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Development of Teaching Materials Based on STEM PJBL-ABMH (Preserved Bioplastic Materials Set) to Improve Students' Creative Thinking Skills

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ABSTRACT

This study describes the process and results of the development of PJBL-ABMH-based learning tools to improve students' creative thinking skills on set material. This research uses Plomp's development model to develop teaching materials in the form of teaching modules and project worksheets on set material with PPA-ABMH project learning design. The pilot test was conducted on 6 grade 7 students in one of the junior high schools in Surabaya, East Java. Data collection and analysis techniques were carried out using validation sheets to determine the validity of learning devices that were rated by validators. Student response sheets were used to determine the practicality of the learning devices that had been developed. Then, pretest and posttest sheets to measure the effectiveness of student's creative thinking skills on set material. Data analysis was carried out using the constant comparative method technique. The results of data analysis showed that the learning tools obtained validity criteria of 77% in terms of content, 80% in terms of graphics, 70% in terms of presentation, and 75% in terms of language. The learning tools developed are practical to implement, with an average student response score of 90%. The results indicates that this teaching material is effectively implemented to improve creative thinking skills. Thus, PJBL-ABMH-based learning devices are declared valid, effective, and practical. For future researchers, they can conduct research using more subjects or conducted with the class test/field test method, conduct research with the integration of other fields of science such as physics, chemistry and others.

Keywords**:** *Sets, Creative Thinking Skills, PJBL-ABMH based Learning Tools*

Pengembangan Bahan Ajar Berbasis Pjbl-Abmh (Awetan Bioplastik Materi Himpunan) Untuk Meningkatkan Keterampilan Berpikir Kreatif Peserta didik

ABSTRAK

Penelitian ini mendeskripsikan proses dan hasil pengembangan perangkat pembelajaran berbasis PJBL-ABMH untuk meningkatkan kemampuan berpikir kreatif siswa pada

materi himpunan. Penelitian ini menggunakan model pengembangan Plomp untuk mengembangkan bahan ajar berupa modul ajar dan lembar kerja proyek materi himpunan dengan desain pembelajaran proyek PJBL-ABMH. Uji coba dilakukan pada 6 siswa kelas 7 di salah satu sekolah menengah pertama di Surabaya, Jawa Timur. Teknik pengumpulan dan analisis data dilakukan dengan menggunakan lembar validasi untuk mengetahui kevalidan perangkat pembelajaran yang telah dinilai oleh validator. Lembar respon siswa digunakan untuk mengetahui kepraktisan perangkat pembelajaran yang telah dikembangkan. Kemudian, lembar pretest dan posttest untuk mengukur keefektifan kemampuan berpikir kreatif siswa pada materi himpunan. Analisis data dilakukan dengan menggunakan teknik metode komparatif konstan. Hasil analisis data menunjukkan bahwa perangkat pembelajaran memperoleh kriteria kevalidan sebesar 77% untuk segi isi, 80% kegrafikan , 70% penyajian, dan 75% bahasa. Perangkat pembelajaran yang dikembangkan praktis untuk diimplementasikan, dengan nilai rata-rata respon siswa sebesar 90%. Hasil kriteria keefektifan mengindikasikan bahwa bahan ajar ini efektif diimplementasikan untuk meningkatkan kemampuan berpikir kreatif. Dengan demikian, perangkat pembelajaran berbasis PJBL-ABMH dinyatakan valid, efektif dan praktis. Bagi peneliti selanjutnya dapat melakukan penelitian dengan menggunakan subjek yang lebih banyak atau dilakukan dengan metode uji kelas/uji lapangan, melakukan penelitian dengan integrasi bidang ilmu lain seperti fisika, kimia dan lain-lain.

Kata Kunci**:** *Himpunan, Keterampilan Berpikir Kreatif, Perangkat Pembelajaran berbasis PJBL-ABMH*

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1. Introduction

Learning is a place to produce students with the intelligence to think and act. Learning mathematics requires thinking intelligence, namely the ability to think creatively (Waluya & Asikin, 2020). Creative thinking is the ability to come up with ideas or solutions to solve problems and create something new or not existing before (Rohana, 2017). According to the Ministry of Education and Culture (2017), the skills needed in the 21st century are 4C (Critical thinking, Collaborative, Communicative, and Creative). Students' critical thinking abilities correspond positively to their problem solving abilities (Setiyowati & Shodikin, 2022). Based on Florida's research (2015), Indonesia ranked 115 out of 139 countries with an index of 0.202. The research shows that the level of creativity in Indonesia is unsatisfactory. It happens because students are lacking in learning activities that train creative thinking. Lubis's research (2018) supports that students' creativity is still low, as evidenced by using test results where each indicator of creative thinking produced by students is declared incomplete. Indicators of creative thinking are fluency, flexibility, originality, and elaboration thinking (Munandar, 2012).

One of the efforts to train creative thinking skills is to implement the learning that involves students with real-life (Corebima, et al., 2017). According to Furmanti & Hasan (2019), teachers must motivate students to learn and not feel bored during learning by applying innovative or varied learning models. Project-based learning (PjBL) is a learning model that the independent curriculum can apply. PjBL learning is a learning model that is learner-centered long-term, focuses on problems to be solved, and provides meaningful and authentic learning experiences for students (Rohana, 2017). The PjBL model can motivate and encourage students to think creatively and independently to produce products, improve

learning outcomes, provide experience building their knowledge, and improve students' ability to communicate their products (Adinugraha, 2018). PjBL integrated learning materials has been proven to improve students' basic abilities such as literacy and numeracy (Sumarno, et, al., 2022, Sumarno, et al., 2024). According to Mubarokah's research (2019), the PjBL learning model can increase students' creative thinking from 62% to 82.31%. Project assignments can also improve creative thinking skills (Handayani, 2020). In addition, PjBL learning can be a forum for students to prepare themselves to welcome the demands of 21st-century skills (Rahayu, 2018).

The teacher is a good facilitator, so learning is conducive and directed in the PjBL learning model (Safaruddin et al., 2020). Group cooperation is needed in every stage of learning (Zahroh, 2020). According to Kristiani (2018), the stages of the PjBL learning model begin with focusing students on questions or problems that will determine the topic of the project, designing project completion steps, preparing a project implementation schedule, completing the project with teacher guidance, preparing reports and publishing project results, and evaluating the process and project results. Risnanosanti Syofiana (2020) stated that every subject matter could be practiced to achieve creative thinking skills. Projects given to students must be tailored to the learning material so that students are encouraged to investigate the real world to complete the project (Farihatun & Rusdarti, 2019). Based on this, this research was conducted to develop teaching materials based on students' daily lives. Researchers want to develop teaching materials for set material, namely grade VII junior high school mathematics. Set material is material that is close to the daily lives of students. However, Eksan (in Natsir et al., 2016) stated that students have difficulty in expressing everyday problems in set form, it is difficult to state the set members, it is difficult to determine the set and not the set so that errors occur in solving the problems given.

