

## **CREATING MANIPULATIVES: IMPROVING STUDENTS' CREATIVITY THROUGH PROJECT-BASED LEARNING**

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### **Abstract**

The purpose of this study is describing the implementation of project-based learning model and analysing the student's creativity improvement in the subject of learning media. We describe the implementation of project-based learning based on our note of the learning syntax during one semester. Then, compared the students' product to measure their creativity improvement in the aspects of originality, novelty, and flexibility. This study used descriptive-qualitative method and involved the students who took the learning media course as its subjects. The results showed that there was an improvement of the students' creativity in the project-based learning implementation. The improvement was measured in the making of the manipulatives. The students' flexibility and novelty were good, while their originality was fair.

**Keywords:** Creativity, Mathematics manipulatives, Project-based learning.

### **Abstrak**

Penelitian ini bertujuan untuk menggambarkan implementasi pembelajaran berbasis proyek dan menganalisis peningkatan kreativitas mahasiswa dalam pembuatan media pembelajaran. Deskripsi tentang pelaksanaan model pembelajaran berbasis proyek didasarkan pada sintaks yang diperoleh melalui catatan lapangan selama satu semester. Kemudian, peningkatan kreativitas mahasiswa berkaitan dengan aspek orisinalitas, kebaruan dan fleksibilitas yang diperoleh dengan membandingkan proyek akhir yang dibuat. Metode penelitian yang digunakan adalah deskriptif kualitatif. Subjek penelitian ini adalah mahasiswa matematika yang mengambil mata kuliah sumber belajar dan media pembelajaran matematika. Hasil penelitian ini menunjukkan peningkatan kreativitas melalui pembelajaran berbasis proyek. Peningkatannya kreativitas ini didasarkan pada proyek pembuatan media pembelajaran matematika manipulatif. Peningkatan kreativitas juga didasarkan pada dipenuhinya aspek fleksibilitas dan kebaruan dalam kriteria baik, sedangkan aspek orisinalitas memenuhi kriteria cukup baik.

**Kata kunci:** Kreativitas, Media pembelajaran matematika manipulatif, Pembelajaran berbasis proyek.

**How to Cite:** Ummah, S. K., In'am, A., & Azmi, R. D. (2019). Creating manipulatives: improving students' creativity through project-based learning. *Journal on Mathematics Education*, 10(1), 93-102.

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Learning media is one of the compulsory subjects for mathematics education students. It becomes compulsory because the students who are going to become professional pre-service teachers are required to be creative in making and using learning media. Based on interviewing students, mathematics learning at schools often uses worksheet and whiteboard to explain the mathematics material.

Project-Based Learning (PjBL) is one of learning models appropriate for learning with certain product as an output, for example, creating learning media. This model is appropriate for students from elementary school level to university level (Jacques, 2017; Burlbaw, 2013). PjBL facilitates students to collaborate in conceptual understanding, to apply prior knowledge, and to gain skills. It can integrate several disciplines to create a project (Capraro & Slough, 2013). Furthermore, the other benefits of PjBL are enabling students to demonstrate higher ability (Crowley, 2015), improving

students' achievement (Ali, Akhter, Shahzad, Sultana, & Ramzan, 2011), challenging students to solve real problems, becoming a good collaborator (Roberts, 2011), motivating students (Liu, 2010), improving content knowledge, and meeting the needs of students with variety of skills and learning styles (Coyne, Hollas, & Potter, 2016).

One of the benefits of PjBL is showing student's higher ability. By using PjBL, we could observe the student's creativity through various projects of school mathematics learning media. Creativity is a process that produces novelty, which is useful, sustainable, or satisfying for people (Sousa, 2012). In mathematics learning, creativity has an important role (Levenson, 2011). One of the benefits of students' creativity in mathematics learning is improving students' knowledge. The students' knowledge is not limited to mathematical knowledge but also the knowledge associated with daily life (Bolden, 2010). This idea is in line with the implementation of PjBL that can improve students' skills, especially the creativity.

We could measure creativity in several aspects, including fluency, flexibility, originality, and novelty (Adams, 2005). Fluency can be measured through many answers. Flexibility can be measured using many variations of ideas to answer the problem. Originality is measured using the question of whether the answer made is different from the other students or whether the answer produced is an unusual answer. Novelty is a measured on how innovative answers made by the students (Guilford, 1959; Torrance, 1974).

