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Enhancing creativity through PjBL-STEAM equipped biogeochemical cycle educational kit on ecosystem materials in junior high school

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Abstract: The 21st Century learning requires students to have innovative and creative abilities. In supporting the learning process, the project-based learning model is used through the STEAM approach. This study aimed to develop PjBL-STEAM-based aquascape biogechemical cycle edukit on ecosystem material that are valid, practical, and effective to practice creative thinking skills. This development research used the ADDIE model including: 1) analyze; 2) design; 3) develop; 4) implement; 5) evaluate. Quantitative data was obtained from the value given by the validator, the results of the practicality tests of teachers and students, as well as the results of effectiveness through pretest and posttest questions. Meanwhile, qualitative data was obtained from teacher interview, comments, and suggestions provided by the validator and the teacher on each indicator in the instrument. Data collection techniques was conducted through interviews, questionnaires, and tests. The data analysis was carried out using percentage analysis and qualitative descriptive. The results of the material validation were 98% while the media validation were 94.25%. The results of the teacher's practicality test were 100% while students were 89%. The results of pretest and posttest showed a difference. The mean results of the N-Gain score for each indicator were categorized as medium with the highest increase results, namely the elaboration indicator and the lowest increase in the flexibility indicator. Based on these results, it can be concluded that the PjBL-STEAM-based aquascape biogeochemical cycle education is very valid, practical, and effective to be use in 7th graders in ecosystem material to train the creative thinking skills.

Keywords: biogeochemical cycle; creative thinking skills; edukit; PjBL-STEAM

1. Introduction

The implementation of an *Merdeka Belajar* curriculum provides an opportunity to realize an innovative learning process in the 21st century (Indarta et al., 2022). The 21st Century learning emphasizes strengthening critical thinking, communication, collaboration, and creativity skills (Andaresta & Rachmadiarti, 2021). In compensating for the development of the learning curriculum, students must have a good mastery of technology and science. Therefore, teaching and learning activities, especially science subjects in schools, need to be adjusted to meet 21st century life skills. One of the skills that students must have is creative thinking. It can provide space for students to design, solve problems, and obtain new ideas (Ladson-Billings, 2021; Pratiwi et al., 2019; Pressman, 2019). The implications of this skill bring students to more easily understand the material and master science learning concepts (Wijayanti, 2023).

Currently, skills are needed that can train creativity so that students can gain insight, one of which is creative thinking (Wahyudi et al., 2022). In addition, creative thinking is a habit of the mind that is trained by turning on the imagination of thinking skills in the learning process (Yasiro et al., 2021). However, students' creative thinking skills are still relatively low, as shown by the results of the Global Creativity Index. In 2023, Indonesia had score 7.95 and ranked 86 out of 93 countries in the creative class (Florida et al., 2015). Indonesia (61st) moves rapidly toward the top 60, following a rise over recent years. Indonesia makes marked improvements in innovation outputs, notably in knowledge creation and online creativity (Dutta et al., 2022). The results of these innovations must

provide real evidence for Indonesian students in learning. It requires creative and innovative learning and implementing concrete learning media (Siregar et al., 2020). In addition, students are still fixated with answers related to concepts in books and opinions of others (Abdurrozak et al., 2016). This needs to be supported by the use of learning media that able to train creative thinking skills.

Science is learning process that demand students active participation of students in discovering, processing, and constructing their own thoughts to be elaborated into a creative mindset (Mardhatilla, 2021). Ecosystem material in science learning is material that is complex and directly related to the environment of daily life (Nurlatifah et al., 2015). For instance, biogeochemical cycle, is abstract and very complex so that it is difficult for students to understand and requires concretizing the material in learning (Lestariningsih, 2016; Mardhatilla, 2021). Therefore, teachers need to provide opportunities for students to elaborate their abilities to show the competencies that students have in learning. This can be done by creating active and innovative learning through collaboration between students and teachers as well as the help of learning media (Indarta et al., 2022; Puspitarini, 2022).

Learning media development is a solution to optimize students' ability to solve problems and enhanching creative thinking skills (Zulaiha & Kusuma, 2020). Learning media must provide benefits in achieving learning objectives. Many science learning media have been developed but the implementation of learning is still not effective, even though the existence of learning media can generate motivation which can have a psychological effect on students (Maula & Fatmawati, 2020; Ismail, 2016). Learning media that is said to be effective, one of the indicators is student-centered (Zulirfan et al., 2021). One of the media that can shape students' creativity can be done by direct learning through educational kit (edukit). Edukit is a creative and innovative learning media with a collection of components assembled into a whole product and packaged in a versatile box and easy to use anytime and anywhere (Prasrihamni et al., 2022; Yetri et al., 2019; Shofiana et al., 2015). The use of learning media including edukit can support the achievement of learning success (Yulianti et al., 2021). Using edukit provides space for students to play an take an active role in their learning due to excitement and creative activity (Prasrihamni et al., 2022).

