Bioedukasi
Jurnal Biologi dan Pembelajarannya

Vol. 24 No 1, February 2026, page 65-78
e-ISSN: 2580-0094; p-ISSN:1693-3931
DOI: 10.19184/bioedu.v24i1.53772
bioedukasi.jurnal.unej.ac.id

Development of Project-Based Learning Eco-Magazine on Environmental Change Material for Class X Phase E

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Article Info

Article history:
Received January 2, 2026
Revised February 28, 2026
Accepted February 28, 2026
Published February 28, 2026

Keywords: (A-Z)
Eco-Magazine
Environmental changes
Project-Based Learning
Teaching materials

ABSTRACT

21st-century skills can be optimally developed through the integration of technology in learning and the use of innovative teaching materials that are tailored to students' learning needs. This study aims to develop an environment-based magazine using Project-Based Learning (PjBL) designed to support class X grade students in phase E in improving their understanding of environmental change concepts and developing critical thinking skills. This study uses the Research and Development (R&D) method based on the Lee & Owens model, which consists of five stages: (1) assessment/analysis, (2) design, (3) development, (4) implementation, and (5) evaluation. Data were collected through structured interviews, questionnaires, expert validation, and student trials. Based on the results of expert validation and field trials, the environmental magazine developed meets the criteria of validity and practicality. Therefore, this environmental magazine contributes as a feasible and practical teaching material that can be used by teachers to facilitate project-based learning and increase student engagement and thinking skills related to the topic of environmental change.

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1. INTRODUCTION

21st century education is essential in preparing a generation that can adapt and compete globally. In the contemporary context, characterised by the rapid advancements in science and technology and the emergence of global challenges, there is an increasing imperative on educators and educational institutions to produce students who are equipped with the requisite 21st-century skills [1], [2] . 21st century skills emphasise not only the mastery of knowledge aspects, but also the ability to think and innovate, known as learning and innovation skills [3]. Learning and innovation skills include the 4Cs (Critical Thinking, Creativity, Collaboration, Communication). The four skills are an integration of higher-order thinking skills, social skills, and an adaptive attitude towards the development of technology and information [4]. The use of information technology in learning will eventually become a necessity and prevalence nowadays. Learning that is not integrated with technology is seen as lagging behind. This cannot be separated from the demand for mastery of life skills in the 21st century, which includes mastery of information technology and the ability to learn through digital social networks [5]. Learning and innovation skills can be maximally achieved by integrating them in learning, both in the learning process and teaching materials.

One of the concrete efforts in developing technology-integrated teaching materials is the creation of digital-based learning resources [6]. In recent years, the widespread use of smartphones among students has provided strong support for the implementation of digital learning materials, as these devices have become an integral part of students' daily lives and learning activities [7]. This condition creates significant opportunities for educators to design learning experiences that are more flexible, accessible, and aligned with students' digital habits.

The utilisation of digital teaching materials offers great potential to create learning that is more interesting, interactive, and accessible [8]. Digital learning materials allow students to learn anytime and anywhere using their personal devices and can present visual, auditory, and interactive content that enhances learning motivation and supports the development of 21st century skills [9]. However, in practice, most instructional materials used in schools remain conventional and text-based and have not been optimally integrated with technology [10]. Existing materials often rely heavily on text and static images, resulting in limited student engagement and reduced

opportunities for active learning and higher-order thinking development [11]. Furthermore, many instructional materials have not yet connected learning concepts with real-life contexts or environmental issues that are relevant to students' daily experiences.

The results of the needs analysis conducted with biology teachers and students at SMA Negeri 8 Malang revealed that digital learning materials for the topic of environmental change are not yet available. The Project-Based Learning model has not been implemented in the teaching of this topic. The learning process conducted by the teacher employed the Cooperative Learning model of the Group Investigation type. However, this approach is considered less effective in meeting the curriculum demands that require students to develop solutions to environmental problems. In addition, students are rarely provided with worksheets (Student Activity Sheets) that are integrated with the Project-Based Learning (PjBL) model. The teacher confirmed that students are already accustomed to using their mobile phones, including for assisting with school tasks. However, digital learning materials that address students' learning needs are currently unavailable. To achieve this, it is necessary to develop learning tools that can foster students' creative thinking skills through varied and informative approaches. Innovative learning tools, such as educational technology, interactive learning media, and collaborative platforms, can facilitate students' access to learning information and make the learning process more engaging [12].Technology-supported learning tools play a crucial role in creating a dynamic, interactive, and effective learning environment [13], the integration of technology in learning is not merely a complementary element, but rather an essential component in creating a learning environment that supports the development of students' creative thinking skills [14], [15].

