, interactions between ecosystem components, energy flows and ecological pyramids. Conservation content on the Belawa Tortoise consists of sample content of ecosystems suitable for survival, an explanation of its conservation status and conservation management management, namely the Belawa Tortoise which is close to the lives of students. Conservation content is presented so that students can criticize the conditions of the Belawa Tortoise tourist attraction so that their critical thinking skills will grow. The following is a snapshot of the appearance of the STEAM-based Belawa Tortoise conservation e-supplement.



Figure 1. Display of STEAM-based Belawa Tortoise Conservation e-supplement.

The e-supplement presented with the vir-

tual tour contains quality images and videos that aim to present the Belawa Tortoise attraction in detail, and students do not need to visit the conservation attraction. Illustrative content in the form of images and videos can help students to make concrete from something abstract. Furthermore, the existence of videos can help students to observe an important event or rare event that is difficult to obtain, it can also display the movement of objects that in reality are too fast or slow to be more appropriate (normal) so that they can be sensed by the eyes (Azizah & Budijastuti, 2021).

E-supplement conservation of Belawa Tortoise is equipped with student activities, namely evaluation in each chapter based on STEAM so that the formation of higher-order thinking skills, namely critical thinking skills and problem-solving skills of high school students. The evaluation contained in Chapter I requires students to make infographics about the characteristics of the Belawa Tortoise. In the STEAM element, making infographics is part of the Arts (art) because students are required to pour out their creativity and pour material about the characteristics of the Belawa turtle is part of the Science element and uses elements of Technology (technology) because it uses techniques using applications on devices or on websites. Infographics are a medium to campaign that the Belawa Tortoise is an endangered animal and was included in the red data book in 2010. In making infographics fostering students' desire to explore information in depth using technology and encourage students to analyze the surrounding situation and correlate with the information obtained so as to get the expected conclusions, the activity aims to foster students' critical thinking skills, namely analyzing according to Facione, (2011). Analysis indicators according to Facione (2011) is an attempt to recognize the relationship between conclusions and actual from statements, concepts, images in order to express a belief, judgment, experience, reason, and information.

The evaluation in chapter II on STEAM-based Belawa turtle conservation e-supplements presents questions about the calculation in point a, namely calculating hatching success in Belawa Tortoises, and in point b, calculating population density in Belawa Tortoise chicks/hatchlings. In the STEAM element, the calculations contained in evaluation II are part of the M (Mathematics) element because students are required to calculate with mathematical calculation operations.

Activities in chapter III are students doing chapter III evaluations in the form of essay ques-

tions as many as 5 questions embedded in the google form. The 5 questions have indicators of problem-solving skills so that students are trained to solve problems such as being required to answer questions 1) why the Belawa Tortoise is an animal that must be conserved, 2) then make a solution to the problem of lack of land in conservation, 3) design an innovation to answer a problem that includes technology and techniques for Belawa Tortoise eggs to hatch quickly, 4) designing a product as a solution by utilizing the art aspects of the Belawa Tortoise hatchling grouper and 5) the important role of students in conservation. There are indicators of problem solving according to Brookhart & Nitko (2011) in the evaluation of Chapter III, namely in the first question has problem solving indicators namely identifying and recognizing problems, in the second question is exploring strategies and possible solutions, in the third question is exploring strategies and possible solutions, in the fourth question is having indicators exploring possible strategies and solutions and in the fifth question has indicators that are defining and representing problem. Therefore, students who do the evaluation of chapter III problem solving skills will be trained.

The questions contained in the evaluation of chapter III number 2, 3 and 4 contain STEAM aspects, namely question no 2 integrating elements of technology (technology), question no 3 integrating elements of technology (technology) and engineering (engineering), and question no 4 integrating elements of art (Arts). By integrating STEAM elements in chapter III evaluations can train learners to have problem-solving skills. According to Syaifudin, (2021), teaching topics / materials that are often taught with a STEAM approach are multidisciplinary topics such as biotechnology, ecology, ecosystem, environmental change. These topics are packaged in learning whose orientation is related to solving problems in everyday life. One of the advantages of STEAM is the strengthening of 21st century skills that students are expected to use to solve their life problems. With STEAM learners can shape their own knowledge and can solve real problems that ultimately spur them to explore their knowledge in various ways.