Biogeochemical education by applying aquascape or aquatic ecosystems is scarecely ever found in the learning process (Ramadhila et al., 2022). Edukit aquascape is a medium for structuring aquatic ecosystems that can provide facilities for students to learn independently (Ramadhila et al., 2022; Yulianti et al., 2021). Through *Merdeka Belajar* curriculum, it can train the formation of a more creative student mindset so as to achieve an effective learning (Susilo et al., 2018; Yetri et al., 2019). The science learning model carried out with the science, technology, engineering, and mathematics (STEM) approach can provide real learning so that it can improve students' creative thinking skills to face the challenges of the 21st century (Banila et al., 2021; Nugroho et al., 2019; Zulirfan et al., 2021).

The National Science Foundation (NSF) designed STEM in the form of a combination to solve problems so as to achieve the development of students' more complex thinking skills (Mu'minah & Aripin, 2019). In its development there is the addition of arts which aims to increase students' creativity and aestetics. The use of the STEAM approach is suitable for science learning because it is comprehensive and unique. STEAM is an approach with various combinations that make students feel learning in accordance with real life so that conceptual understanding is achieved (Nuangchalerm et al., 2020). In addition, arts elements also provides opportunities for students for inquiry, problem solving, and creative thinking skills (Psycharis, 2018). The STEAM approach requires the teacher to provide an active role for students in learning, so that they are able to produce their own learning and provides an opportunity for students to

produce an innovation that can solve problems by integrating their creativity problems by integrating their creativity skills (Badriyah et al., 2020).

The STEAM approach is appropriate for combined with the Project-based Learning (PjBL) learning model because it can provide a direct role for students to produce a work so that it can increase student productivity (Spoelstra et al., 2014). The PjBL learning model is also adapted to activities carried out by students through the suitability of the material and the competencies they have (Ilma et al., 2022; Indranuddin et al., 2024; Saliba et al., 2017). The PjBL learning model was created to provide a learning environment that matches the mindset of students to solve various problems in daily life. With the PjBL model, it is suitable when integrated with STEAM because it can build problem solving skills, higher-order thinking skills, and student-centered learning to provide real-world experience (Fiteriani et al., 2021; Fitriyani et al., 2020; Siew & Ambo, 2018; Sukmawijaya et al., 2019). With the PjBL-STEAM model, students get an enjoyable learning experience through various problem-solving and to increase students' interest and motivation in learning, especially in increasing creativity (Alkautsar et al., 2023; Siew & Ambo, 2018).

Based on the results of the needs analysis conducted in Junior High School 1 of Pakisaji, it shows that students have difficulty in science material because the material is too dense, lack of learning media, and is teacher centered. Learning of biogeochemical cycles in ecosystem material is 62.5%. As many as 59.45% students stated that learning media is an important component in learning but 81.1% students stated that the learning media that already exist in schools are boring. In the learning process, teachers always using worksheet as teaching material. On the other hand, as many as 64.86% of students prefer and easily understand science through hands-on activity. Due to that situation, learning tends to be monotonous impacted to students' creativity.

Based on previous research conducted by Prasrihamni et al (2022), edukit can create innovative learning media and stimulating students' creativity. In addition, Ramadhila et al (2022) states that the development of learning media in the field of biology in the form of mini aquascape ecosystem material is effective because it can train students' creative thinking skills. In addition, similar research was also conducted by Ayuningsih et al (2022). The application of the PjBL-STEAM model provides better learning outcomes and fosters student creativity. However, from previous research, he contextualization of the problems discussed has not been comprehensive only on certain materials. Therefore, materials are developed with media that are in accordance with the needs of students. In addition, the learning implemented has not used a learning approach to support creative thinking skills and has not been in accordance with the independent curriculum. Therefore, research is needed on the development of STEAM-based biogeochemical cycle edukit on ecosystem material to optimize learning in training students' creative thinking skills.

This research aims to develop valid and practical PjBL-STEAM-based biogeochemical edukit and to determine its effectiveness in training students' creative thinking skills in ecosystem material. This media needs to be developed because the ecosystem is one of the complex materials, especially the subject matter of the biogeochemical cycle so that teachers need learning media to apply the material in the real world so that it is understood directly by students.