The development of an Eco-Magazine serves as an effort to enhance learning tools through the creation of interactive teaching materials. The electronic magazine provides a variety of content that can broaden students' knowledge and enhance their skills. This aligns with research findings indicating that the integration of technology in learning can enrich students' learning experiences [16]. The Eco-Magazine helps students recognize the connection between local actions and global impacts, as well as understand the complexity of environmental issues. This product is an electronic-based teaching material that offers flexibility and accessibility unrestricted by space and time, allowing it to be used effectively in various learning contexts [17]. Providing learning materials that can be accessed independently through electronic magazines offers students the opportunity to explore concepts more deeply and think creatively in formulating answers or solutions to the problems they encounter. The use of magazines in learning can stimulate students' desire and interest to learn. The delivery of information through magazine media can foster students' thoughts, interests, attention, and emotions, thereby supporting the achievement of educational goals in terms of both effectiveness and efficiency [18].Eco-Magazine allows for real-time content updates, making up-to-date information essential in the ever-evolving world of education [19]. As a learning tool, the Eco-Magazine enables students to focus on various perspectives and diverse ideas, stimulating their imagination and enhancing their ability to think beyond conventional boundaries [20]. Thus, the Eco-Magazine serves as an effective medium for enhancing students' creative thinking skills, facilitating interactive learning, and enriching their overall learning experience.

The use of technology in the form of an Eco-Magazine requires an appropriate learning model to guide the learning process in achieving its objectives. The learning model that best fits this context is Project-Based Learning (PjBL). PjBL model is a pedagogical approach that emphasizes learning through real-world projects, focusing on the active engagement of students in the learning process. PjBL aims to enhance students' creativity, critical thinking, and collaborative skills in solving real-life problems. PjBL encourages students to identify problems relevant to environmental issues and subsequently determine the specific problem to be the focus of their project [21]. PjBL is a project-oriented learning method that provides students with opportunities to actively engage in the learning process by identifying and solving real-world problems, including environmental issues. In this context, PjBL involves students in understanding their environment, identifying existing problems, and designing applicable and innovative solutions [22]. After identifying the problem, students are guided to design and develop creative solutions to address the issue [23]. Students will engage in projects focused on environmental issues, thereby increasing their awareness and concern for the cleanliness and quality of their surrounding environment. Based on these issues, this study aims to develop a Project-Based Learning (PjBL)-based Eco-Magazine learning medium on environmental change material designed to support 10th grade students in phase E in improving their understanding of environmental change concepts and creative thinking skills. In addition, this study also aims to determine the validity level of the Eco-Magazine medium based on expert assessments and the practicality level of the medium based on the results of testing its use in the learning process.

2. RESEARCH METHOD

This type of research is development research (research and development). The Eco-Magazine based on Project-Based Learning for the Biology subject on environmental change material for Grade X students at SMA Negeri 8 Malang was developed using the Lee & Owens model [24]. The stages consist of (1) assessment/analysis, (2) design, (3) development, (4) implementation, and (5) evaluation. However, in this research and development process, data collection was limited to the development stage, as the study aimed to produce a valid and practical

product through formative evaluation. The sequence of processes developed by Lee & Owens [24]represents a systematic framework for solving research problems that lead to the creation of a multimedia product.

a. Sample or Participant

The research subject in this development research are; 1) material experts, media and teaching materials exxperts, and Biology Education practitioners with have taught for at least five years. 2) The field trial subjects in this study were students of class X.9 who were about to study the environmental change material. The sample consisted of one class selected through a random sampling technique.

b. Instrument

The instruments used in this study included several data collection techniques. At the analysis stage, interviews were conducted to identify field conditions, existing problems, and potential alternative solutions. In addition, a questionnaire was administered to students to collect information regarding the learning media they used. To evaluate the validity of the product, a validation sheet was used and assessed by subject matter experts, media and teaching material experts, as well as Biology learning practitioners. A student response questionnaire was also administered to gather their feedback regarding the attractiveness of the Eco-Magazine as a practical teaching material.

c. Data Analysis Technique

The data analysis techniques in this study consisted of validity testing and practicality testing. Each test was analyzed using appropriate methods to ensure the quality of the Eco-Magazine as an electronic teaching material for environmental change.

