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Development of STEM-Based PjBL Model Science Learning Tools to Train Middle School Students' Creativity Through Flood Detection Alarm Project Taks

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ABSTRACT

The purpose of the research is to develop a STEM-based PjBL model of learning tools to train students' creativity through the Flood Detection Alarm project task. The research development design is a 4D model (Define, Design, Develop and Disseminate). Methods of collecting research data using validation, questionnaires, observation, assessment, and documentation.The validity of the learning device has an average score above the value of 3 (valid). The practicality of learning devices is in the very good category, obstacles that occur during learning can be resolved with several solutions so that learning can run smoothly as expected. The effectiveness of the learning tools is effective in terms of the creativity of the students, the average score is 87.6% (very creative) and the students' responses are the average score is 94% (positive). The conclusion that can be underlined from the results of this study is the development of science learning tools with the PjBL model with a STEM approach that is suitable for training students' creativity in making Flood Detection Alarm products on Dynamic Electricity material.

INTRODUCTION

The Ministry of Education and Culture of the Republic of Indonesia issued circular letter number 15 of 2020 concerning Implementation Guidelines during the emergency spread of Covid-19. The circular stated the objectives of implementing Learning From Home, including ensuring that students receive educational services during the pandemic with meaningful learning activities and adding experience and life skills education for students, without having to complete all curriculum achievements. Along with this, the Minister of Education, Culture, Research and Technology Nadiem Makarim (2022) said that the Prototype Curriculum is based on the Project Based Learning model. Learning the Project Based Learning learning model is more fun, and focuses on essential and relevant competencies in everyday life, so that educators are more independent in designing the learning process.

Project Based Learning (PjBL) is a learning model that involves students in project work to solve real problems through a series of processes from designing, working on products, to compiling reports with a predetermined time allocation (Ministry of Education and Culture of the Republic of Indonesia, 2017). In the research conducted by Tambunan (2016) about the implementation of PjBL can affect the creative attitude of students. Sari (2017) also conducted research on PjBL having an influence on students' creative thinking abilities and activities. Baidowi (2015) in his research found that students are motivated to compete to produce the best products.This is a breath of fresh air for educators to develop learning tools with Project Based Learning models to train students' creativity through meaningful learning activities, so that students have life

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skills and skills in solving real problems in everyday life. The implementation of learning activities with the PjBL model is adjusted to the steps in the Figure 1.

Figure 1. PjBL model steps chart.
Source: SEAMEO Regional Center for QITEP in Science. (2018).

Some of the advantages of the Project Based Learning model (Ministry of Education and Culture, 2016): Develop problem solving skills; train creativity; train teamwork; improve skills in communication; facilitate students in gaining experience in applying concepts to practice in carrying out project assignments; facilitating gain experience; creating a fun and meaningful learning atmosphere. Meanwhile, the weaknesses of the PjBL model include: Constraints in understanding and implementation if they are unable to manage information; There are students who are not active; Understanding of the material is not complete. Educators can reduce the weaknesses of PjBL model learning by providing understanding guidance, facilitating available equipment, sorting project tasks so that students can easily implement them to save time and money expenditure. Educators provide support to students so that learning is fun and does not feel pressured by the project assignments given (Ministry of Education and Culture, 2016).

The description above explains that learning with the PjBL model can train students to be involved in designing, working, creating products, and reporting the results of activities in solving real problems according to the creativity of students. PjBL can improve the ability of students to understand and compile the information they have obtained and be responsible for project activities. In addition, PjBL enhances group collaboration, continuity between theory and practice. The implementation of learning activities is adjusted to the PjBL learning steps. PjBL has advantages and disadvantages but weaknesses can be reduced by several actions. Some researchers combine PjBL with STEM. According to Mawarni (2020) that learning with the STEM-based PjBL model is very good for training students' creative thinking skills. Juhariyah (2017) also conducted research on increasing students' creative thinking skills when participating in STEM-based PjBL learning models. Fajrina (2018) also conducted research on the creative thinking abilities of students who differed between students who were treated with PjBL-STEM learning models with students participating in conventional learning.