Set material can be presented using PjBL-based teaching materials. It can be mastered with the syntax of the PjBL learning model and inserting creative thinking indicators to train creative thinking ability. Fluency indicators can be achieved by evaluating project processes and results. In contrast, flexibility indicators can be achieved by determining project topics and evaluating project processes and results. As long as learners design the steps to complete the project, it is an effort to train the achievement of the elaboration indicator. In addition, the originality indicator can be achieved by preparing a project implementation schedule, completing the project with teacher guidance, and preparing a report. Through applying the PjBL model, the creative thinking process of students can be developed by giving project tasks in the form of grouping living things around the neighborhood and school. These living things are then identified based on their characteristics. The student's identification results are preserved in bioplastics as a learning medium that can be utilized to facilitate the learning process. Research on the development of bioplastics as learning media shows that bioplastic learning media can improve students' creative thinking skills (Faris et al., 2017).

In previous studies, these bioplastic preserves were used in learning biology material on the diversity of living things (Handayani et al., 2013), classifying Animalia-Arthropoda (Nita & Irwandi, 2021), and classifying moss plants (Prihartiwi et al., 2020). Based on this research bioplastic preserves are used in classification or grouping, this study will use bioplastic preserves in learning mathematics set material because the definition of a set is a set of objects or objects that can be identified. In addition, bioplastic media is a form of media in the form of animals or plants preserved in resin blocks to be used as learning media. The advantages of bioplastic media are that preserved animal or plant samples can be seen from all sides, and samples wrapped in plastic will last longer than preserved sample media such as herbarium and insectarium. So, it is suitable to be used as a learning media on set material, considering the advantages of bioplastic preservation. In this study, bioplastic preservation

will be used to create a set consisting of plants, so one bioplastic preservation represents a certain set.

From the explanation above, researchers develop students' creative thinking skills by applying one alternative learning model, namely the PjBL model, through making bioplastic preserves to students' creative thinking skills. The PjBL model was chosen because its advantages lie in its application, which involves students actively working on a worthwhile project to solve problems. Learners are trained to analyze problems, explore, gather information, interpret, and assess projects related to the problems studied. This learning allows students to develop their creativity in designing and making projects that can be used to solve problems (Yudha et al,2023).

The development of teaching materials also uses the STEM approach. Integrating the four aspects of STEM (Science, Technology, Engineering and Math) in learning will help students solve contextual and conceptual problems in a much more comprehensive and meaningful way. Furthermore, STEM approach as an interdisciplinary approach to learning in which various scientific concepts are combined/related to real-world events when students apply science, technology, engineering, and math in a context that connects schools, communities, and workplaces to improve STEM literacy and compete in the new economic market (Tsupros et al., 2009)

One of the suitable learning designs for PJBL is STEM (Science, Technology, Engineering, abd Mathematics). In PJBL, students can understand concepts through making products, while in STEM learning students will carry out the process of designing and designing products (Hidayah et al., 2022). The PJBL model integrated with STEM gives students the freedom to explore learning activities, carry out projects collaboratively, and produce solutions that are solutive and creative (Hidayah et al., 2022).

Research shows that the STEM learning approach affects students' creative thinking (Sirajudin et al., 2021). Another research conducted by Ameer et al., (2021) that the STEM learning approach in addition to increasing students' creative thinking also improves students' mathematics learning achievement. By using the STEM approach, students learn to connect the four fields of science, technology, engineering, and mathematics so that they are able to generate new ideas and create original works that have never existed before through experiments, and practicum which is one of the creative thinking skills (Jawad et al., 2021). Further research showed that there was an increase in creative and critical thinking in students who used STEM-based student worksheets based on STEM (Yulianti et al., 2020). In addition, the study also showed that learning by using STEM-based worksheets can also improve students' mathematical content knowledge, which can be obtained not directly through memorization, but through a meaningful learning process.

The selection of objects using bioplastic preserves is because these bioplastic preserves contain two disciplines in STEM, namely science and mathematics. Then two other aspects are contained as follows Technology aspects, namely the bioplastic preserves themselves, Engineering aspects, namely the techniques in making bioplastic preserves. Based on the description above, this study aims to describe the feasibility of developing teaching materials based on PjBL-ABMH (Bioplastic Preservation of Set Material) to improve students' creative thinking skills. This description can be used as a reference by teachers in explaining the concept of sets.

2. Research Method

2.1 Participants

This research was conducted in one of the junior high schools in Surabaya by taking the population of grade 7 students who had not received set material. Data collection was

carried out using a learning trial design, namely a limited trial by selecting six research subjects with different mathematical abilities (high, medium, low) of 2 subjects each in each ability group. The reason for taking 2 subjects in order to avoid control variables is based on gender.

The selection of subjects in this study used a purposive sampling technique. In this purposive sampling, samples are selected based on specific criteria according to research needs. This type of purposive sampling is based on suitability for the study; this type of selection is also called deliberate or judgmental sampling (Bhardwaj, 2019). Using this technique, the subject of this study was chosen by giving the criteria of the research subject to the mathematics teacher in one of the schools in Surabaya; then, based on these criteria, the mathematics teacher took the six subjects we needed. This subject was chosen due to considerations of the efficiency of the time used. Apart from being based on the teacher's recommendation, the researcher also considered the students' mathematics ability as seen from the students' scores in mathematics learning.

The selection of subjects was based on the recommendation of the mathematics teacher at the school because the teacher already knew the students' mathematical abilities and characteristics and also based on the students' mathematics scores. In accordance with other studies that also use purposive sampling based on teacher recommendations in accordance with the criteria desired by researchers (Zulaikha, et al., 2020). There are six subjects (high, medium, low) that we obtained, and we gave the initials (GB), (ML), (AZA), (RB), (BW), and (APA).

2.2 Instrument and Procedure

This research is a type of development research, namely the development of learning devices using the Plomp development model with five phases: the Initial Investigation Phase, Design Phase, Realization / Construction Phase, Test, Evaluation, and Revision Phase (Akker, 2013). Learning devices developed in the form of teaching modules and project worksheets. Data collection and analysis techniques were carried out using validation sheets to determine the validity of learning materials tested to validators. Student response sheets are used to determine the practicality of the learning materials that have been developed. Then, the pre-test and post-test sheets measure the effectiveness of students' creative thinking skills on set material. The effectiveness is seen based on whether or not there is an increase in student learning outcomes. The pre-test and post-test questions have been assessed for validity by the validator. The following are the two questions (pre- and post-test) that were used as research instruments:

PRE-TEST QUESTION (SET)

Read the questions below carefully and write your answers in the boxes provided. Do not forget to write your identity.