1) Validity Test

Data from expert validation were analyzed using a Likert scale. The data obtained from the expert validation sheets were calculated based on the average score for each evaluated indicator. The data for the validity test were obtained from validation sheets completed by subject matter experts, media and teaching material experts, as well as Biology learning practitioners. The validity criteria of the Eco-Magazine refer to the score ranges used to measure its level of validity, as presented in Table 1.

Tabel 1. Criteria for the Validity Level of the Eco-Magazine

Value Range (%)	Validity Criteria
100	Highly valid, meaning the product can be used without any revisions.
$85{,}00 \leq X \leq 99{,}99$	Highly valid, meaning the product can be used with minor revisions.
$70{,}00 \leq X < 85{,}00$	Valid, meaning the product can be used with moderate revisions.
$55{,}00 \leq X < 70{,}00$	Less valid, meaning the product requires major revisions before it can be used.
$40{,}00 \leq X < 55{,}00$	Invalid, meaning the product cannot be used.
$X < 40{,}00$	Highly invalid, meaning the product cannot be used.

Source: adapted [25]

The validity of the Eco-Magazine was tested using a formula. The results obtained from these calculations can be used to analyse the validity criteria in accordance with Table 1 on the validity criteria of Eco-Magazine. Following analysis through the validity criteria, the level of validity can be determined. It is imperative that the validity level of the material is 100% for this to be achieved. The Eco-Magazine validity formula employed is as follows.

$$\textbf{Expert validation} = \frac{\textbf{The total score from the validation results}}{\textbf{The total maximum attainable score}.} \textbf{ x 100\%}$$

2) Practicality Test

The data on the practicality test came from the students' answers to a questionnaire made by the researcher on the Eco-Magazine. The way the student response scores were analysed used the following formula.

$$\textbf{V} = \frac{\textbf{Tse}}{\textit{Tsh}} \textbf{ x 100\%}$$

Description:
V = Validation from users
Tse = Total empirical score achieved
Tsh = Expected Total Score

The results obtained from the analysis of student response scores using the above formula were used to analyse the practicality criteriaThe criteria for practicality encompass the range of scores utilised to ascertain the level of practicality of the Eco-Magazine, as presented in Table 2.

Tabel 2. Criteria for Eco-Magazine Practicality Level

Value Range (%)	Kriteria Kepraktisan
100	Highly practical, meaning the product can be used without any revisions.
$85{,}00 \leq X \leq 99{,}99$	Highly practical, meaning the product can be used with minor revisions.
$70{,}00 \leq X < 85{,}00$	Practical, meaning the product can be used with moderate revisions.
$55{,}00 \leq X < 70{,}00$	Less practical, meaning the product requires major revisions before it can be used.
$40{,}00 \leq X < 55{,}00$	Impractical, meaning the product cannot be used.
$X < 40{,}00$	Highly impractical, meaning the product cannot be used.

Source: adapted [25]

3. RESULT AND DISCUSSION

The development of the Eco-Magazine refers to the Lee & Owens model with the following stages:

a. Assessment/Analysis

The analysis stage is the first stage of the Lee and Owens development model. This model has two stages: needs analysis and comprehensive analysis. The needs analysis was conducted through a preliminary study, which comprised the administration of structured interviews to teachers and the distribution of a needs analysis questionnaire to students in semester 1 of class XI who had taken environmental change material. The comprehensive analysis went through several stages; 1) student analysis, 2) technology analysis, 3) situation analysis, 4) task analysis, 5) critical incident analysis, 6) goal analysis, 7) media analysis, 8) available data analysis, 9) cost analysis. The results of the assessment/analysis stage indicated the absence of digital teaching materials and the non-application of the Project-Based Learning (PjBL) model for environmental change material. The learning process is facilitated by the Group Investigation cooperative learning model, which has been found to be inadequate in meeting the demands of the curriculum. The curriculum is designed to equip students with the ability to develop solutions to environmental problems. In addition, learning activities rarely include student worksheets that are integrated with Project-Based Learning (PjBL). Students are used to using their phones for everything, even for their schoolwork. But there are no digital teaching materials that meet students' needs. Based on the information that there is no learning media or teaching materials that can support the learning process and train 21st century skills, this is a serious problem. Based on the results of the needs analysis, teachers and students expect innovation in learning by using Eco-Magazine based on Project-Based Learning that can be used to facilitate students.