The government's policy in implementing independent learning education places more emphasis on the concept of STEAM (Science, Technology, Engineering, the Arts, and Mathematics). It aims to integrate the national education curriculum with the needs of the industry in the future. Yamin & Syahrir (2020); Rifandi & Rahmi (2019) explained about the purpose of STEM learning, namely to improve students' skills in science, operate technology, problem solving techniques and math skills to adapt in the 21st

century. Indrawati (2018) argues that students who are forged through learning the STEM approach (Science, Technology, Engineering, and Mathematics) can compete in the 21st century. The STEM approach integrates the concepts of science, technology, engineering and mathematics that are applied in the field of learning to solve problems and produce products that are beneficial to others. Asmuniv (2015) explained that through STEM, scientific literacy is to examine observations and measurements of natural phenomena. Technology is a human effort to transform nature in meeting the needs to be comfortable, safe, and fast. Engineering is the ability to apply scientific concepts and principles to design tools, aircraft, machines, and systems that are useful to humans. Mathematics connects numbers into patterns to solve problems, and connects science, technology, and engineering. The benefits of the STEM approach include: A change in the educational process, an increase in scientific understanding, an increase in human resources, the growth of engineering and technology, and the key to progress and renewal.

The description above explains that learning with the PjBL model can train students to be involved in designing, working, creating products, and reporting the results of activities in solving real problems according to the creativity of students. PjBL can improve the ability of students to understand and compile the information they have obtained and be responsible for project activities. In addition, PjBL enhances group collaboration, continuity between theory and practice. The implementation of learning activities is adjusted to the PjBL learning steps. PjBL has advantages and disadvantages but weaknesses can be reduced by several actions. The description above explains that STEM is a learning approach to forge students to integrate the concepts of science, technology, engineering, and mathematics in order to produce products that are beneficial to others. Through the STEM approach, it is hoped that students can adapt in the 21st century. The STEM approach if developed in learning has several benefits for change and progress for the better. The National Disaster Management Agency in 2018 presented data that there were 500 to 2000 flood phenomena in the past year. Yohana (2017) argue that flooding is an event due to the accumulation of water on the ground surface and cannot be absorbed by the soil. Eldi (2020) stated that the flood problem was caused by several factors, including: urban dynamics and development; land management and land use change that have an impact on the environment. Floods are a real problem that students immediately feel the negative impact.

Flood Detection Alarm is a tool that serves to give a marker that a flood will occur somewhere. Flood detection alarms generally consist of electrical components arranged in such a way that current can flow in the circuit and produce a signal such as sound and light. Ikhsan & Hendrasari (2020) conducted a study by testing the Arduino Uno Alarm as a flood sign that can be accessed through residents' smartphones. Herawati (2020) conducted research by making a Prototype Alarm with a Funduino water level sensor based on the Arduino Uno that could be monitored via an LCD which is useful for reducing losses due to flooding. Ananda (2019) explains that the level of complexity of flood detectors varies, ranging from simple to complex according to the needs and creativity of the maker.

Science learning consists of activities such as observing, determining problems, making hypotheses, conducting tests, collecting data, analyzing data, and concluding (Widodo, 2016). Learning science uses four approaches, namely Attitude, Process, Product, and Application. Through science learning, educators can invite students to

make an alarm product to detect floods early according to the creativity of students. Educators can use the flood phenomenon and the negative impacts it causes as a topic of problems in science learning, so that students can take precautions and take action to reduce all possibilities for losses caused by floods. Afgani (2020) argues that creative education requires students to develop the work they make as attractive as possible. The characteristics of the product's creativity have never been created, there are combinations or product innovations before and the product is useful, better, more effective and more efficient. Yuliani (2020) conducted a study on the effect of product creativity by reviewing that successful entrepreneurs must think creatively to solve every problem. Marlinah (2017) argues that one of the supports for community welfare is to develop creative abilities and the ability of people's creativity to produce a product.