Name :

Class :

Table 1. Alternative Answers to Pre-Test Questions

No	Question	Alternative Answers
1	What do you know about sets?	A set is a collection of different objects that can be clearly defined so that they can be grouped into one unit.
2	Write down 3 groups that are sets and 3 groups that are not sets.	**3 groups that are sets:** The set of odd numbers, the set of whole numbers, the set of negative integers **3 groups that are not sets:** The set of beautiful flowers, the set of tall students, the set of nice houses

3	Given some numbers written as follows: **S = {0, 1, 2, 3, 4, 5}.** Make several different sets of these numbers.	N is the set of natural numbers less than 6 N= {x ∈ S | x ≤ 6 and x is natural numbers} = {1,2,3,4,5} O is The set of odd numbers between 0 and 6 O = {x ∈ S | 0 ≤ x ≤ 6 and x is odd numbers} = {1,3,5} I is the set of positive integers less than 6 I = {x ∈ S | x ≤ 6 and x is positive integer} = {0,1,2,3,4,5}
4	There are the following data: **Sheep, Lion, Crocodile, Horse.**	A is the set of animals that reproduce from the given data A= {x| x∈ The set of animals that reproduce from the given data} = {Sheep, Lion, Horse} B is The set of animals laying eggs from the given data B = {x| x∈ The set of animals laying eggs from the given data} = {Crocodile} C is the set of 4-legged animals from the given data C = {x| x∈ The set of 4-legged animals from the given data} = {domba, singa, buaya, kuda} D is the set of herbivorous animals from the given data D = {x| x∈ The set of herbivorous animals from the given data} = {domba, kuda} E is the set of carnivorous animals from the given data E = {x| x∈ The set of carnivorous animals from the given data} = {singa, buaya}
5	Consider the following sets: A = { the letters in the word "belajar"} B = { the letters in the word "himpunan"} C = { the letters in the word "mudah"} Name each member of the above sets, then create set D, which is the union of sets A, B, and C.	A = {b,e,l,a,j,r} B = {h,i,m,p,u,n,a} C = {m,u,d,a,h} D = {a, b, d, e, h, i, j, l, m, n, p, r, u}

Table 2. Indicators of Validation of PJBL-ABMH Learning Materials

The following are indicators of validation of PJBL-ABMH learning devices:

No	Validity Criteria	Learning Materials
1.	Contents	The suitability of the Teaching Module and project worksheets content with Merdeka Curriculum The suitability of the material in the Teaching Module with learning outcomes The suitability of the material in the Teaching Module with learning objectives Suitability of Teaching Module with PJBL-ABMH learning method a. There is a concept map that is completed with the existence of a relationship between the with the subject matter b. There is prerequisite material c. Each learning objective consists of subject matter, sample problems, and practice questions The correctness of the substance of the learning material a. Accuracy of concepts and definitions
2.	Graphics	The Teaching Module and project worksheets format makes it easy for learners in learning

		Selection of style, size, and color Alignment between text color, background, images, and tables
3.	Presentation	Cover presents the content of the Teaching Module and project worksheets There is a place to write the answer as needed Serving order a. Consistency of presentation system b. Conciseness of concept c. Linkages between sections d. Wholeness of meaning Providing motivation and attraction Interaction (stimulus and response) a. Learner engagement b. Compliance with chemical characteristics
4.	Validity	Clarity of information presented Conformity with good and correct Indonesian writing rules correct a. Language accuracy b. Spelling accuracy c. Appropriateness of the use of terms, symbols or icons Effective and efficient use of language (clear and concise) a. Accuracy of sentence structure b. Sentence effectiveness c. Sentence rigor d. Information comprehension

2.3 Data Analysis

In this development research, three stages of data analysis are used, namely proving the instrument's validity, testing the teaching module's practicality using a student response questionnaire, and the results of the pre-test and post-test to test the effectiveness of the teaching module. In product being developed, validator will validate is a learning materials in the form of a teaching module. The teaching module will be validated by two validators, the first validator is one UNESA mathematics education lecturer and the second validator is one UNESA science education lecturer. The first validator was chosen because he is an expert in his field, namely the field of mathematics education so that it is relevant to the teaching materials developed, namely using set material and engaged in education with the PJBL model. The second validator was chosen because he had conducted research on improving students' creative thinking skills through blended learning using schoology, the second validator is an expert in his field, namely the field of science so that it is relevant to the teaching materials developed, namely using bioplastic preserves. The validity score criteria can be seen in the table below (Mardapi, 2012; Ahmad, 2020).

Table 3. Validity Criteria

Score Interval (100%)	Category
$X < \overline{X}_i - 1.Sb_i$	Less Valid
$\overline{X}_i > X \geq \overline{X}_i - 1.Sb_i$	Fairly Valid
$\overline{X}_i + 1.Sb_i > X \geq \overline{X}_i$	Valid
$X \geq \overline{X}_i + 1.Sb_i$	Very Valid

Description:

X = score achieved

$\overline{X}_i$ (Average ideal score) = 1/2 (maximum score + minimum score)

Sb_i (Ideal standard deviation) = 1/6 (maximum score - minimum score)

ideal maximum score = $\sum$ criteria item × highest score

ideal minimum score = $\sum$ criteria item × lowest score

In this development research, three stages of data analysis are used, namely proving the validity of the teaching module, testing the teaching module's practicality using a student response questionnaire, and the results of the pre-test and post-test to test the effectiveness of the teaching module. Teaching module practicality instrument in terms of student response questionnaire. The practicality score criteria can be seen in the table below (Mardapi, 2012; Ahmad, 2020).

Table 4. Practicality Criteria

Score range (100%)	Category
$X < \overline{X_i} - 1.Sb_i$	Less Practical
$\overline{X_i} > X \geq \overline{X_i} - 1.Sb_i$	Practical enough
$\overline{X_i} + 1.Sb_i > X \geq \overline{X_i}$	Practical
$X \geq \overline{X_i} + 1.Sb_i$	Very Practical

Description:

X = score achieved

$\overline{X_i}$ (Average ideal score) = $\frac{1}{2}$ (maximum score + minimum score)

Sb_i (Ideal standard deviation) = $\frac{1}{6}$ (maximum score - minimum score)

ideal maximum score = $\sum$ criteria item × highest score

ideal minimum score = $\sum$ criteria item × lowest score

The instrument of the effectiveness of the teaching module is reviewed from the presence or absence of an increase in students' creative thinking skills. To do this, the researcher chose the research design one-group Pre-Test Post-Test Design, an experiment carried out in only one group without a comparison group; this design uses a pre-test before being given treatment. Thus, the treatment results can be known more accurately because they can compare the situation before treatment (Tsupros et al., 2009). For more details, the researcher describes the design in the scheme below:

O_1 X O_2

Schematic Description :

O_1 = Before the treatment is given

O_2 = After the treatment is given

X = Treatment provided

Because this study only uses six people in the same class, it means that there is only an experimental group before being given treatment first given a pre-test. After the pre-test, the treatment is given by learning using teaching materials in PJBL-ABMH-based teaching modules. The posttest was conducted after the treatment was given so that the researcher could know more precisely the increase in the level of creative thinking skills of students before and after the treatment was given.

Given that only limited tests were carried out with a small number of subjects, non-parametric statistical data analysis was used. In addition, to facilitate researchers in comparing the two pre-test and post-test data given to students. After obtaining the necessary data, the researcher tabulates all the values from the pre-test and post-test results with the help of a helper table

and processes the data with the following Wilcoxon Matched Pairs Test formula (Noether, 1992; Harris & Hardin, 2013; Ayvaz & Durmuş, 2021).

$$z = \frac{T-\mu_r}{\sigma_r}$$

Description:

Z : Wilxocon Matched Pairs Test statistical test results

T : Small number of levels or ranks

μ_r : $\frac{n(n+1)}{4}$

N : Number of samples

σ_r : $\sqrt{\frac{n(n+1)(2n+1)}{2}}$

Description of the steps taken in the data analysis process as follows collect pre-test and post-test data, recapitulating pre-test and post-test results in the table, entering data in the auxiliary table with the formula pre-test (O2) – post-test (O1), processing pre-test and post-test data with the Wilcoxon matched pair test formula, the first step is to calculate the mean/mean and standard deviation, after the Z count result (z_h) is found, continue by finding the Z table value (z_t), comparing the results of z_h with z_t through a crisis value of 5% = 0,05 to find the results of the data analysis/hypothesis, and testing the hypothesis and formulating conclusions from the comparison results.