2. Research Methods

2.1 Research Design

This research uses Research and Development (RnD) model. The selection of development research is carried out to refine or develop more effective products (Hardiansyah & Mulyadi, 2022; Rochsun & Agustin, 2020). The use of this research method is to produce products and test the effectiveness of these products (Sugiyono, 2014). The product developed is STEAM-based biogeochemical cycle edukit. The model

used in this research is ADDIE with its stages, namely analysis, design, develop, implementation, and evaluate (Branch, 2009). In the ADDIE stage model, the evaluation process is carried out at each stage to revise the product or media developed so that the resulting product is more reliable and has high validity. The ADDIE model is suitable for use in this development research because it uses a structured design at each step so that it is effective in its development (Priangga, 2021). The concept diagram of the ADDIE stages is presented in the form of a diagram in Figure 1. This research was also continued with an effectiveness test through an experiment with a type of pre-experimental design. This research is designed to include one class or group that is given pre and post-test treatment (pretest and posttest). This treatment was carried out with the type of one group pretest and posttest without a control or comparison group (Sugiyono, 2018).

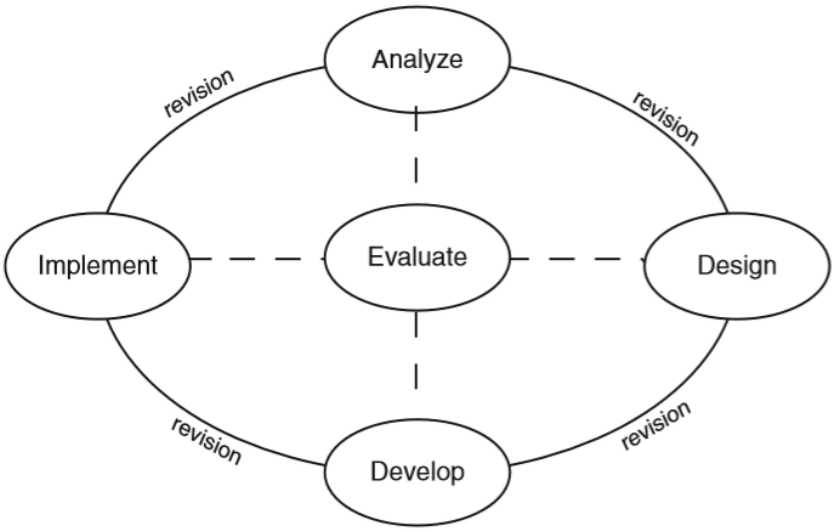


Figure 1. ADDIE stages concept

2.2 *Research Subject*

The population involved in this study were the students (teachers). The data collection was carried out in one trial class, namely in seventh grade at State Junior High School 1 of Pakisaji, Malang Regency, East Java. In the research in the trial class there were 31 students who had diverse skills. There is no superior class in the school so the ability of students in one class is spread equally.

2.3 *Research Instrument*

The research instruments needed vary at each stage of the research in accordance with the ADDIE development research model. When conducting a needs analysis, a needs analysis instrument is needed which is filled in through the google form platform and interview guidelines. This guideline is used by researchers to facilitate data collection so that the results obtained and processed are more accurate. After the needs analysis stage is complete and has designed the product developed, the researcher tests the product by conducting validation. The instruments needed in conducting validation include media and material validation instruments. After the product is said to be valid, product trials can be carried out to be implemented in placement schools or classes that are used as experiments. In this implementation process, researchers need complete media instruments ranging from guidebooks, edukit, teaching modules, and equipped with handouts. At this stage, students also conduct written tests, namely pretests and posttests to find out the differences in their thinking abilities after applying the developed product. In addition, the product was also measured for practicality by teachers and students through filling out a practicality test questionnaire.

2.4 Procedure and Data Analyze

The first stage, namely analyze, includes a needs assessment conducted by interviewing the seventh grade science teacher and filling out a questionnaire through the google form link by the eighth grade students who have taken the ecosystem material to find out the needs and VIII grade students who have taken ecosystem material to find out the needs and difficulties experienced by students during science learning. In addition, the interview stage is also to find out the implementation process of science learning at school. At this stage, qualitative data was obtained based on the results of interviews through interview guidelines. In the analysis stage, material analysis and curriculum analysis are also carried out to determine materials that are relevant to the learning objectives needed. The second stage is design, which includes making a design that is carried out by designing biogeochemical cycle edukit through making an edukit storyboard that contains the design of a series of biogeochemical edukit along with its learning tools, namely teaching modules which include worksheet, handouts, and research instruments along with a guidebook for using STEAM-based biogeochemical cycle edukit.