Validity of STEAM-Based Belawa Tortois Conservation E-Supplement

The results obtained in this study are data in the form of STEAM-based Belawa turtle conservation e-supplement quality scores based on the assessment of media validators and materials that have been analyzed using the aiken'V met-

hod. According to Arikunto, (2014) "Validity is a measure that indicates the level of reliability or validity". The following is an expert assessment of the media that has been analyzed using Aiken's V formula presented in Table 1.

Table 1. Media Expert Validation Results.

No	Aspect	Aiken'V Number	Coefficient Criteria Aiken'V
1.	Assessment Design	0,953	Valid
2.	Letter fit	1	Valid
3.	Suitability of writing	0,933	Valid
	Average	0,962	Valid

Based on the data in Table 1 An average result of 0.962 was obtained with a valid category with a significance of 99% so that the STEAM-based Belawa Tortoise conservation e-supplement is said to be suitable for use in learning. The first aspect is the assessment design with valid criteria. The developed e-supplement has a harmonious appearance of elements, colors and content layout, the cover illustration illustrates the contents of the e-supplement and has appropriate illustrations and image captions and has creativity, innovation and attractive appearance. The importance of teaching materials that are arranged attractively in order to attract students to learn it and make students learn themselves. Teaching materials that are arranged attractively can make students awaken their knowledge and enthusiasm for learning (Fatmawati, 2021).

The second criterion is the conformity of letters with valid criteria. E-supplements developed already have typeface suitability, the use of typeface combinations that are not excessive, the use of font variations is not excessive (bold, italic, underline), the title font size is more dominant and has the suitability of spacing between letters. Font selection needs to be considered in the development of a media, especially related to font size and the selection of fonts or fonts used. In font selection, it is recommended to choose normal, unadorned fonts, and use capital and lower-case letters proportionally (Azizah & Budijastuti, 2021).

The third criterion is the suitability of the writing to have valid criteria. This shows that the e-supplement developed already has the readability of writing, the suitability of writing placement and is able to reveal the meaning or meaning of objects. The easy-to-understand layout

allows learners to easily access content, follow the learning path, and interact intuitively with the content in the e-supplement (Radhiani, 2023). So the conclusion from media experts is that STEAM-based Belawa Tortoise conservation e-

supplements are feasible to use. The following is an expert assessment of the material that has been analyzed using Aiken's V formula presented in Table 2.

Table 2. Material Expert Validation Results.

No	Aspect	Indicators	Aiken'V Number	Coefficient Criteria Aiken'V
1.	Serving Components	Content	1	Valid
		Learning Design	0,933	Valid
		Content Eligibility	0,942	Valid
		Eligibility of Presentation	0,965	Valid
2.	Completeness of presentation	Completeness of content	1	Valid
3.	Components of Legitimacy	Suitability to the level of development of learners	0,965	Valid
		Communicative	0,965	Valid
		Dialogical	0,965	Valid
		Businesslike	1	Valid
		The demands of the mindset	1	Valid
		Conformity with the correct rules of Indonesian	0,976	Valid
4.	Characteristic aspects of STEAM-based Belawa Tortoise conservation e-supplement in improving high-rise thinking skills and environmentally caring character	Characteristic aspects of e-supplements in improving critical thinking skills	1	Valid
		Characteristic aspects of e-supplements in improving problem-solving skills	1	Valid
		Characteristics of STEAM in e-supplements	1	Valid
		Characteristic aspects of e-supplements in improving the character of environmental care	1	Valid
Average			0,980	Valid

Based on the data in Table 2. An average result of 0.962 was obtained with a valid category with a significance of 99% so that the STEAM-based Belawa Tortoise conservation e-supplement is suitable for use.

E-supplements have material completeness, completeness of presentation, have validity, and Characteristic aspects of STEAM-based Belawa Tortoise conservation e-supplements can improve high-rise thinking skills. This is in accordance with the statement of Azizah & Budijastuti (2021), that learning by relating the environment can improve student learning outcomes. Ecosystem material is very suitable to be included in teaching materials because students have a close relationship with the surrounding environment. The ecosystem material inserted in the e-supplement is accompanied by applications to endan-

gered animals in life close to students as local wisdom so that students know the local potential of the surrounding area and foster an attitude to protect the surrounding nature. The importance of local wisdom needs to be introduced early, through the family first and then the education level will continue.