b. Design

The design stage of the Eco-Magazine project is intended to address the needs of students by means of a review of material on environmental change. The purpose of this stage is to validate the products that have been made and verify the methods used [26]. Eco-Magazine is packaged in the form of a website (Google Sites) so that it does not require other applications to open it and students can access it easily, not limited by time and place. The Eco-Magazine has been made following the rules for creating teaching materials from the Ministry of Education and Culture in 2018. These rules consist of; cover, instructions for use, learning activities, glossary, and supporting features designed to enhance learning effectiveness. The initial outline can be started by creating some menus that need to be included in the learning media. The content can then be determined and organised by developing each menu in the outline. At the same time, we collect information about changes to the environment. The menu in the Eco-Magazine is made up of a cover component that contains the title, subject name, topic or learning material, author, class, UM logo and agency. The table of contents and glossary give you the main ideas of the text, a short description of the material, reasons for what you will learn, things you need to know before you start (if there are any), and instructions for using the Eco-Magazine. Furthermore, this stage encompasses the design of validation and learner response sheets, in addition to projects related to PjBL. It also involves the collection of illustration references and other supporting materials, such as relevant images and videos.

c. Development

The purpose of the development stage is to realise the design ideas that have been created. The stages of development according to Lee & Owens are; pre-production, production, and post-production. In this developmental stage, the processes of product development and validation were conducted by incorporating material experts, media and teaching materials experts, and field practitioners. This approach was adopted to ensure the quality and effectiveness of the Eco-Magazine that was developed. the practicality of the product was ascertained through a product trial involving one class of students who had studied environmental change materials. These students had sufficient initial understanding to assess the feasibility of the content and presentation of the Eco-Magazine. The results of the development stage are outlined in Table 3.

Tabel 3. The results of the development stage

No	Image	Description
1		The home page is a cover that consists of several components. The first component is the title of the material along with a description of the E phase level for high school. The second component is the logo of the Eco-Magazine on the top left. Meanwhile, on the top right is the main menu that displays the entire content of the Eco-Magazine.
2		The menu display on the main page consists of several options, namely preface, instructions for use, learning, learning journal, teacher teaching module, evaluation, assessment format, and developer profile.
3		The preface page contains an expression of gratitude to God, thanks to those who have supported the development, and the developer's hope that the Eco-Magazine can be used optimally. Through this preface, the developer also wants to convey the co-Magazine as a useful and fun learning media.
4		The instructions for use page contains guidelines intended for both students and teachers. This guide is presented in a concise and clear manner, and is equipped with animations to make it more interesting and easy to understand.

No	Image	Description
5		The table of contents page displays the Learning Outcomes (CP) along with a brief description of the material to be learnt. On this page, there is also a main menu that allows users to directly access various important sections, including learning, exercises, learning journals, evaluations, teacher teaching modules, and assessment rubrics.
6		The learning menu page presents three main sections of material that can be accessed directly. The first section discusses environmental balance and change, the second outlines waste management, while the third discusses climate change.
7		The learning activities page displays several components At the beginning, there is an introductory video material that serves to provide an overview of the topic to be studied. Next, learning objectives are displayed so that students know the competencies that must be achieved. In addition, the LKPD menu is available. There is a material description menu that presents a systematic explanation of concepts that are integrated with the Canva Pro application.
8		The LKPD menu display is equipped with instructions for use for students and teachers. The activities in the LKPD are arranged based on the stages of the Project-Based Learning model. In addition, there is a feature to download LKPD as well as a space for collecting work through a Google Drive link.

No	Image	Description
9		The material description menu page in Eco-Magazine has been integrated with Canva Pro. In this section, several important components are presented, namely the table of contents to facilitate navigation, Learning Outcomes (CP) as competency standards that must be achieved, and learning objectives so that students understand the direction of learning. In addition, there is a concept map that illustrates the relationship between topics, a reference list as a source of reference, and a glossary to help students understand important terms.
10		The evaluation menu page in the Eco-Magazine contains assessment instruments designed to measure creative thinking skills and the character of the Pancasila Learner Profile. The evaluation also functions as a pretest and posttest. All student work data is automatically saved in Google Form,
		The evaluation menu page in the Eco-Magazine contains assessment instruments designed to measure creative thinking skills and the character of the Pancasila Learner Profile. The evaluation also functions as a pretest and posttest. All student work data is automatically saved in Google Form,
11		The rubric menu page is designed to provide clear guidance for teachers in evaluating the creative thinking skills indicators and character elements of the first-dimensional Pancasila learner profile.