The third stage is develop which is carried out by developing biogeochemical cycle edukit based on the design that has been made to become a real product. At this stage, validation was carried out by one media expert validator and one material expert validator. Validity is defined as the level of ability of a data in measuring what is to be measured (Sundayana, 2018). The validity test was carried out by expert validators based on the validation instrument on the questionnaire sheet. The data obtained from this validity test includes qualitative and quantitative data. Qualitative data obtained through the validation instrument based on the results of comments and suggestions given by the validator which was analyzed descriptively. Quantitative data is obtained based on the scores given by the validator on the validation instrument. The analysis carried out on this quantitative data uses percentage analysis. The validity test conducted by media and material expert validators as well as the practicality test on teachers and students was carried out using an assessment questionnaire that refers to the Likert Scale adapted in Table 1. The assessment refers to the Guttman Scale with a score criterion of 1 means "Yes" and 0 means "No" is used in material validation for the aspect of the correctness of the concept of STEAM-based biogeochemistry education.

Table 1. Rating criteria on a likert scale

Score	Criteria
4	Very Good
3	Good
2	Not Good
1	Very Poor

After conducting the validation test, the pretest and posttest questions used to measure the level of creative thinking skills are also tested for validity and reliability. The questions given during the pre-test and post-test were adjusted to the indicators of critical thinking skills. There are five questions that have met the critical thinking indicators. Reliability is a measure that can or consistent measurement results from time to time when used as a measuring tool (Sundayana, 2018). The validity and reliability tests of the questions carried out include quantitative data types. Data This data is continued at the analysis stage using SPSS software to determine whether the question sheet is valid and reliable.

The next stage, implementation by conducting practicality tests conducted by teachers and students. If the results of the practicality test get a decent qualification, the media can proceed to the stage of limited implementation in classroom learning. This practicality test was carried out through the technique of filling out a questionnaire on

the practicality test sheet. Furthermore, the effectiveness test can be carried out to determine the effectiveness of the media developed as learning media in the classroom (Puspita et al., 2017). The effectiveness test was conducted before and after the implementation of learning using the developed media. Learning is carried out sequentially according to the PjBL-STEAM syntax, namely questioning, planning, scheduling, monitoring, assessing, and evaluating. This learning model is carried out to train students' creative thinking skills. This is in accordance with Gridos et al (2021) that the PjBL-STEAM model is effectively used to train students' creative thinking skills which refer to Torrance with indicators of fluency, flexibility, originality, and elaboration (Weiss & Wilhelm, 2022).

Media products are said to be effective can be seen based on the results of the effectiveness test through the creativity test question instrument by analyzing the results of students' pretests and posttests. The results of the pretest and posttest assessments in the effectiveness test are grouped into quantitative data types. The data obtained was analyzed using SPSS software and percentage analysis using Ms. Excel. Data analysis was carried out by calculating the average quantitative data whose results were represented in percentages to determine the feasibility of STEAM-based biogeochemical education. To calculate the average results of quantitative data with a percentage formula such as the following equation Formula (1).

$$P = \frac{\Sigma x}{i} \times 100\% \quad (1)$$

Index:

P = Percentage of validity
Σx = Average number of overall aspects
i = Maximum scale of research

Based on the results of the above equation, the validity assessment categories are presented in Table 2. The validity criteria is refers to Yulianti et al (2021).

Table 2. Validity criteria

Range	Criteria
x < 20	Not valid
20 < x ≤ 40	Less valid
40 < x ≤ 60	Valid enough
60 < x ≤ 80	Valid
80 < x ≤ 100	Very valid

The categories in the table above can also be used to indicate product practically. The limited effectiveness test of STEAM-based biogeochemical education was carried out using pretest and posttest questions which were analyzed using IBM SPSS Statistic 25. Normality test was carried out as a prerequisite test to determine normality and homogeneity test to determine the variance of the data obtained. After the two tests were carried out, the independent sample t-test was continued to determine the difference in values. In the normality test, namely the Kolmogrov-Smirnov test, if the significance> 0.05 is obtained, it means that the data is normally distributed and the homogeneity test if the results show significance (>0.05), the data has the same variance. While in the independent sample t-test test with the results there are differences in pretest and posttest scores. After testing the independent sample t-test with the results there is a difference in the pretest and posttest scores, the N-Gain test is carried out on each indicator to determine the effectiveness of the media used before and after learning (Nuryadi et al., 2017). The hypothesis tested is as follows.

H_0 : There is no significant difference in students' creative thinking skills before and after learning using edukit

H_a : There is a significant difference in students' creative thinking skills before and after learning using edukit

To calculate N-Gain using a formula such as equation 2.

$$N - gain = \frac{\text{Posttest score} - \text{Pretest score}}{Ideal\ score - Pretest\ score} \quad (2)$$

Based on the results of the equation above, as a basis for decision making to determine the criteria for the results of the N-Gain calculation, we can use Table 3 presented below.