The importance of mathematical creativity in the learning media course can be seen in conceptual and constructive activities in making learning media. Students are required to construct the concept independently to apply the making of mathematics learning media by utilising the tools and materials around the student's environment (Tienken, 2010). The media is something connect the source of information to the recipient (Sulisworo & Permpayoon, 2018). Learning media can be defined as a software or a model to deliver educational message or information presented by using a teaching aid (Yazgan-Sag & Emre-Akdoğan, 2016). In mathematics learning, manipulative learning media can develop an understanding of the students towards the abstract concept (Hidayah, Dwijanto, & Istiandaru, 2018). Manipulative media could help students represent abstract concepts in the form of concrete learning media (Yazgan-Sag & Emre-Akdoğan, 2016; Ozel, 2014).

The ability to create and use manipulative learning media in mathematics learning is important for pre-service teacher. Creation of manipulative media that requires a long process and time can be adjusted to the model of PjBL (Cope, 2015). It could happen because each syntax will be able to analyse and to describe the results.

## **METHOD**

The approach used in this research was descriptive qualitative. Qualitative approach was used to describe and to express the implementation of project-based learning based on the instruments we have prepared. Then, we analyse the students' creative ability and the product of manipulative

learning media. The subjects in this study were students of the mathematics education department of University of Muhammadiyah Malang who took the course of learning media in the third semester of 2016/2017 academic year.

### ***Research Steps***

This study follows some steps, namely: (1) initial observation and interview, (2) studying the relevant literature, (3) preparing instruments, (4) implementing project-based learning, (5) addressing basic question, (6) designing the learning media, (7) discussing the schedule, (8) monitoring, (9) examining the result, (10) evaluation, (11) interview, (12) data reduction, and (13) analyzing the data. First, we observed and interviewed the mathematics teachers and students to find out the prominent problem in mathematics learning media. We also reviewed previous studies related to the problem and preparing the instrument to collect data. Once the instruments were ready, we started to implement the project-based learning in the classroom.

Regarding the manipulative project, we started by addressing basic questions about the project, e.g. the main subject, the core competence, the basic competence, the learning indicators, and the idea of learning media. Furthermore, we provided a storyboard format for the students to design the manipulatives and then discussed the timeline of the making of manipulatives. Once the timeline agreed, the students started to make the manipulatives and we monitored the progress of the project. When the students finished their projects, we asked them to present the products in front of the class. After that, we conducted an exhibition and interview to evaluate the manipulatives. Finally, we analyze the data using data reduction and comparing the data with the relevant literature.

### ***Data Collection and Technique and Instruments***

We used observation and interview to collect data. The observation was done to look at the manipulative learning media produced by the students, while the interview tried to look at the creative aspects of flexibility, originality, and novelty of the media. The instruments used in this study include field note format, project assessment, and interview guidelines. Instruments were prepared based on supporting theory obtained from the literature study. We also prepared storyboard contained: (1) basic questions, (2) tools and materials, (3) estimated time of manufacture, (4) mode of use, (5) estimated time of media use in class, and (6) sketch of learning media to help the students designing the media.

In the monitoring steps, we asked the students filling out logbook then guided them during the manufacture of media. While in the evaluation step, we analyzed the weaknesses and advantages of learning media. The presentation of the results of the data presentation was reinforced through interviews in the making of learning media. Through this way, we could know how the students' creativity in making mathematics learning media built. The written conclusion was based on the concept of improving the creativity of mathematics education students through project-based learning in the learning resources and learning media.

## RESULT AND DISCUSSION

The implementation of the project-based learning took place during the odd semester of the 2016/2017 academic year. The participants were students of mathematics education department. They got the material about the concept of learning resources and learning media, especially in mathematics. This study focused on the manipulative learning media. The students got the material of manipulative media in mathematics in each meeting.

### *Basic Questions*

Earlier, the implementation of project-based learning was started by determining the fundamental questions. They were about: (1) main material, (2) core competence, (3) basic competence, (4) learning indicators, and (5) idea of learning media. The topic, core competences, and basic competences are determined based on the 2013 curriculum at junior high school level. The ideas to make learning media were obtained through browsing, reading research journals, and the development of learning media products. The result of this first step was that the students chose the mathematical topic of planar geometry. The students also had an idea to make learning media in the form of wall magazines or stickers, and to create a learning media by changing the shape and colour of learning media that the other researchers have ever developed. All of these results were obtained from the student's presentation in the classroom. We asked questions based on the five fundamental questions. The student's creativity is visible in the flexibility aspect, i.e. students can develop ideas freely and various ideas of making learning media. Aspects of flexibility are increased due to changes and the addition of colour and shape compared to the previous study.