Budiarti (2015) explains that creativity is a manifestation of a new innovative idea, or a person's unique productive endeavor. Wulandari (2018) explains that students' creativity is influenced by environmental factors other than talent factors. According to Adinda (2020) argues that educators have a responsibility to develop creativity from an early age by providing stimulation support and facilities needed by students. This research was developed so that students are trained in making a creative product. Through science learning, it is hoped that the creativity of students can be trained as early as possible to be more independent in dealing with all the real problems they face. Students can be trained in their creativity by making an alarm product to detect floods early. Assessment is a process of collecting data on student learning outcomes as material for making educational decisions. Described practice assessment, project appraisal, and performance appraisal (product/work) as performance appraisals. Performance appraisal includes observing the performance of skills when students carry out activities, making products or works, results/products of performance tasks. Product assessment is carried out by assessing the quality, quantity and beauty of the work or product. The results of the work in the form of products, works, including project reports. Project appraisal usually considers the time in completing project tasks. Project assessment describes the skills of students in mastering and practicing the knowledge they already have. The assessment of the creativity of the work or product produced can be assessed from the attractiveness of the product made by students. Creativity assessment can also be assessed based on product novelty, product combination and innovation, as well as product benefits, quality, effectiveness and efficiency. Based on the above background, researchers are interested in conducting research by developing learning tools through the provision of projects in the form of Flood Detection Alarm products to train students' creativity. The formulation of the problem raised is "How can the use of learning devices with the Project Based Learning learning model with a STEM approach in science lessons train the creativity of junior high school students through the Flood Detection Alarm task?" There are several things to solve the problem formulation by conducting the validity of the learning tools, the practicality of the learning tools, and the effectiveness of the learning tools developed in this study.

RESEARCH METHOD

This study uses development research with the aim of finding, expanding, and validating learning device products. Development research uses the 4D method (Design, Define, Develop, Dessiminate) to train students' creativity through assignments to make Flood Detection Alarm products. The research subjects were 60 students of class IX Public

Middle School 2 Bangkalan for the 2020/2021 academic year. The stages of the 4D development model are described in the Figure 2.

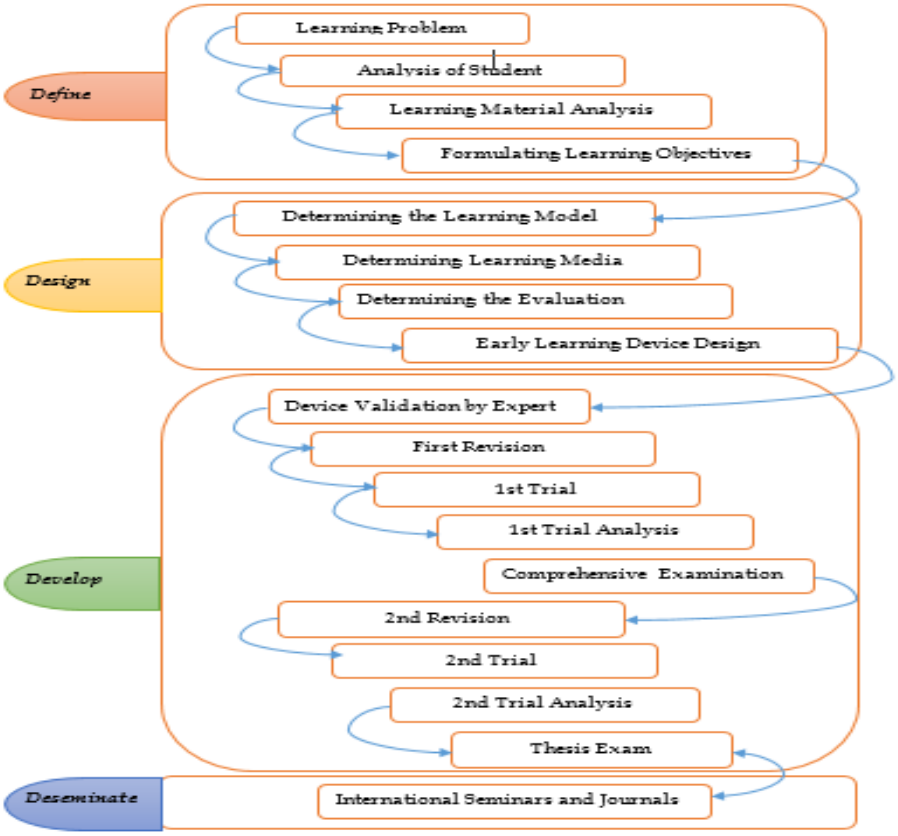

Figure 2: Stages of a modified 4D model from Thiagarajan (1974)