No	Image	Description
12		The developer profile display page presents brief information about the research student as the main media developer, as well as two supervisors. This display aims to give appreciation to the parties involved as well as confirm the credibility of the product developed.

d. **Evaluation**

E Valuation in the development model proposed by Lee & Owens consists of two types, namely formative evaluation and summative evaluation. Formative evaluation is carried out during the development process to improve and refine the product. Summative evaluation is carried out after the product is widely implemented to assess its effectiveness on learning outcomes [27]. In this research, the developer's discourse was limited to formative evaluation, as the research was focused on the product development stage, with no elaboration provided on the implementation stage. Formative evaluation was conducted by involving material experts, media and teaching materials experts, and Biology education practitioners to assess the quality of validity. In addition, grade XI students to assess the practicality of the developed media. Hasil evaluasi menunjukkan bahwa *Eco-Magazine* berada pada kategori sangat valid dan sangat praktis, sehingga dapat disimpulkan bahwa produk yang dikembangkan layak digunakan dalam proses pembelajaran. Evaluasi formatif ini juga berperan penting dalam memberikan masukan terhadap aspek tampilan, isi, dan interaktivitas media sehingga produk akhir yang dihasilkan menjadi lebih berkualitas dan siap diuji pada tahap implementasi berikutnya [28].

1) Validity by Material Experts

Material validation is a process that aims to assess the level of feasibility and suitability of the learning content presented in the media. The purpose of this assessment is to ensure that the material is in line with the objectives, indicators, and learning needs that have been determined [29]. The validation stage entailed the assessment of the validity of the Eco-Magazine material by material experts on two occasions. This assessment encompassed several aspects, namely the suitability of fulfilling content requirements, the feasibility of material content, presentation standards, and language standards. In accordance with the findings of the initial material validity assessment, the mean validation score was determined to be 91. The score shows that the Eco-Magazine product is very good. Although the result is already high, it should ideally be close to or equal to 100. This is important because it concerns the accuracy of the material, which will be used directly by students in the learning process. Furthermore, the comments and suggestions provided will serve as the primary reference in the process of enhancing the Eco-Magazine, with the objective of ensuring that the final product is not only valid from a scientific perspective, but also more relevant, accurate, and useful for students. The comments and suggestions are presented in Table 4.

Tabel 4. Suggestions and Revisions from Material Experts

No	Revision Suggestions	Revision Result
1	The presentation of some text material is made more concise and interactive so as not to look too dense.	The presentation of text material has been simplified with more concise language and is equipped with illustrations, key points, and visual media in the form of videos to make it easier for students to understand.
2	Image and video illustrations used in the Eco-Magazine need to be accompanied by clear reference sources,	Every image and video in Eco-Magazine is checked to make sure it is accurate and real.
3	There is a need to integrate formative evaluation, for example in the form of short quizzes, in each contextual segment to strengthen students' understanding of the material.	Each contextualised segment comes with a formative evaluation, such as a short quiz, so that students can immediately gauge their level of understanding of the material.
4	Need to include geographical representations, such as maps on climate change material that	The 3rd lesson on climate change has been linked to current geographical representations in the form

No	Revision Suggestions	Revision Result
	displays the impacts and dynamics of climate change in Indonesia so that the material is more contextualised and easy to understand.	of maps, to visually show the impacts and dynamics of climate change in different parts of Indonesia.

The results of the second material validation obtained that the Eco-Magazine product has an average validation score of 100 so that it is a product with a very valid category. The results of the second validity test by material experts can be seen in Table 5.

Tabel 5. Results of the Second Validity Test by Material Experts

No	Assessment Aspect	Score	Criteria
1.	Fulfilment of content requirements	100	Highly valid
2.	Appropriateness of material content	100	Highly valid
3.	Presentation standard	100	Highly valid
4.	Language standard	100	Highly valid
	Average	**100**	**Highly valid**

The very high validity in this study indicates that the material presented is relevant and in accordance with the expected competencies. The quality of the material is a major aspect in the preparation of teaching materials because it directly affects the effectiveness of the learning process and student understanding [30]. Quality materials are those that are complete, free from conceptual errors, and in line with the latest scientific developments [31].The completeness of the material is also very important because it ensures that all core and basic competencies are covered so that students get enough information to understand the concept thoroughly [32].