After completing the data analysis results, the interpretation of the analysis results is carried out with the following guidelines, If Z count $(z_h) <$ Z table (z_t), then H_0 is accepted which means that there is no increase between the use of PJBL-ABMH on student learning outcomes and If Z count $(z_h) >$ Z table (z_t), then H_0 is rejected which means that there is an increase between the use of PJBL-ABMH on student learning outcomes. If there is an increase in learning outcomes, the teaching material can be said to be effective and vice versa.

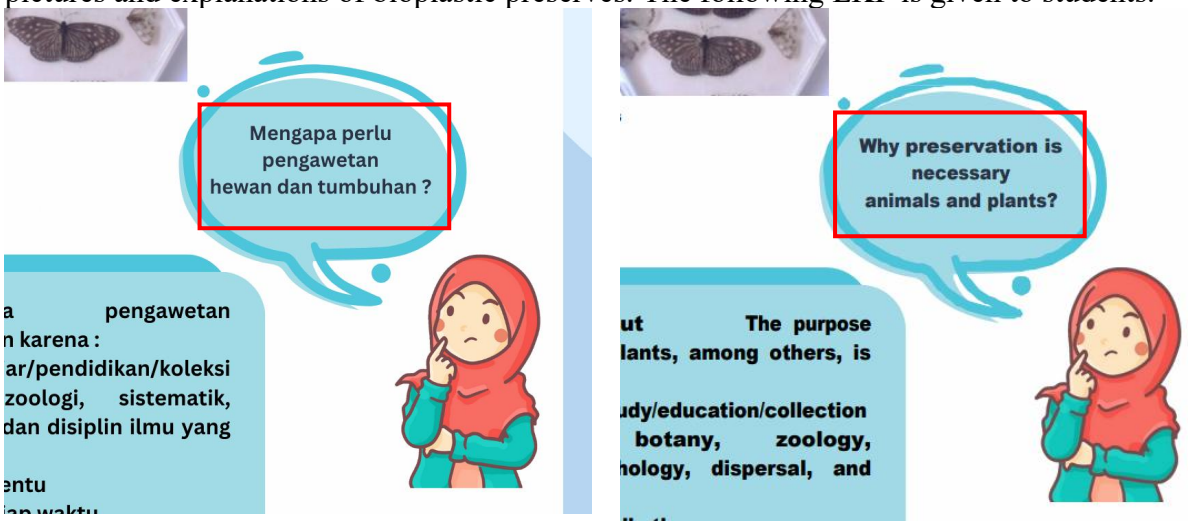
3. Result and Discussion

The teaching materials developed in this study are teaching modules and project worksheets. The teaching materials development process refers to Plomp's development model, which consists of the Initial Investigation, Design, Realization/Construction, Test, Evaluation, and Revision phases (Baharuddin & Hardianto, 2019). In the initial investigation phase, learning needs were analyzed through observation, interview and literature study. In the design phase, the integration of the four aspects of STEM (Science, Technology, Engineering and Math) in learning is carried out because the four aspects will help students solve contextual and conceptual problems in a much more comprehensive and meaningful way. In this phase, the activities carried out are determining the STEM learning framework in set learning. In addition, EDP (Engineering Design Process) design is also carried out on each teaching materials. For the realization/construction phase, teaching materials and research instruments are developed. The validity test is carried out on the validator in the test, evaluation, and revision phase. If it has met the validity, it is continued by carrying out a limited trial to determine the effectiveness of the teaching materials. Finally, data on the practicality of the teaching materials will be collected with a learner response sheet.

In the initial investigation phase, some results were obtained from observations and interviews with grade 7 math teachers at one of the schools in Surabaya regarding the set material learning model applied in this school in the previous year. The teacher stated that the set material was presented by giving explanations from the teacher and discussed together. Set lessons have never been done with project learning and have never done integrated learning

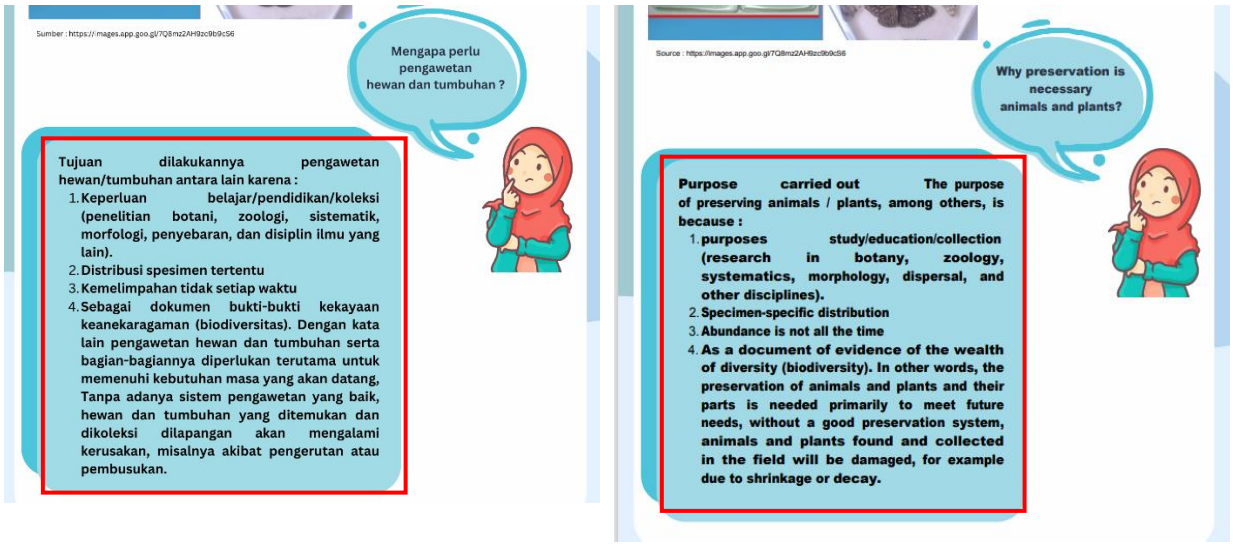
with other subjects. Set material is also one of the materials that are difficult for students to understand. Therefore, the selection of research topics by conducting PJBL-ABMH-based mathematics learning in set material was proposed in the target school.

In the design phase, the integration of the four aspects of STEM (Science, Technology, Engineering and Mathematics) in learning is carried out because the four aspects will help students solve contextual and conceptual problems in a much more comprehensive and meaningful way. In this phase, what researchers did was to determine the design and framework of STEM learning. The main activity is the Bioplastic Preservation Project, which groups plants around a set material in mathematics. In project worksheets, students are given pictures and explanations of bioplastic preserves. The following LKP is given to students.



Picture 1. Aspects of EDP Ask

The EDP Ask aspect contained in the LKP relates to questions that students need to consider related to the preservation of plants and animals, which are then related to the problems raised in this project.