Table 3. N-Gain criteria

Score	Criteria
0.70 ≤ g ≤ 1.00	High
0.30 ≤ g < 0.70	Medium
0.00 < x < 0.30	Low
g = 0.00	No Increase
1.00 ≤ g < 0.00	Decrease

3. Results

The resulting product (Edukit) including manual books (a guidance on how to use edukit), teaching modules (worksheet and handout) as well as pretest and posttest questions. In this process, the edukit was adjusted to the ecosystem material on the subject of the biogeochemical cycle and the mapping of the teaching module with the PjBL-STEAM learning model to train students' creative thinking skills (Felder & Brent, 2016; Im et al., 2015). At stage of develop the products produced are the box edukit, aquascape edukit complete with tools, manual book and materials and teaching modules containing learning steps, worksheet, and handout with pretest and posttest questions (Fitriani et al., 2017; Utomo et al., 2020).

The product resulting from this development is a biogeochemical aquascape edukit component with an aquarium size that has dimensions of 30 cm × 17 cm × 20 cm. The aquarium is used as a habitat for aquatic ecosystems equipped with abiotic components and biotic components. In aquascape ecosystems, the water, sand, and rocks as abiotic while aquatic plants such as *Hydra* sp., moss, and glofish tetra as biotic. Those components will be interact each other to make a connection in aquatic ecosystem (Brachet et al., 2015; Irfan & Alatawi, 2019). Edukit is also equipped with a pH sensor that functions to detect the acidity level to assure aquascape in good condition at all time . In addition, there are pH indicators and nitrate-nitrite test strips to determine the pH level and nitrate or nitrite content in the aquascape. The display of the aquascape is presented in Figure 2.

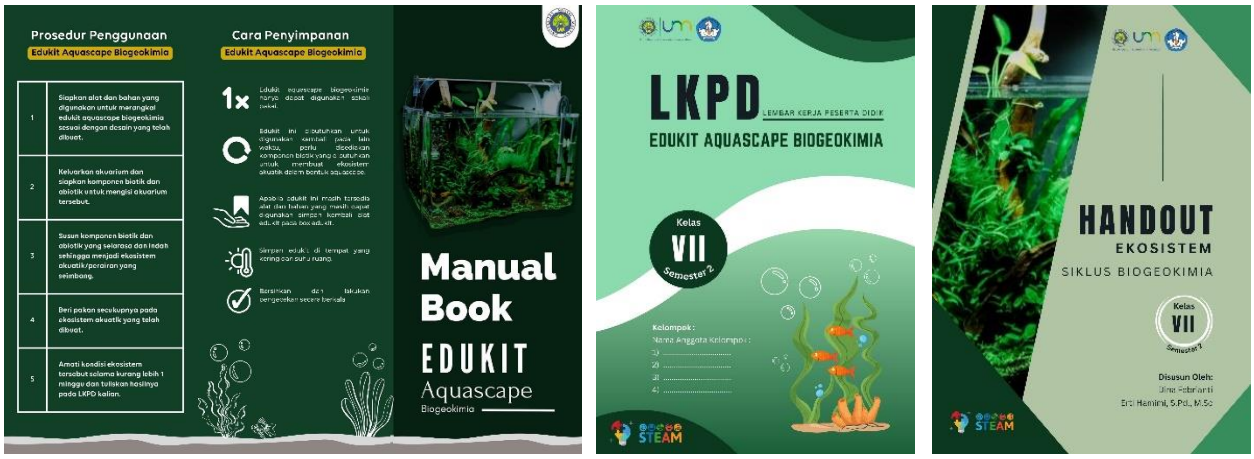
Figure 2. Realization of aquascape edukit with its components

The next product development is aquascape edukit will be packaged in box with a design according to the topic of ecosystems, this box has dimensions of 31 cm × 18 cm × 21 cm with strong and safe cardboard material to store components coupled with a design that has an attractive and modern appearance. The picture of the box edukit has been presented in Figure 3.

a) b)

Figure 3. Edukit box display (a) Exterior and (b) Interior

The next product is a manual book and teaching materials that are compiled in accordance with *Merdeka Belajar* curriculum. The form of teaching materials from the application of the independent curriculum is a teaching module. The teaching module is arranged in accordance with the syntax of PjBL-STEAM, indicators of creative thinking skills, and involving biogeochemical aquascape education in the learning process. While the manual book contains components contained in the edukit ranging from components of tools and materials, work procedures, how to store the edukit. The resulting manual book has been designed in accordance with the subject matter of biogeochemistry on ecosystem material and printed like a leaflet layout so that it is easy to store in a box and easy to understand in assembling the edukit. The entire student learning process is contained in the worksheet which has been arranged based on the PjBL-STEAM syntax and is also adapted to the indicators of creative thinking. The supporting material in learning using this edukit is fulfilled in handouts that are compiled from valid and credible sources. The appearance of the teaching module learning device is presented in Figure 4.



a) b) c)

Figure 4. Display of learning device (a) Manual book (b) Worksheet, and (c) Handout

The product, media and material validity tests were also carried out. This validity test was conducted by experts. Based on the results of the media validity test presented in Table 4.