2) Validity by Media and Teaching Material Experts

Media and teaching materials validation is a process to assess the quality, feasibility, and suitability of learning media and teaching materials developed, before they are used in the learning process. The media aspects assessed by experts are design, graphics, and Eco-Magazine characteristics. The media and teaching materials experts in the research and development of Eco-Magazine are lecturers with minimum criteria of having taught for 5 years and have expertise in the field of media and teaching materials. Media validation was conducted twice. The results of the first media and teaching materials validity test showed an average validation score of 95. Thus, the Eco-Magazine product is in the highly valid category but still requires improvement in several media elements. There were comments and suggestions for improvement from the media and teaching material expert validators submitted which became a reference for revising and improving the product. The comments will be presented in Table 6.

Tabel 6. Suggestions and Revisions from Media and Teaching Materials Experts

No	Revision Suggestions	Revision Result
1	The instructions for students use simple language for easy understanding.	Instructions for use are written in clear and simple language as suggested.
2.	Instructions for use for teachers are equipped with animations to make it more interesting and easy to understand.	Instructions for use for teachers have been presented with additional animation.
3.	The table of contents in the Eco-Magazine's material descriptions is complemented by page links that connect directly to all sections.	The table of contents in the Eco-Magazine is organised interactively by linking all sections of the page with page links.
5.	Added concept maps of each material and linked to each section.	Concept maps to the 3 materials have been added and can direct users to the desired section.
6.	Each learning activity starts with an introduction video from the developer. The video explains the material, the learning objectives and the instructions for students.	The learning video is made directly by the developer according to the number of material topics.
7.	Chemical formulas must be written correctly to follow the rules.	The writing of chemical formulas in the material description is improved in accordance with the rules for writing chemical elements.
8.	Eco-Magazine in each learning activity needs to be equipped with a glossary that is relevant to the material.	A glossary was added to the Eco-Magazine on the last page of the material description.

Subsequent to implementing enhancements, the product was revalidated by specialists in order to guarantee its quality. The findings of the second stage of the validation process for media and teaching materials indicated that the Eco-Magazine product attained an average score of 96, thus classifying it within the "highly valid" category. The results of the second stage validity test by media and teaching materials experts are presented in Table 7.

Tabel 7. Results of the Second Validity Test by Media and Teaching Material Experts

No	Assessment Aspect	Score	Criteria
1.	Design	91	Highly valid
2.	Graphics	100	Highly valid
3.	Characteristics of Eco-Magazine	96	Highly valid
Average		**96**	**Highly valid**

3) Validity by Biology Education Practitioner Experts

Biology education practitioner validation is the process of assessing the feasibility of a media or teaching material conducted by Biology teachers. The aspects assessed for Eco-Magazine validation by educational practitioners are the feasibility of material content, presentation, language, design and graphics, and usability. Validation of biology education practitioners in this research and development is a biology teacher with a minimum criterion of 5 years of teaching experience. This validation is only done once because there are no suggestions for improvement and has received a positive response by the teacher. The results of the validation of biology education practitioners are presented in Table 8.

Tabel 8. Biology Education Practitioner Validation Results

No	Assessment Aspect	Score	Criteria
1.	Kelayakan isi materi	97	Sangat Valid
2.	Penyajian	98	Sangat Valid
3.	Bahasa	96	Sangat Valid
4.	Desain dan grafika	97	Sangat Valid
5.	Kegunaan	96	Sangat Valid
Rerata		**97**	**Sangat Valid**

Based on the results of the validity test conducted by experts, the Eco-Magazine developed in the form of a website is declared valid and ready to be accessed for field trials through devices..