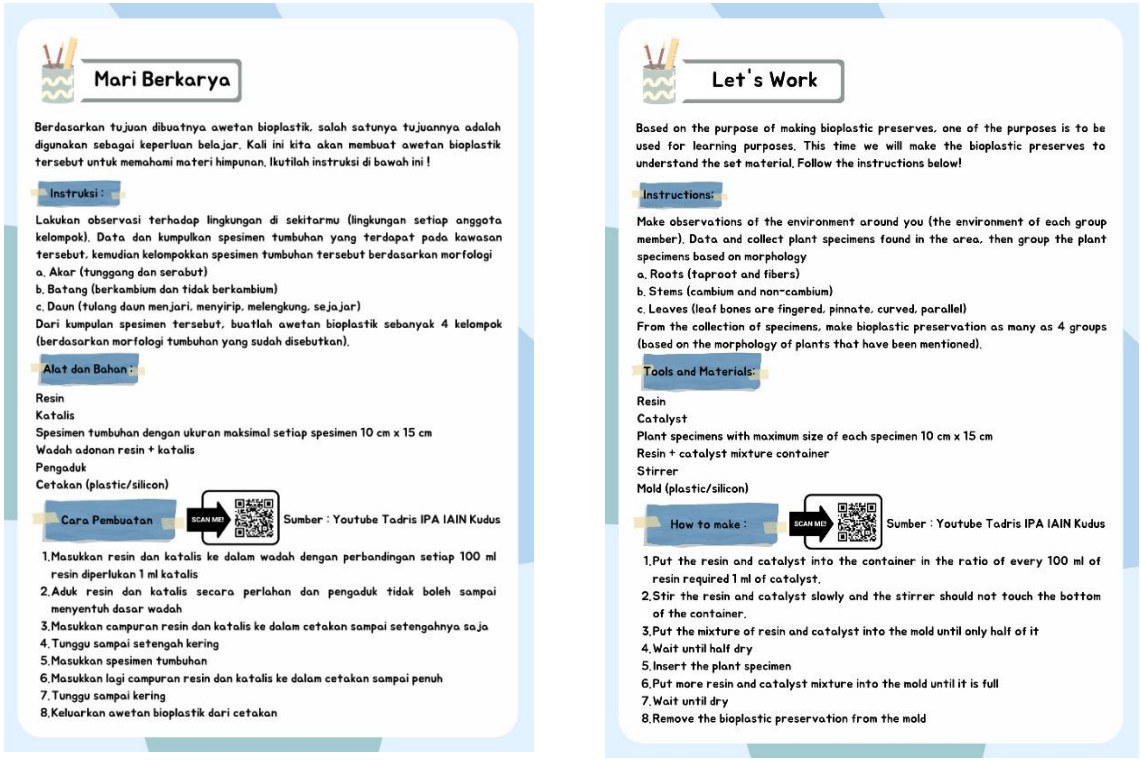


Picture 2. EDP aspect: Imagine

The EDP Imagine aspect contained in LKP is related to the direction of solving or solving problems raised in STEM learning. Where the purpose of preserving animals and plants is presented, bioplastic preservation is made.

Picture 3. EDP Plan Aspects

The EDP Plan aspect listed in the LKP is the preparation of a timeline of activities related to the implementation of the STEM project shown in the figure above. The project implementation plan is described according to the activities and deadlines for implementing the activities.



Picture 4. EDP Create Aspect

The EDP Create component within the LKP is evident in the instructions provided for creating a herbarium album. The process or steps for implementing the project are detailed in the instructions accompanying each activity description. The EDP Improvement aspect is identified in the Project Results Presentation activity, during which both students and teachers engage in reflective exercises on the learning activities and collaborative projects they have undertaken.

Beyond formulating the EDP for learning tools, the pre-test and post-test questions in this phase are designed to assess the enhancement of students' creative thinking skills. The five questions devised cover four categories of creative thinking. Alongside the assessment tools, researchers have crafted validation instruments and learner response mechanisms to gather information regarding the learning devices' validity and student reactions to project-based learning implementation.

During the implementation or construction phase, learning tools are developed in accordance with the designs established in the planning phase. The activities in this phase include 1) deliberating on learning indicators for crafting learning tools, 2) creating teaching modules as a guide for developing Project Worksheets, 3) formulating project Worksheets, 4) creating pre-test and post-test instruments, 5) generating learning device validation instruments, and 6) designing learner response instruments.

In the testing, evaluation, and revision phase, the teaching materials undergoes validation by 2 validators, namely a lecturer from the UNESA mathematics department and a lecturer from the UNESA sains department. Following validation and incorporating feedback, the teaching materials is then tested on the research subjects, chosen to represent a diverse range of mathematical abilities among students with high, medium, and low proficiency.

The results of developing teaching materials are reviewed on validity, practicality, and effectiveness. These results are described as follows:

A. Validity

The validation process of the research tools involved the assessment of Project Worksheets and Teaching Modules, which functioned as learning tools where the project worksheets were attachments to the teaching modules, through validation by two validators comprising lecturers specializing in mathematics education and science education. The outcomes of the validation for these learning devices were subjected to analysis, and they were deemed valid if they met or exceeded a minimum validity criterion of ≥ 61.

Table 5. Teaching Module Validation Results

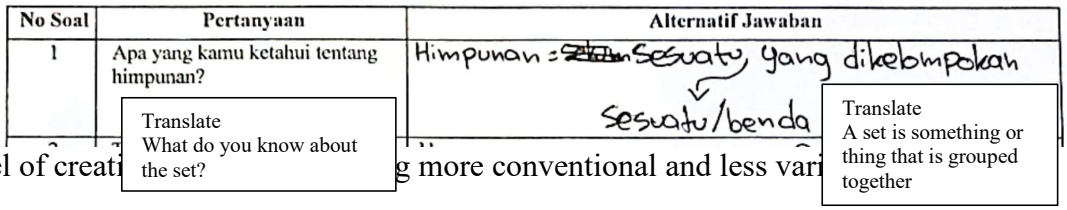
No	Assessment Aspect	Expert Assessment		Average	Criteria
		Validator I	Validator II		
1	Contents	74%	80%	77%	Valid
2	Graphics	80%	80%	80%	Valid
3	Presentation	70%	70%	70%	Valid
4	Linguistics	80%	75%	75%	Valid

Following the validation and analysis of the Teaching Module, it was determined that the content aspect achieved an average validity score of 77%, meeting the criteria for validity. In terms of the graphical aspect, the average was 80%, also satisfying the validity criteria. The presentation aspect garnered an

average score of 70%, meeting the valid criteria, while the linguistic aspect achieved an average score of 75%, also meeting the validity criteria. Thus, the Teaching Module based on PJBL-ABMH is deemed suitable for use in the learning context.