Four stages of the 4D development model were carried out in this study:

1. **Defining Phase**, namely carrying out problem analysis in learning, in the form of analyzing the characteristics of students, analyzing learning materials, and formulating learning.
   a. Analysis of the characteristics of class IX students of Public Middle School 2 Bangkalan is more interested in learning by doing activities in the form of performances or making products individually or in groups rather than just listening to explanations or watching learning videos.
   b. The analysis of the learning materials applied in this research includes the concepts of the Hydrosphere, Archimedes' Law, and Dynamic Electricity which are learned by students in the science subjects of SMP which are packaged in one learning theme in the project assignment in the form of a Flood Detection Alarm product. Core Competencies and Basic Competencies for Hydrosphere, Archimedes Law, and Dynamic Electricity materials based on the 2013 Curriculum (Minister of Education and Culture Regulation Number 24 Year 2016). The researcher made a concept map of the material analysis of Hydrosphere Science, Archimedes' Law, and Dynamic Electricity which was integrated with STEM as in Figure 3.

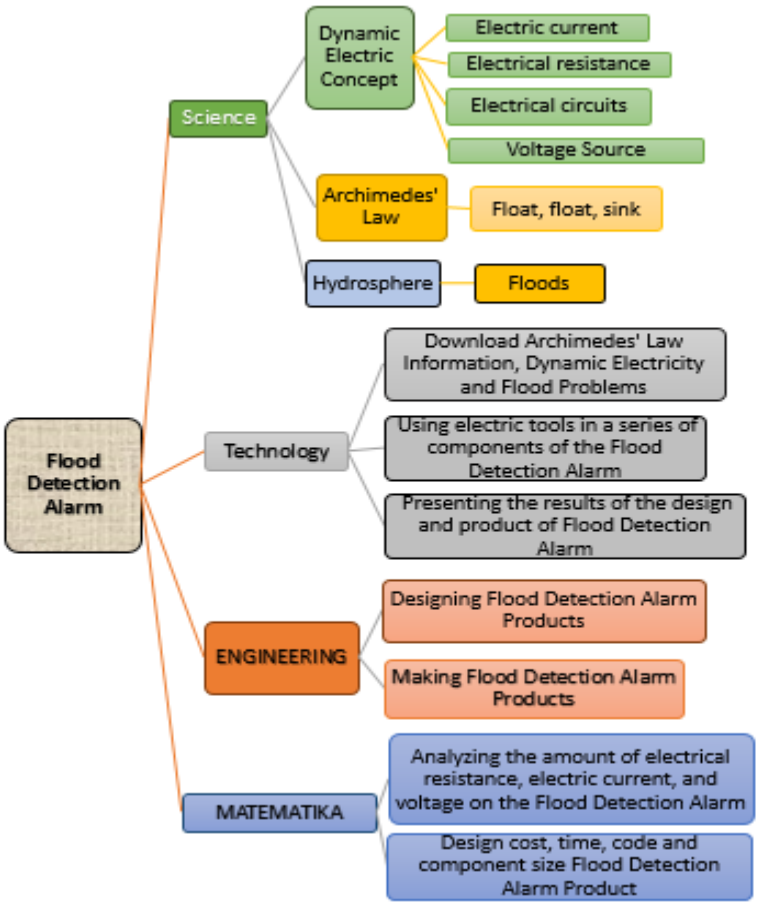

Figure 3. Material analysis concept map chart Hydrosphere Science, Archimedes' Law, and STEM-integrated Dynamic Electricity.

2. **Design Phase:** The stage of designing learning tools to be tested in the experimental class. The design stages include: determining learning strategies, selecting learning media, and compiling evaluation instruments.
3. **Development Phase:** Testing learning tools in the form of: a). Validation from experts/experts, b). revision based on the input of the validation results, c) the device will be implemented in the classroom at the trial stage, d) the test results will be analyzed whether it is good and feasible to use.
4. **Disseminate Phase:** Dissemination of research results is carried out within the scope of the State University of Surabaya and the school where the research is located, namely, Public Middle School 2 Bangkalan. In addition, researchers also disseminate through participation in the publication of international seminars and journals.