4) Practicality of Eco-Magazine

The Eco-Magazine has been declared to meet the validity criteria by the relevant experts. The next step in the process is to carry out practicality testing through field trials. The present experiment was conducted in one class of 32 students who had previously studied the subject of environmental change. The field trial was conducted subsequent to the individual and small group trials, with the objective of obtaining the final product evaluation. The main purpose of this stage is to obtain the final and most thorough evaluation of the product from users in a real learning environment. After using the Eco-Magazine product in the learning process, students were asked to fill out a response questionnaire to determine the practicality, convenience, and usefulness of the product. The questionnaire was filled out to get an overview of the extent to which the Eco-Magazine can help students' understanding in learning. Student response data was then analysed to evaluate the strengths and weaknesses of the developed product. The results of the field trial showed that the Eco-Magazine was in the "higly practical" category. This means that the Eco-Magazine provides easy accessibility for students in utilising the contents available therein. This practicality includes the ease of using teaching materials because it is accompanied by easy-to-understand instructions for use, ease of navigation, clear display, and materials that are in accordance with learning needs [33].According to [34]. Teaching materials that are good are simple and easy to understand, but still interesting for students. Practical teaching materials will help users to understand the material and achieve learning objectives [35]. Furthermore, the utilisation of practical teaching materials has been demonstrated to enhance student engagement, as these materials facilitate a more seamless progression through the learning sequence. The practicality of the product is evident in its ability to assist students in their learning, thereby enhancing their overall educational experience [36]. The results of this field trial are the basis for determining the practical feasibility of the product to be used more widely in learning. The results of the field test can be seen in Table 9.

Tabel 9. Field Trial Results

Student's serial number	Average	Score	Category Value
Student 1	5,0	100	Highly practical
Student 2	4,7	93	Highly practical
Student 3	4,8	95	Highly practical
Student 4	4,3	86	Highly practical
Student 5	4,2	84	Highly practical
Student 6	4,5	89	Highly practical
Student 7	4,5	91	Highly practical
Student 8	4,4	88	Highly practical
Student 9	4,5	91	Highly practical
Student 10	4,7	93	Highly practical
Student 11	4,4	88	Highly practical
Student 12	5,0	100	Highly practical
Student 13	4,8	95	Highly practical
Student 14	4,7	93	Highly practical
Student 15	4,4	88	Highly practical
Student 16	4,4	87	Highly practical
Student 17	4,4	88	Highly practical
Student 18	4,5	89	Highly practical
Student 19	4,5	89	Highly practical
Student 20	4,2	84	Highly practical
Student 21	4,7	94	Highly practical
Student 22	4,5	91	Highly practical
Student 23	5,0	100	Highly practical
Student 24	5,0	100	Highly practical
Student 25	4,7	93	Highly practical
Student 26	4,1	82	Highly practical
Student 27	5,0	100	Highly practical
Student 28	4,7	93	Highly practical
Student 29	5,0	100	Highly practical
Student 30	4,6	92	Highly practical
Student 31	4,6	92	Highly practical
Student 32	5,0	100	Highly practical
Average	**4,6**	**92**	**Highly practical**

4. CONCLUSION

Following the conduction of the validity and practicality tests, it can be concluded that the Eco-Magazine developed is a viable resource for use as a teaching material in the context of biological learning, particularly with regard to the subject of environmental change. The material expert validation results, with a value of 100%, are indicative of the 'highly valid' category. The results obtained by media and teaching material experts were 96% for the category 'highly valid'. Similarly, the results obtained by biology education practitioners were 97% for the category 'highly valid'. Furthermore, the results of the practicality test conducted through trials to students showed a value of 92%, with a 'highly practical' category. The Eco-Magazine is characterised by an aesthetically pleasing visual design, relevant contextual content, and interactive features, which collectively facilitate an independent, engaging, and meaningful learning process for students. Beyond its technical feasibility, the Eco-Magazine provides important pedagogical implications by supporting the development of students' creative thinking skills and character. Through Project-Based Learning activities embedded in the Eco-Magazine, students are encouraged to explore environmental issues, generate creative ideas, and propose innovative solutions, thereby fostering creative thinking skills. In addition, the integration of contextual environmental content promotes the development of positive student character, such as environmental awareness, responsibility, collaboration, and independence. Therefore, the Eco-Magazine can be effectively utilized as a digital learning resource to support meaningful biology learning while enhancing both students' creative thinking skills and character development.

5. ACKNOWLEDGEMENT

The authors would like to express their gratitude to the supervisors, examiners, and validators for their invaluable direction, input, and guidance. The authors would also like to express their gratitude to all teachers, students, school staff, and colleagues for their support, cooperation, and contributions during the research process.

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