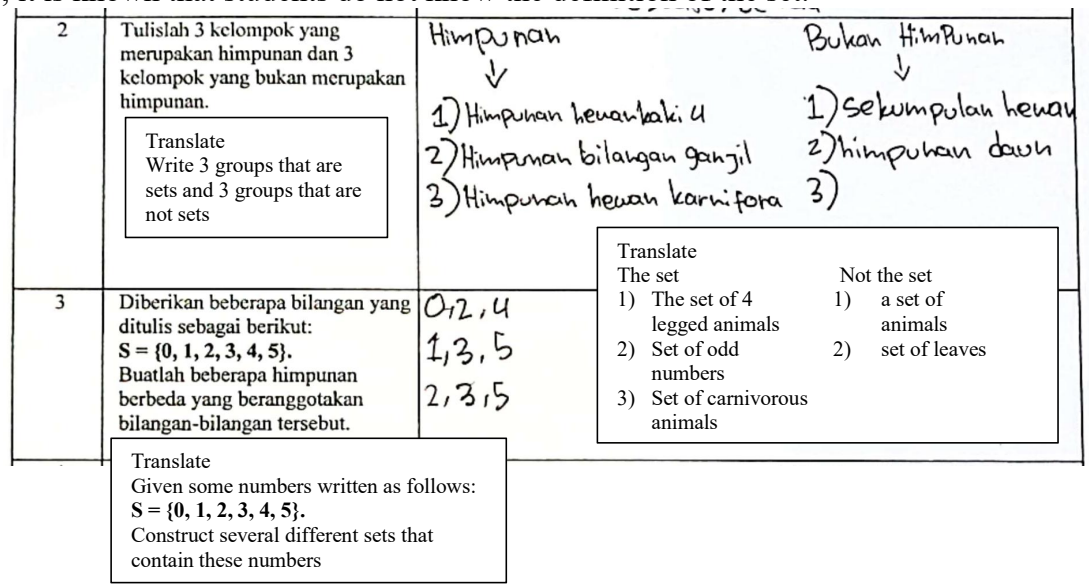
B. Effectiveness

Following the successful validation process, the subsequent phase involves the implementation of STEM learning tools in the designed instructional setting. Prior to commencing the learning activities with PjBL-ABMH-based tools, students undergo a pre-test to assess their grasp of the subject matter. Six learners, encompassing individuals with high, medium, and low proficiency in mathematics, are chosen for this preliminary assessment. Within the learning design, these six learners are divided into two groups, each comprising one student from the high, medium, and low proficiency categories. The results of the pre-test indicate that students exhibit low levels of creative thinking skills, averaging at 43.3. Among the five pre-test questions, three learners with a high understanding of mathematics demonstrate a flexible level of creative thinking, showcasing diverse answers from various perspectives. Conversely, the remaining three learners exhibit a fluency level of creati g more conventional and less vari



Picture 5. Pre-Test of RB learners

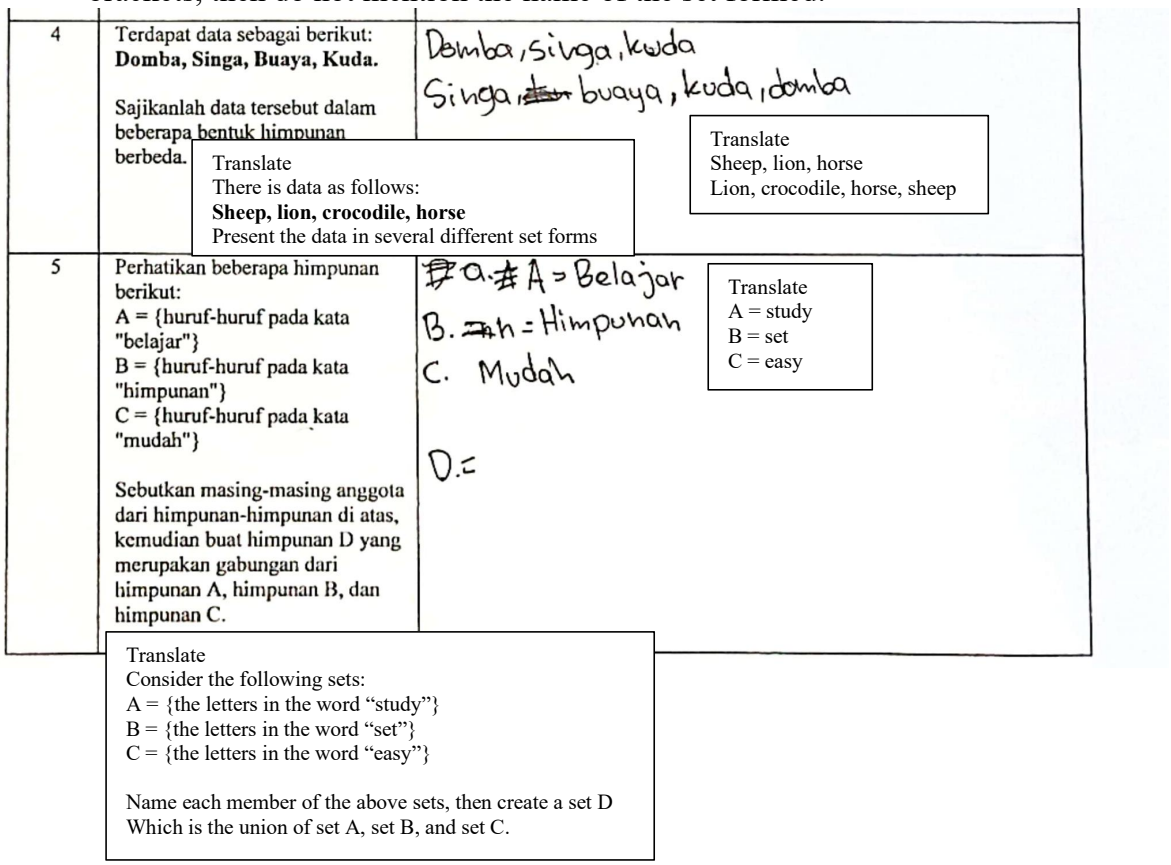
In working on the pre-test questions of RB students according to the picture above, it is known that students do not know the definition of the set.



Picture 6. Pre-test of RB learners

In questions, no. 2 and 3, RB learners are at the fluency stage because they can answer questions as in general, but in question no. 2, RB learners cannot mention groups that are not set. Then, at number 3 RB, learners can form a set group, but the

use of set notation is not by the concept, where the writing of the set should use brackets, then do not mention the name of the set formed.



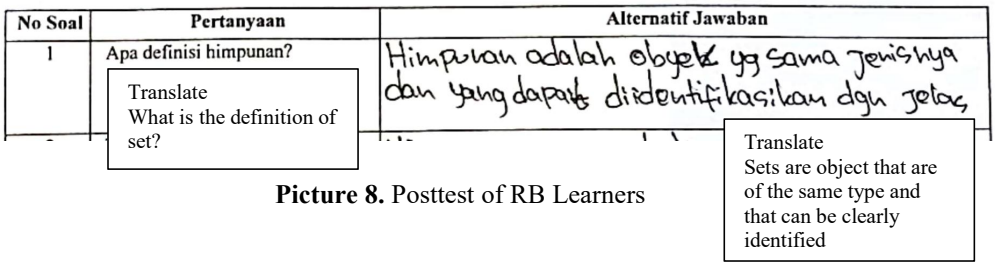
Picture 7. Pre-test of RB learners

In question number 4, a situation similar to question number 3 arises for RB students. Specifically, these students can only form groups, but their use of set notation diverges from the prescribed concept. The set notation, which should employ brackets, is omitted, and the name of the set formed is not specified, rendering it ineligible to be termed a proper set. Moving on to question number 5, RB learners encounter challenges as they merely restate the set presented in the problem. Expressing a lack of comprehension for the problem's meaning, one student admits to struggling with the task, highlighting an overall deficiency in the learners' problem-solving fluency. This difficulty extends to other learners as well.