Table 4. Media validation test results

Indicator	Percentage (%)	Qualification
Aspects of the feasibility of edukit graphics	94.57	Very Valid
Aspects of the feasibility of teaching modules graphics	95.00	Very Valid
Aspects of use	91.67	Very Valid
Aspects of linguistic	90.00	Very Valid
Aspects of edukit suitability	100.00	Very Valid
Average Score	94.25	Very Valid

The graphic feasibility of edukit obtained a score of 94.57%, which is considered very good. Some reasons that support this assessment are the size, packaging, design, components of tools and materials, and other completeness that have met the aspects developed according to the standards adjusted based on the material being studied. However, for the perfection of edukit, the presentation of tools and materials can be labelled to make it easier for users to assemble edukit. Regarding graphic practicality, the teaching module obtained a score of 95%, which qualifies as very practical. It is because the aquascape biogeochemistry unit has been equipped with a teaching module containing learning steps, student worksheets, and handouts developed with attractive designs. Attractive media can change negative impressions into positive impressions so that the learning process runs smoothly (Syahwela, 2020). In terms of use, it obtained a score of 91.67% with a very practical qualification, which shows that education is easy to use with a manual book.

The linguistic aspect of this edukit obtained a score of 90%, which is a very practical qualification because the manual book and teaching modules developed have been arranged according to the level of understanding of junior high school students. According to Baram-Tsabari and Lewenstein (2013), learning media with easy-to-understand language can help the learning process understand the material concept. However, some development shortcomings include the addition of references to increase the credibility of the handouts developed. Based on the validation achievement criteria in Table 4, the biogeochemistry of the aquascape unit is categorized as very practical and valid for use as a learning medium. The results of the material validation test on the biogeochemistry of aquascape edukit based on PjBL-STEAM got an average score of 100% with very valid criteria. It proves the media product has been arranged according to the teaching materials based on the syntax used to achieve learning objectives. Syntax is used to achieve learning objectives. In addition, other aspects have met the standards of learning devices. They can be used in the application of learning devices and can be used in the application of learning because they have met the criteria of being very practical. The results of the material validation are presented in Table 5.

Table 5. Validation material test results

Indicator	Percentage (%)	Qualification
Teaching modules	100	Very Valid
Handout	100	Very Valid
Feasibility of display	100	Very Valid
Feasibility of linguistic	100	Very Valid
Contextual asessment	100	Very Valid
Concept correctness	100	Very Valid
Pretest and posttest question	100	Very Valid
Average Score	100	Very Valid

Several indicators that have been validated have received perfect scores. This is because the preparation is adjusted to the curriculum and learning syntax used. In terms of material, the learning tools developed have met the National Education Standards Agency. Based on the validation results, the teaching module developed is in accordance with the learning model used and the steps of learning activities are coherent according to the PjBL-STEAM syntax. This is also supported by the learning activities contained in the worksheet which are also in accordance with PjBL-STEAM and can train creative thinking skills that refer to Torrance with its indicators, namely fluency, flexibility, originality, and elaboration (Gridos et al., 2021). This is evidenced by the results of the validation of the suitability of learning devices in the teaching module getting a score of 100% which is categorized as very practical as presented in Table 5. This is also supported by the statement that every teaching material must be adjusted to the learning model used so that learning is effective and learning objectives are achieved (Magdalena et al., 2020).

Based on the results of the practicality test conducted by students and teachers in Table 6, it shows that the that the biogeochemical aquascape edukit media is qualified as very practical. The results of the practicality test by teachers get a percentage of 98% while for students get a percentage of 89%. This practicality test result shows that aquascape edukit media products are said to be practical to be implemented by teachers in learning on ecosystem material, especially the subject matter of the biogeochemical cycle. In addition to the product practicality test conducted by teachers and students, a learning assessment was also carried out in the use of the edukit in direct learning in the field. The results of the learning assessment obtained an average result of 100% which is shown in Table 7. This result interpreted that learning using biogeochemical aquascape edukit to train students' creative thinking skills is very good or very practical. In accordance with research conducted by Ramadhila et al (2022) that learning media aquascape ecosystem material can support the learning process by implementing it as a teaching materials and is very effective in improving students' creative thinking skills.