Research variable

Research variables in terms of:

1. Validity of learning tools: carried out by expert reviewers or validators using instruments and learning device validation sheets which include Syllabus, Lesson plan, Teaching Materials, Student Worksheets, Question Instruments, and Observation Sheets. Learning devices are said to be suitable for use if the minimum level of validity reaches a score of 3. Quantitatively the scores are interpreted according to the criteria in Table 1.

Table 1. Quantitative description of learning device validation score.

Value Range	Value Criteria	Explanation
4	Very valid	worth applying without repair
3	Valid	worth implementing with minor improvements
2	Not enough valid	need major repair
1	Not valid	not recommended to apply

(Adapted from Allamin Sophia, 2018)

Mathematically the assessment agreement of the validators is calculated by:

$$Percentage\ of\ Agreement\ = \left(1 - \left[\frac{A-B}{A+B}\right]\right) x\ 100\%$$

Description :

A : Highest score

B : Lowest score

The assessment of the validator is categorized as agree, if the result of the Percentage of Agreement has a value of > 75% (Borich in Allin Sophia, 2018).

2. The practicality of the science learning tools carried out includes:
   a. The implementation of learning is defined as the level of achievement of the stages in learning activities with the STEM-based PjBL model carried out by researchers. The assessment of the implementation of this learning was observed by two observers using an observation sheet with reference to the RPP steps. The observer's assessment score when observing the learning process has a range of 1 to 4. The interpretation of the results of the assessment of the implementation of learning is in Table 2.

Table 2. Likert scale criteria for Implementation of RPP.

Criteria	Score
Very good	4
Good	3
Not enough good	2
Not good	1

(Adapted from Allamin Sophia, 2018)

The formula used to obtain the percentage is as follows:

$$\%\ Implementation = \frac{the\ average\ score\ of\ the\ observations}{max\ score}\ x\ 100\%$$

The results of the percentage of implementation are categorized qualitatively as in Table 3.

Table 3. Categories of quality of learning implementation.

Percentage	Criteria
0% - 20 %	Very bad
21% - 40 %	Bad
41% - 60 %	Quite good
61% - 80 %	Good
81% - 100 %	Very good

(Allamin Sophia, 2018)

b. The activities of students during learning were observed using an observation sheet by observers. The observer's assessment score when observing the learning process has a range of 1 to 4. The interpretation of the results of the assessment of the implementation of learning is in Table 2. The results of the percentage of implementation are categorized qualitatively following the percentages and criteria as in Table 3.
c. Obstacles in learning are obstacles or obstacles during learning activities using the STEM-based PjBL model in the science field of junior high school through the Flood Detection Alarm project task which was observed by two observers using the observation sheet for implementation constraints in learning.

3. Effectiveness: defined as the process that students must go through in obtaining learning outcomes. The level of effectiveness is based on:
   a. Student creativity profile: Creativity profile is a product creativity profile during STEM-based PjBL activities. Product creativity profile is information on the creativity of students to create products as solutions to problem solving based on the assessment of aspects of novelty, tool use, level of complexity, appearance, and application of dynamic electricity in Flood Detection Alarm products. Product creativity scoring has a score range of 1 to 4 with an explanation of the description on each scale. The rating scale categories are as in the Table 4.

Table 4. Student creativity criteria.

Scoring scale	Category
>81,25 - ≤ 100	Very creative
>62,50 - ≤ 81,25	Creative
>43,75 - ≤ 62,50	Quite creative
>25,00 - ≤ 43,75	Not creative

(Adaptation: Allamin Sophia, 2018)

Students are said to have creative product categories if they meet the acquisition value > 62,50 - ≤ 81,25.

   b. Student responses: Students are asked to provide responses to learning activities using the STEM-based PjBL model in the science field of junior high school that they have experienced during the Flood Detection Alarm project assignment. Response questionnaires were distributed in two experimental and control classes. Learning devices are categorized as effective if the average percentage obtained has a minimum of strong criteria, namely a minimum percentage of > 75% with Good criteria (Borich in Allamin Sophia, 2018).