The outcomes of the pre-test underscore the relatively low creative thinking abilities of students, with most demonstrating proficiency at the fluency level. Some questions posed during the pre-test proved insurmountable for certain students. Subsequently, researchers introduced STEM learning tools in a limited trial group, implementing the tools within a two-week period encompassing three meetings focused on the Project Worksheet.

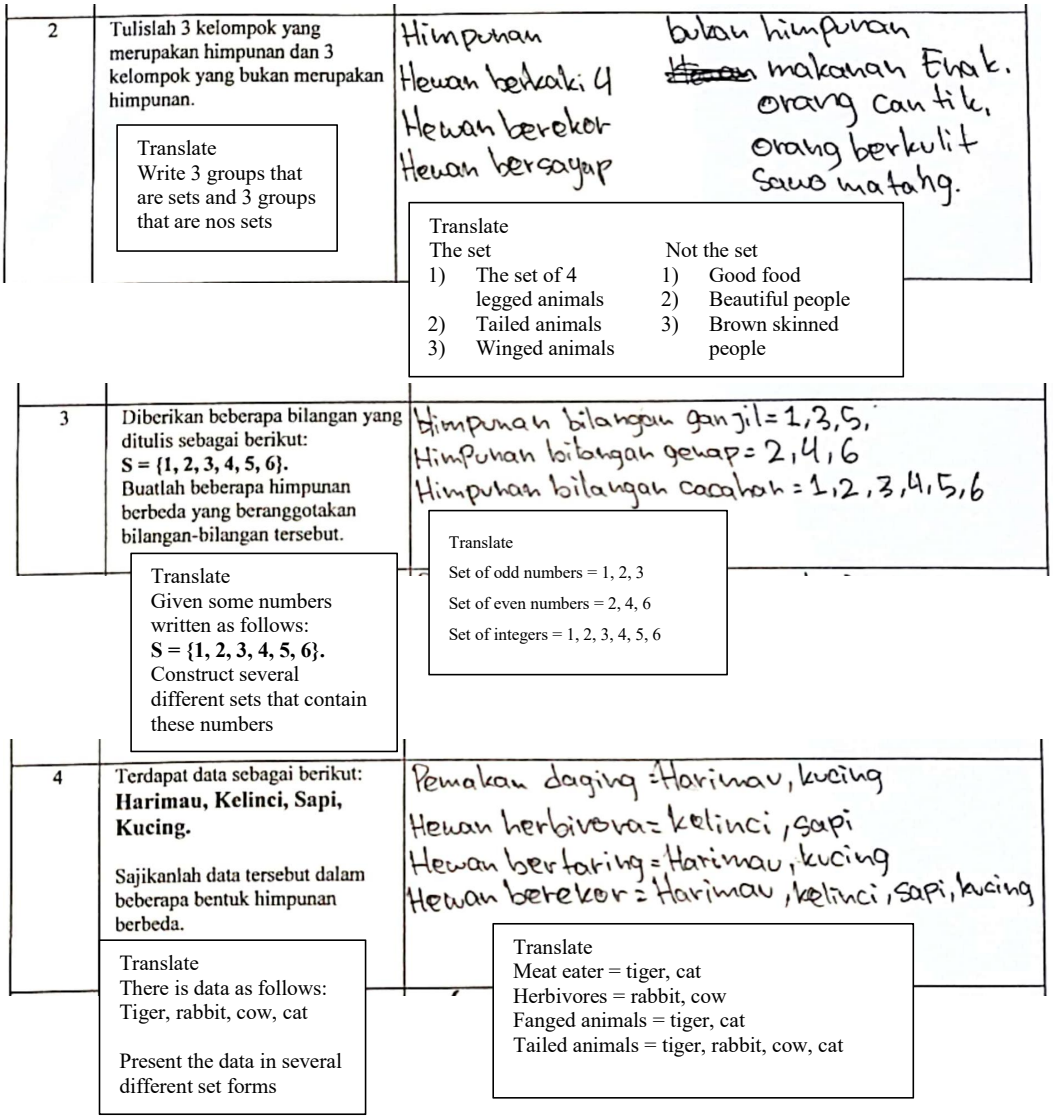
Following the learning intervention, post-test questions were administered to assess students' creative thinking abilities after participating in PJBL-ABMH project-based learning. The post-test results revealed an average score of 85, indicating a notable increase of 41.6 points compared to the pre-test. The levels of creative thinking displayed progress, with students showcasing flexibility by considering various perspectives, demonstrating originality by providing unique answers, and reaching the highest creative thinking level – elaboration – by expounding on diverse alternative answers.

The posttest responses of RB learners exhibited a significant improvement after engaging in PJBL-ABMH-based learning activities. Whereas their previous responses were confined to the fluency level, the participation in PJBL-ABMH learning empowered RB learners to elaborate on their thought processes concerning the set material.



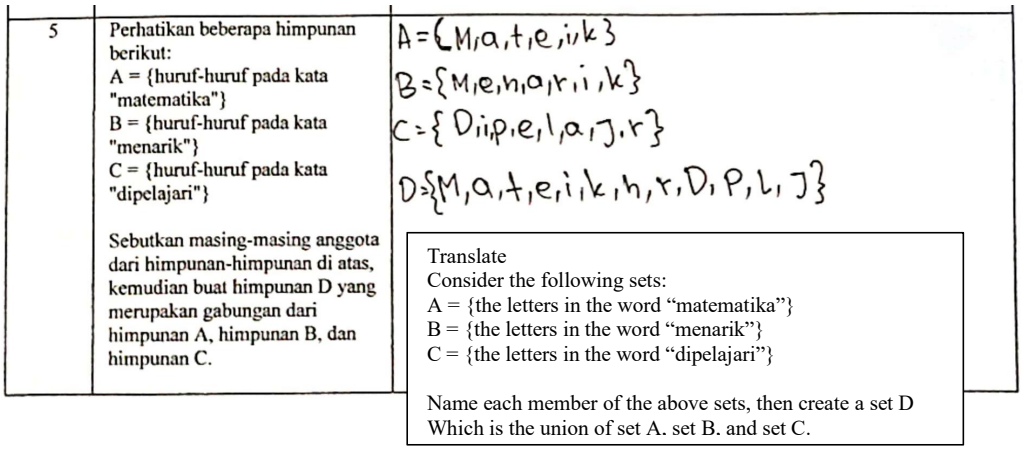
Picture 8. Posttest of RB Learners

In question number 1, RB learners can correctly write the set definition.



Picture 9. Posttest of RB Learners

In problem number 2, RB learners can mention the set group and not the set correctly. Then, in questions number 3 and 4, RB learners can write the set correctly and more variedly and completely but have not been able to use set notation correctly, namely set notation that uses brackets.



Picture 10. Posttest of RB Learners

From this work, RB learners combine other information to make a set and write it down in detail. He presents more varied answers with clarity and completeness.

Data analysis using non-parametric statistical analysis with the Wilcoxon Match Pair Test Formula. The following are the stages in the data analysis process:

a. Compile a change table containing the difference value of each sample using the formula post test value (O2) - pre test value (O1). After that, calculate the level value of each sample to find positive (+) and negative (-) values and find the T value (the smallest number of levels/ranks).