Table 6. Practicality test results

Indicator	Percentage (%)	Qualification
Teacher practicality	98	Very practical
Student practicality	89	Very practical

Table 7. Learning implementation asessment results

PjBL-STEAM Syntax	Percentage (%)	Qualification
Questioning	100	Very practical
Planning	100	Very practical
Schedule	100	Very practical
Monitoring	100	Very practical
Assessing	100	Very practical
Evaluating	100	Very practical

Overall, the learning activities that have been carried out have gone well. That is, all the learning syntax of the chosen learning model has been implemented. However, in the process there are some common obstacles such as poor classroom conditions. So that the teacher's role is needed in controlling and mastering the class to maximize the learning process. After the media was declared valid and practical, the research continued by conducting an effectiveness test. Questions that are declared valid by material validators will be used to measure the effectiveness of the developed media. The results of the validity test showed that all questions were valid as evidenced that the the correlation coefficient value of all questions is more than 0.3. In accordance with Sugiyono (2013)

that if the value of the correlation coefficient ≥ 0.3 then the question is declared valid and can be used as a measuring tool. The valid questions are continued in the reliability test with the results of the Cronbach's Alpha coefficient of 0.610. This result shows that the question can be used as a research measuring instrument because the Cronbach's Alpha value of > 0.60 can be said to be reliable. Based on Sundayana (2018) by using valid and reliable instruments are a requirement for obtaining good data. Validity test results presented in Table 8 and Table 9.

Table 8. Validity test results

Question Number	Correlation Coefficient	Criteria
1	0.605	Valid
2	0.738	Valid
3	0.945	Valid
4	0.440	Valid
5	0.689	Valid

Table 9. Reliability test results

Cronbach Alpha	Number of Question	Criteria
0.610	5	Reliabel

The effectiveness test in the experimental class to measure students' creative thinking skills through pretest and posttest questions. Based on the results of the pretest conducted by 31 students, the average score was 41.5 while the posttest score was 63.2. The results of the pretest and posttest scores were then tested for normality which is presented in Table 10. The test results were then continued with the T-test and N-Gain.

Table 10. Normality test results and homogenity creative thinking skills

Test	Test Result (sig)	Criteria
Normality	0.200	Normal
Normality	0.086	Normal
Homogenity	0.007	Non-homogenous

Table 10 shows that the pretest and posttest results of students' creative thinking skills are normally distributed and not homogeneous. The homogeneity test according to Nuryadi et al (2017) is used to determine the variance of the data distribution obtained. The homogeneity test shows that the significance value is less than 0.05 so that the data is declared not homogeneous and can be continued with the independent t-test. inhomogeneous data indicates that the research samples have unequal variances. The results of the independent t-test show that by using the sign criterion $\alpha = 0.05$ that H0 is rejected. This shows that the test results are different in creative thinking skills between pretest and posttest and it is concluded that STEAM-based biogeochemical aquascape edukit can train the thinking skills of seventh grade students.

Table 11. T-Test Results

Average Pretest	Average Posttest	Sig. (2 Tailed)	Mean Difference
17,52	26,06	0,000	-8, 548

Tabel 12. N-Gain results

Indicator	Percentage (%)	Qualification
Fluency	0.32	Medium
Flexibilitiy	0.23	Low
Originality	0.39	Medium
Elaboration	0.42	Medium

The results of the independent t-test test show that the significance value of the pretest and posttest is 0.000 as presented in Table 11. Based on the N-Gain indicators contained in Table 3 and interpreted on the results of pretest and posttest scores can be qualified into the moderate category.

4. Discussion

According to the results of the learning implementation carried out by the observer, it shows that all stages of PjBL-STEAM arranged in the teaching module have been implemented appropriately. In this case, the use of edukit is designed to provide a more in-depth learning experience, including active involvement in learning, especially improving creative thinking skills (Suryaningsih et al., 2022). The effectiveness test showed that there was an increase in creativity scores, as seen from the pretest and post-test assessments Table 13.

Table 13. Creative thinking question mapping

Indicator	Question	Pretest	Posttest
Fluency	1,2, dan 3	51,9	68,3
Flexibilitiy	3	46,8	62,1
Originality	1, 2, 3, dan 4	50,2	70
Elaboration	5	17,3	52,4

Fluency of thought refers to a person's ability to generate many ideas in a certain time (Rahmazatullaili et al., 2017). The N-Gain results show that student fluency is in the moderate criteria (0.32). In addition, in the final test after learning (post-test), there was an increase of 16.4 points compared to the pretest. These results indicate that student fluency can increase after learning through edukit activities. In this case, asking questions (at the beginning of learning), packaged through dialogue in groups, provides space for students to brainstorm ideas for solving problems of ecosystem imbalance (Palmgren-Neuvonen et al., 2021; Pressman, 2019). If carried out consistently, this kind of discussion activity can train students to think more sharply to produce many ideas and perspectives (Droessiger & Vdovinskiene, 2020). Something very progressive in solving a problem. Moreover, in the process, students are involved in hands-on activities designing aquascape ecosystems (Wang et al., 2021; Zulirfan et al., 2021). Both activities can simultaneously strengthen each other and balance between understanding theoretical concepts and direct implementation (Sunnemark et al., 2023; Sutaphan & Yuenyong, 2019).