The data collection methods used are: validation, questionnaire, observation, assessment, and documentation. While the data analysis techniques used include:

1. Analysis of learning device data.
2. Data analysis of the practicality of learning devices consisting of observations of the implementation of learning, analysis of student activity observations, and analysis of learning barriers.
3. Data analysis on the effectiveness of learning tools consists of analyzing the profile of student creativity and student responses.

The research method matrix is presented in the Table 5.

Table 5. Research method matrix.

Research Purposes	Research Variable	Operational Definition of Research	Research Instruments	Data Source	Data Collection Techniques
Explain whether or not the learning device is valid.	Learning Media	Assessment of learning device validation by validators.	Validation sheet	Validators	Validation
Describe the practicality of learning devices.	Practical learning	The use of learning tools includes: a) The implementation of learning is the ongoing stages of activities in accordance with the RPP	Learning implementation sheet.	Observer	Observation
		b) Student activities are all activities carried out by students during the learning process using STEM-based PjBL model learning tools	Student activity sheet.	Learners	Observation
		c) Obstacles in learning are obstacles observed by observers during learning activities	Observation sheet	Researchers and Observers	Observation
Describe the effectiveness of learning tools.	Learning effectiveness.	Learning effectiveness includes: a) The profile of student creativity is a description of the creativity of students in learning the STEM-based PjBL model through the project task of making a Flood Detection Alarm product.	Product rating sheet	Learners	Observation
		b) Participants' responses to the components and learning activities.	Student response questionnaire	Learners	Questionnaire

RESULTS AND DISCUSSION

The results of this study discuss the validation of STEM-based PjBL model learning tools that have been carried out by three validators. The results of data analysis regarding the validity of learning tools, practicality, effectiveness of the learning device trials.

1. Validation of learning tools.

The validation of learning tools includes:

a. Results of Data Analysis of Learning Device Validation

The results of the Data Analysis of Learning Device Validation are shown in the Figure 4.

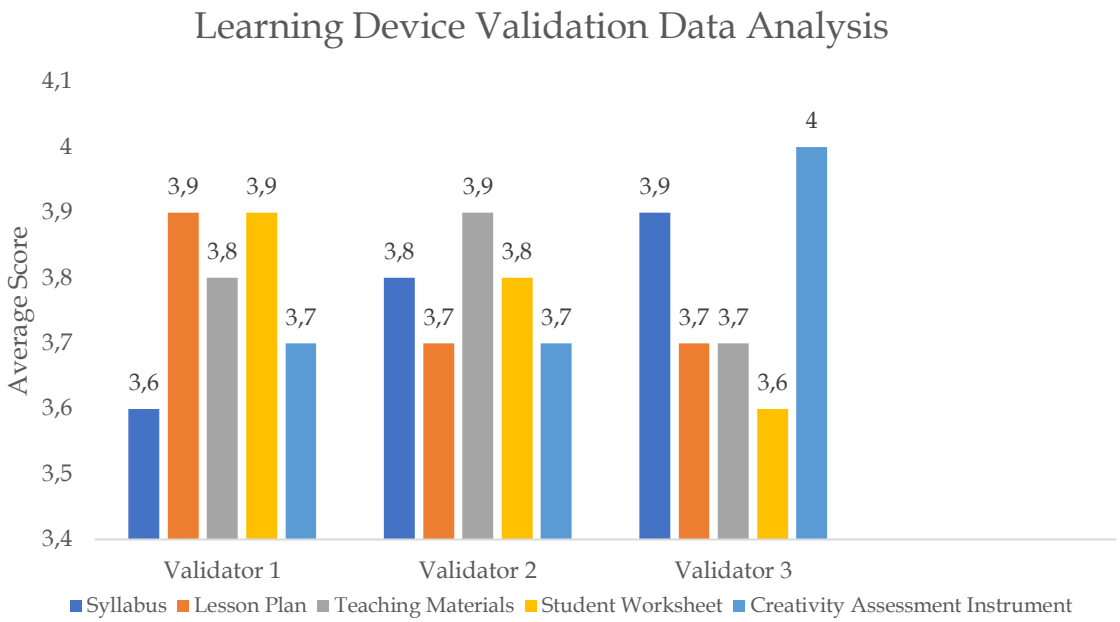

Figure 4. Analysis of learning device validation data.