Table 6. Wilcoxon Test Helper

No	Name	Pre-test	Post-test	Difference	Ranking	Sign +	Sign -
1	RB	40	90	50	5	5	0
2	APA	25	80	55	6	6	0
3	BW	35	75	40	3,5	3,5	0
4	GB	60	90	30	1	1	0
5	ML	50	90	40	3,5	3,5	0
6	AZA	50	85	35	2	2	0
Total					21	W=21	T=0

b. Calculating the average value (μ_r)

Mean :

$$(\mu_r) = \frac{n(n+1)}{4}$$
$$= \frac{6(6+1)}{4}$$
$$= \frac{6(7)}{4}$$
$$= \frac{42}{4}$$
$$= 10{,}5$$

c. Calculating the standard deviation (σ_r)

standard deviation:

$$\sigma_r = \sqrt{\frac{n(n+1)(2n+1)}{24}}$$

$$\sigma_r = \sqrt{\frac{6(6+1)(2\times6+1)}{24}}$$
$$\sigma_r = \sqrt{\frac{6\times7\times13}{24}}$$
$$\sigma_r = \sqrt{\frac{546}{24}}$$
$$\sigma_r = \sqrt{22,75} = 4,769692 = 4,77$$

d. Furthermore, the mean and standard deviation were entered into the Wilcoxon Match Pair-Test formula.
Wilcoxon test formula :

$$Z = \frac{T-\mu_r}{\sigma_r}$$
$$= \frac{0-10,5}{4,77}$$
$$= \frac{-10,5}{4,77}$$
$$= -\ 2,20125786 = 2,20$$

Based on the calculation with the calculation formula $z_{table} = 1,96 < z_{count} = 2,20$ which means that H_0 rejected and H_a is accepted.

These results indicate that the PJBL-ABMH effectively improves students' creative thinking skills on set material. Because it shows an increase between the use of PJBL-ABMH on student learning outcomes.

C. Practicality

a) Students' Responses to Learning Using Teaching Materials Based on PJBL-ABMH (Bioplastic Preservation of Set Material)

Table 7. Practicality Test Results of Teaching Materials

Question	Percentage Analysis	Category
Learning with bioplastic preserves makes me better understand the set material	100%	Very Practical
Learning with bioplastic preserves makes it easier for me to find new ideas related to set material	90%	Very Practical
Learning with bioplastic preserves makes me better understand the set material	96%	Very Practical
Learning with bioplastic preserves makes me more skillful in understanding the concept of sets	83%	Very Practical
Learning with bioplastic preserves makes plant classification material more accessible to remember	90%	Very Practical
Learning with bioplastic preserves makes the set material more accessible to remember	90%	Very Practical

Learning with bioplastic preserves is interesting to learn	96%	Very Practical
Learning with bioplastic preserves did not give me new insights into the set of	83%	Very Practical
Learning with bioplastic preserves makes it difficult for me to understand the set material	86%	Very Practical
Learning with bioplastic preserves makes me more confused about the concept of sets	73%	Practical

Based on the table above, it is found that in students' responses to the learning design and LKP, the majority of statement items received efficient criteria, which means that PJBL-ABMH-based learning is practical for improving creative thinking skills.

Discussion

The study's findings indicate that the use of PJBL-ABMH-based teaching materials can enhance students' creative thinking skills related to set material, meeting criteria for validity, effectiveness, and practicality. Validation criteria were satisfied through the validation of teaching modules, including project worksheets, by external validators, ensuring the attainment of valid standards. The implementation of these learning tools proved effective in enhancing student learning outcomes with respect to set material. Participants who initially demonstrated limited creative thinking in terms of fluency or flexibility were able to progress to higher levels of originality and elaboration following their engagement in this learning approach. Furthermore, the practicality of the learning tools was confirmed by assessing data derived from students' responses to the PJBL-ABMH-based teaching materials, specifically those related to the Bioplastic Preservation of Set Material.

Many studies with similar themes also use STEM-based PJBL. An investigation titled "Development of Pjbl-Based Learning Devices Integrated with Stem-Jas to Improve Students' Creative Thinking Skills on Set Material" also met validity, effectiveness, and practicality criteria (Plomp & Nieveen, 2013). Nonetheless, what sets this research apart is its focus on teaching materials involving the creation of herbarium albums to enhance creative thinking skills. Whereas in this study teaching materials will be developed in the form of PJBL-ABMH-based teaching modules, namely making bioplastic preserves from plants around the house to help students understand set material.

In a study conducted by Nita and Irwandi, the PjBL model demonstrated an effect on the creative thinking skills of class X students at SMA Negeri 1 North Lebong (Nita & Irwandi, 2021). This particular project-based learning model enhanced creative thinking skills by engaging students in systematic projects focused on making bioplastic preserves, facilitating a better understanding of Animalia-Arthropoda material. Meanwhile, this research is aimed at junior high school students and raises set material.

Another study, concludes that students exposed to PjBL showed significant increase in creative thinking skills compared to students in a conventional learning environment (Handayani, et al, 2020). These study targeted elementary school students, while this study is aimed at junior high school students and differs in the use of set materials and bioplastic preserves as teaching materials, departing from the previous emphasis on food and health subjects (Rohana et al, 2017).

Designing effective learning tools involves grappling with challenges related to determining and developing the learning design. The PjBL learning model underscores contextual learning with intricate activity designs, fostering iterative learning, collaboration, and the production of a product (Yudha et al., 2023). Research should delve into the intricacies of learning design to offer contextualized experiences that actively engage learners.

Additionally, STEM learning designs should encompass all four disciplines, even if focused on specific subjects, to present a project learning context that captures learners' interest and motivation (Dwi et al., 2019).

Integrating STEM aspects into project learning demands consideration of the Engineering Design Project (EDP) framework as a STEM learning strategy. According to Şahiner & Ünlü (2022), a clear EDP serves as a bridge for learners in problem-solving, identifying solutions that adhere to specified criteria or constraints (Beneroso & Robinson, 2022). The EDP delineates steps in the learning process and generates alternative solutions, aiding learners in problem-solving through analysis, solution determination, and modeling. The mastery of EDP concepts in developing STEM learning is crucial for guiding learners in adapting problem-solving strategies to various questions or problems presented (Khamhaengpol et al., 2021). Consequently, PJBL-ABMH project-based learning emerges as a valuable approach for enhancing creative thinking skills, aligning with and supporting existing theories and previous studies.

4. Conclusion

To sum up, it can be concluded that the PJBL-ABMH-based learning materials obtained have been validated with valid criteria for four aspects of assessment, namely in terms of content, graphics, presentation, and language. In terms of content, it obtained a score of 77%, 80% grammar, 70% presentation, and 75% language. The PJBL-ABMH based learning materials in terms of the results of the students' response questionnaire obtained very practical criteria for implementation. PJBL-ABMH based learning materials in terms of pre-test and post-test implementation obtained a value of $z_{table} = 1{,}96 < z_{count} = 2{,}20$ which means that H_0 is rejected and H_a is accepted which indicates that this teaching material is effectively implemented to improve creative thinking skills. which indicates that this learning materials is effectively implemented to improve creative thinking skills. The results of this study can provide information that STEM-based learning can improve critical thinking skills. For future researchers, they can conduct research using more subjects or conducted with the class test / field test method, conduct research with the integration of other fields of science such as physics, chemistry and others.

5. Acknowledgments

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