In addition to fluency, the use of edukit also has an impact on students' flexibility in viewing problems from several perspectives (Weiss & Wilhelm, 2022; Zhou, 2021). This ability to think flexibly is one indicator of a person's creativity. Creativity is closely related to how a person can think out of the box about a problem or several factors inherent in the problem (Im et al., 2015; Zulkarnaen et al., 2017). The increase in flexibility scores by 15.3 points is strongly indicated by the impact of the integration of brainstorming activities and solution planning for aquascapes created by students. However, although there was an increase in pretest-posttest scores, the level of student flexibility was still relatively low. That is undoubtedly natural because improving thinking skills is closely related to culture and habits (Ghanizadeh, 2017; Koyama & Watanabe, 2023). Changes that appear quickly cannot be generalized as an absolute increase in thinking skills, but they indicate good progressiveness.

Creativity is also closely related to originality of thought. This originality of thought ultimately makes a real difference between someone who can think critically or not. In this case, an increase of 19.8 points with a medium N-gain level indicates the originality

of student thinking in the learning process. How can this happen? The strongest indication is the original, different, and novel aquascape design activity (Firmansyah et al., 2022). The originality of students' thinking skills can be seen from how they express ideas in designing aquatic ecosystems using the aquascape biogeochemistry edukit on the worksheet and model images that are made (Shriki, 2013; Thuneberg et al., 2018). On the other hand, the material validity test and practicality test results show that the edukit aquascape learning media has stimulated students to produce a solution idea for the given problem.

The last indicator that can be measured in observing creative thinking skills is the ability to elaborate (Rahmazatullaili et al., 2017). This ability refers to how students can explain in more detail, even examples relevant to the solutions they create. According to some experts, good elaboration can increase the potential for an idea to be accepted. Moreover, good elaboration may increase understanding of the ideas behind a solution. An idea that can be elaborated well also has the opportunity to receive objections or input for better improvements in the future. Through learning activities with edukit, students are asked to write down the tools and materials, the uses of making aquascapes, and how the design is carried out. It ensures that students can describe the concepts and reasons behind them. In this case, the questions are integrated with the student worksheet and evaluation sheet. The results of the validity and practicality tests show that edukit can stimulate and provide practice for students to elaborate creative ideas well. Al Adawiah et al (2019) stated that the elaboration indicator is the ability to describe or detail the ideas that have been put forward, from imaginary to more objective.

To sum up, the integrated PjBL-STEAM steps in edukit can facilitate all indicators of students' creative thinking abilities and provide space and opportunities to explore concepts with their creative abilities (Ayuningsih et al., 2022). The effectiveness test results showed that elaboration experienced the most significant increase, namely 35.1. One indication is the ability of students to detail components based on the designs made. In addition, edukit also increases the active role of students in the learning process so that they can apply their creativity more optimally (Prasrihamni et al., 2022). This condition shows that students can better solve problems by associating mathematical abilities with everyday life. However, several other indicators of creativity, such as flexibility, experienced different increases in scores, including the N-gain score. If students' cognitive abilities are not reasonable, it will cause difficulties in their learning process. Therefore, teacher facilitation is a crucial factor, especially in conducting observations throughout the completion of student projects. When teacher facilitation can provide space for students to think from multiple perspectives, students will slowly be trained to be skilled at creative thinking (Idris et al., 2018). Good creative thinking skills cannot just appear but require a practice process (Al Adawiah et al., 2019). Once students are accustomed to being trained, they will be able to produce diverse ideas and solutions to various problems.

5. Conclusion

Development of PjBL-STEAM-based biogeochemical cycle education media on ecosystem material obtained practical results from the media validation, material validation, and practicality tests conducted by teachers and students. Based on the results of the effectiveness test, it was found that there was a difference between the pretest and post-test scores. In contrast, the t-test and N-Gain test were obtained with the average score on each indicator of creative thinking skills, including the medium category. However, overall, the development of PjBL-STEAM-based aquascape biogeochemical cycle educational media is valid and practical and can be used as an effective learning medium in training creative thinking skills.

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