Figure 4 shows the results of the validation of learning tools with an average score above the value of 3 which has valid assessment criteria to be applied in learning.

b. The average reliability (%) of learning devices is presented in the Figure 5.

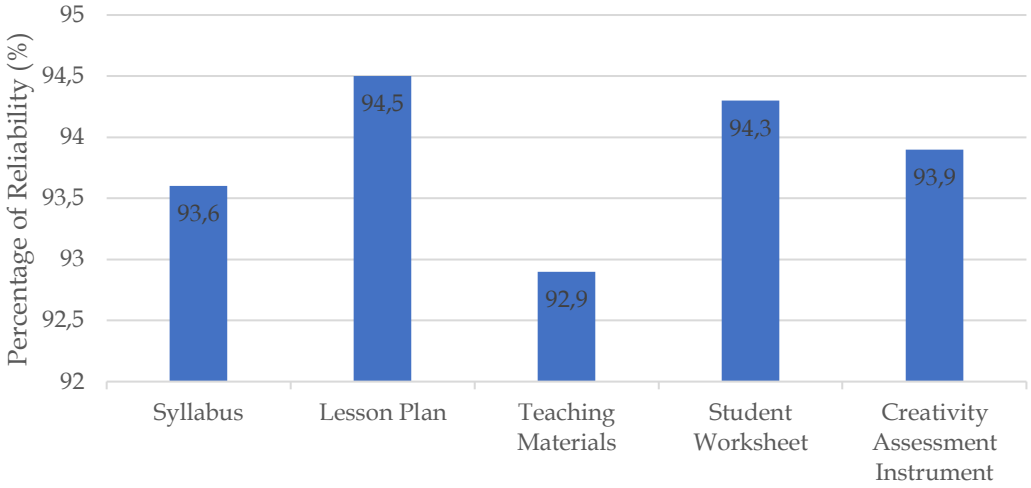

Figure 5. The average validator rating reliability.

A learning tool that is feasible to use is if there is an agreement on the percentage of match between the three validators, it has a reliability percentage of 75% (Borich in Allamin Sophia, 2018). So, the conclusion from the diagram above is that the validity of the STEM-based PjBL model learning tools to train students' creativity that has been developed includes Syllabus, Lesson Plan, Teaching Materials, Student Worksheet, and Creativity Assessment Instruments are included in the valid criteria and suitable for use in learning activities.

2. Practicality of learning tools.

The practicality of STEM-based PjBL model learning tools to train students' creativity through assignments to make Flood Detection Alarm products that have been developed based on the following:

a. Implementation of learning: validation of the assessment of the implementation of learning at meetings 1 to 3 gets a mode score of 4 with very good criteria. The reliability of the assessment results from the two observer teachers is 86% - 100%, with the highest percentage being 100%, meaning that the assessment of implementation by observers has a good match. Based on these results, it shows that the learning activities of the STEM-based Project Based Learning model are carried out well by the teacher, including the very good criteria.

b. Student activities: In the 1st to 3rd meetings, student activities get a score of 4 with very good criteria. The reliability of the assessment results from the two observer teachers was 100%, meaning that the assessment of implementation by the observers had a good fit. Based on these results, it shows that the activities of students in learning with the STEM-based Project Based Learning model to increase the creativity of students through the assignment of the Flood Detection Alarm project are included in very good criteria.

Figure 6 are student activities when presenting designs and products for Flood Detection Alarms.

Figure 6. Photos of student activities when presenting designs and products for Flood Detection Alarms.

c. Barriers and obstacles encountered during the learning process can be resolved with several solutions so that learning can run smoothly as expected.

The practicality of STEM-based PjBL model learning tools to train students' creativity through the assignment of making Flood Detection Alarms that have been developed include the implementation of learning and student activities in very good criteria, as well as obstacles encountered during the learning process can be solved with several solutions so that learning can run smoothly as expected.