The results of material validation show that e-supplements developed in aspects 1) characteristics of e-supplements in improving critical thinking skills, can provide stimulus to grow students' critical analysis power, problems presented in learning related to the real world, evaluation trains critical thinking power, assessment instruments based on critical thinking indicators, has clear pictures, tables, graphs to stimulate thinking skills critical. 2) The characteristics of e-

supplements in improving problem-solving skills, e-supplements have the potential to motivate learners to be actively involved in problem solving, help learners conduct investigations in solving problems, can encourage learners in obtaining appropriate information, carrying out investigations and seeking clarity of solutions. 3) The characteristics of STEAM in e-supplements already include aspects of science, technology, engineering, arts, and mathematics and have the potential to make students more active in learning. The STEAM approach is one of the important elements in structuring learning so that later it can produce people who are able to think higher order (HOTS). This STEAM is carried out systematically by combining the subjects of Science, Technology, Engineering, Arts and Mathematics as a medium to develop inquiry in students, communication and critical thinking during the learning process. This can improve critical thinking skills in students (Sukmawati & Rakhmawati, 2023). Furthermore, STEAM makes students more creative in finding solutions to problems in running their lives because in the implementation of education it is necessary to anticipate the challenges of the times so that they can give birth to children who can adapt to the times (knowledge

and technology), but still prioritize noble moral values in society and in accordance with the goals of national education (Atiaturrehmaniah *et al.*, 2022). So the conclusion of the material expert is that the STEAM-based Belawa Tortoise conservation e-supplement is feasible to use.

Teaching materials that are coherent, systematic, interesting, informative, and accompanied by examples or facts can connect the knowledge and abilities of students. Students can learn independently and optimally by providing intellectual, emotional, physical and scientific experience in the learning process. Teaching materials need to be validated and assessed so that their quality and feasibility are known so that their application can make it easier for students to learn them (Astuti *et al.*, 2022).

A small-scale test was conducted on 10 students of grade XI MIPA 5 MAN 3 Buntet Pesantren Cirebon which aimed to test the readability of the e-supplements that had been developed. Students are invited to read and observe the Belawa Tortoise conservation e-supplement as a reference in filling out the questionnaire. The following are the results of small-scale tests presented in table 3.

Table 3. The result of the readability e-supplements.

No	Assessment criteria	Percentage (%)
1.	The appearance of e-supplements is different from the printed ones so I am interested in opening and studying them.	92,5
2.	The use of typefaces, fonts in e-supplements is appropriate and easy for me to read.	95
3.	The sentences and paragraphs in this e-supplement are clear and easy for me to understand	90
4.	The images contained in the e-supplement helped me understand the ecosystem material.	95
5.	The use of language and terms in this e-supplement is easy for me to understand and understand	90
6.	The sentences in this e-supplement are written communicatively so that I have no difficulty in understanding them.	97,5
7.	The simple language in this e-supplement makes me have no difficulty in understanding it.	95
8.	I easily understand the whole ecosystem material presented in e-supplements.	92,5
9.	The activities in e-supplements can help me understand and discover concepts about ecosystems.	95
10.	The problems in e-supplements are easy for me to understand	95
11.	The video in the e-supplement can make it easier for me to get an idea of the Conservation contained in the Belawa Tortoise Attraction	97,5
12.	The use of e-supplements encourages me to think critically about the problems that occur around me	95

Based on Table 3, the developed e-supplements obtained an average of 94.6 with excellent criteria. This shows that the use of typefaces that are not too varied so that they are easy to understand, the sentences are clear, the language is simple, the images represent objects in the Belawa Tortoise tourist attraction and the e-supplements developed can stimulate students to have critical thinking skills, problem-solving skills and environmentally caring characters in line with Alfiana & Iswari (2022), that the typography used does not contain letters ornamental and superfluous.

The results of small-scale tests show that the material compiled has provided benefits and comfort in the learning process. The readability and ease of use provided by this e-supplement has made it easier for learners to understand the material taught. The results that show a high level of readability are an indication that the e-supplement has met or even exceeded the expectations of users in the field. This evaluation is an important benchmark in evaluating the quality of e-supplements and their success in achieving learning objectives (Prihatni et al., 2023). The conclusion of the small-scale trial is that the STEAM-based Belawa Tortoise conservation e-supplement can be used by learners without revision.

CONCLUSION

STEAM-based Belawa Tortoise conservation e-supplements have characteristics that there are local wisdom dishes with conservation content, virtual tours equipped with representative images and videos, STEAM-based student activities. E-supplements are valid and feasible to use based on the assessment of material experts and media experts with small-scale test results having an average of 94.6 with excellent criteria and unrevised qualifications. Based on the research, it can be concluded that the STEAM-based Belawa Tortoise conservation e-supplement is declared feasible, potentially to improve the higher-order thinking skills of high school learners.

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