3. The effectiveness of learning tools.

The effectiveness of the learning device is seen from the creativity of the Flood Detection Alarm product and the students' responses to the learning that has been carried out. The results of the data analysis of the effectiveness of learning devices:

a. The creativity of students is based on the assessment of the Flood Detection Alarm product made by students based on aspects: Novelty, Complexity, Appearance, Use of the tool and Application of Dynamic Electricity material on the tool. The results of the data analysis of the product creativity assessment are presented in the Table 6.

Table 6. Results of student product creativity assessment data analysis

No	Aspect Creative Skills	Score (%)		Average Score (%)	Criteria	R (%)	Category
		P 1	P 2				
1	Novelty	85	90	87,5	Very creative	97,1	Reliable
2	Complexity	88	90	89	Very creative	98,9	Reliable
3.	Appearance	87	85	86	Very creative	98,8	Reliable
4.	Use of the ool	88	90	89	Very creative	98,9	Reliable
5.	Application of Dynamic Electricity material on the tool	88	85	86,5	Very creative	98,3	Reliable
	Average			87,6		98,4	

Explanation:
P1 : Rating by 1st observer
P2 : Rating by 2nd observer
R (%) : Reliability (%)

The results of the assessment of the two observers on the creativity of students' products have an average score of 87.6% which has very creative assessment criteria (based on Table 4). The agreement on the assessment between two observers on the creativity of students' products is 97.1% - 98.9%, which means that they have a good fit. The average agreement on the assessment is 98.4%, which means that the assessment of the assessment aspect of creativity performance (project) and student products has a match if the percentage is 75% (Borich in Allamin Sophia, 2018).

Figure 7 is the documentation of some student Flood Detection Alarm products.



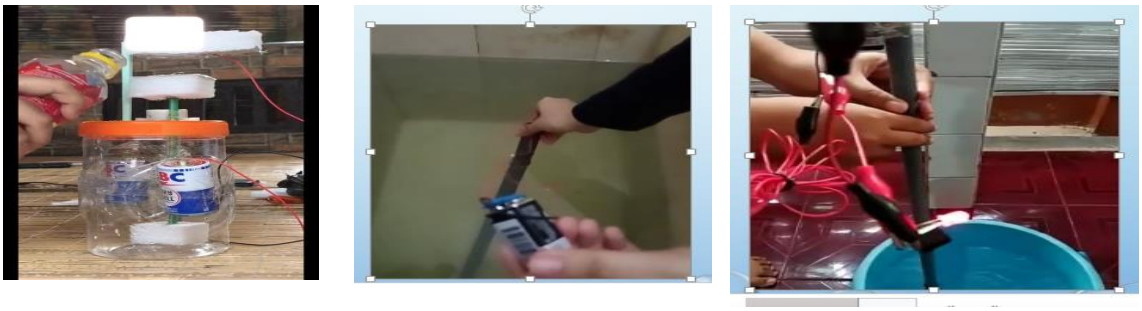

Figure 7. Flood detection alarm products.

b. Student responses: The results of observations and assessments of observers on student responses get an average score of 94% with positive response criteria. Based on these results, it shows that the students' responses to learning include strong criteria. The analysis of the results of the effectiveness of learning devices in terms of student creativity and student responses is included in the effective criteria.

CONCLUSION

Based on the research findings above it can be concluded that, the PjBL model of science learning tools with a STEM approach can train the creativity of junior high school students through the assignment of making Flood Detecting Alarms that have been developed including: (1) The validity of the learning device has an average score above the value of 3 which has the assessment criteria valid and suitable for use in learning; (2) The practicality of learning devices is in the very good category, obstacles that occur during learning can be resolved with several solutions so that learning can run smoothly as expected; (3) The effectiveness of learning tools including the effective criteria in terms of the creativity of students with a score has very creative assessment criteria and student responses has an average score with positive response criteria and is included in the strong criteria. The conclusion that can be underlined from the results of this research is the development of science learning tools with the PjBL model with a STEM approach that is suitable for use and trains students' creativity in making Flood Detection Alarm products on Dynamic Electricity material. Future research can take in another level education.

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