### *Project Schedule*

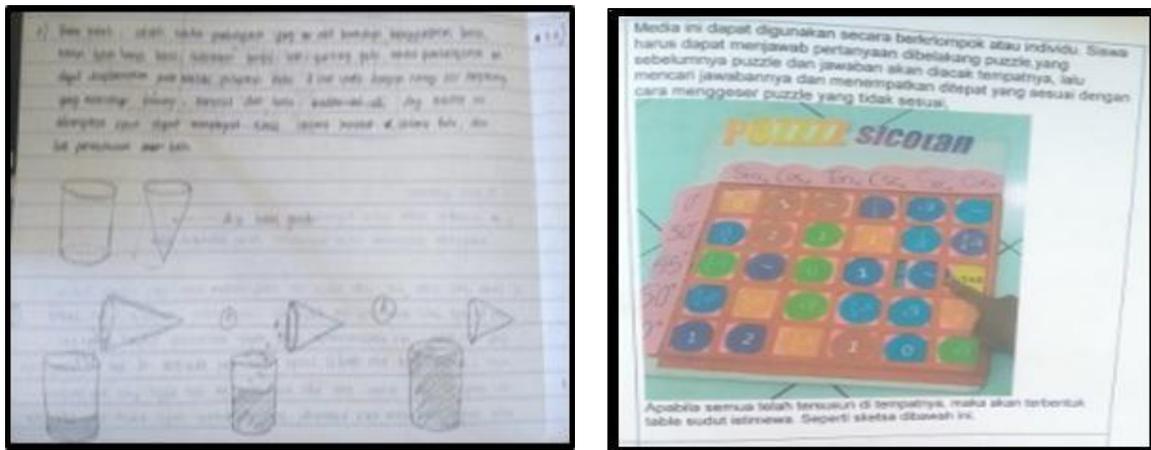
The second step is obtaining the schedule. The schedule is discussed in the class and can be seen in Table 1.

**Table 1.** The schedule of project-based learning

No	Time	Activity	Place
1	Week 1 of October 2016	Obtaining the basic idea to answer the fundamental questions	Common building, Room 3.06
2	Week 2 of October 2016	Obtaining schedule	Common building, Room 3.06
3	Week 3 of October 2016	Designing project planning, completing the storyboard, and submitting the plan	Common building, Room 3.06
4	Week 4 of October 2016	Monitoring: storyboard presentation	Common building, Room 3.06
5	Week 2 of November to Week 4 of December 2016	Testing the project result: Presenting the learning media	Common building, Room 3.06
6	Week 1 of January 2017	Evaluating: Outdoor exhibition of learning media	Park

### ***Planning the Project***

The designed activities of project planning were done by creating and presenting the storyboard. Storyboard made referring to the following format: (1) main material, (2) core competence, (3) basic competence, (4) learning indicators, (5) tools and materials, (6) estimated time of manufacture, (7) how to use, (8) estimation of media usage time in class, and (9) sketch of learning media. Through the activities of storyboard, the students have been able to design the learning media according to the ideas that have been stated previously. A total of 23 students changed their idea different to the first plan. Based on the interview, the students stated that they had additional ideas based on reading literature. This phenomenon can be seen through the design changes, colours, and ways of using media. For example, students named LR had an idea to make learning media in the form of the concept of space geometry, but when designing the storyboard, LR changed the media into trigonometric puzzles. Storyboard drawings and early sketches can be seen in Figure 1.



(a) First sketch

(b) Storyboard

**Figure 1.** Mathematics manipulatives 1

Student creativity looks through aspects of originality and flexibility. The originality aspect is said to increase because of the idea of doing a puzzle that is not owned by other students as well as the selection of different puzzle material with the puzzle that has been developed previously. An increased aspect of flexibility can be seen that the student LR easily replace the material along with customized learning media.

### ***Monitoring***

The fourth step of project-based learning activity is monitoring. Monitoring is not done by filling the logbook but presenting the storyboard that has been made then do the revision on the storyboard and the media created (Cope, 2015). Through the storyboard, presentation activities can be seen that the students make changes to the learning media on the grounds to avoid similarities with the media that is owned by other students. Students also revised learning media based on inputs and

suggestions from lecturers and other students so that it can be concluded that students can decide changes in learning media according to the learning objectives that have been set themselves (Cope, 2015; Ozel, 2014).

The existence of statistical learning media evidenced the aspect of sufficient originality with the topic of presenting data in the form of graphs. Student EN used paper beam material (See Figure 2a) while Student HN used the pipe (See Figure 2b) to create a bar chart. The weakness is seen in bar charts using paper because it is not durable or quickly damaged, but it is more interesting and more interactive than just drawing on a piece of paper (Ozel, 2014).



(a) Bar chart using pipes

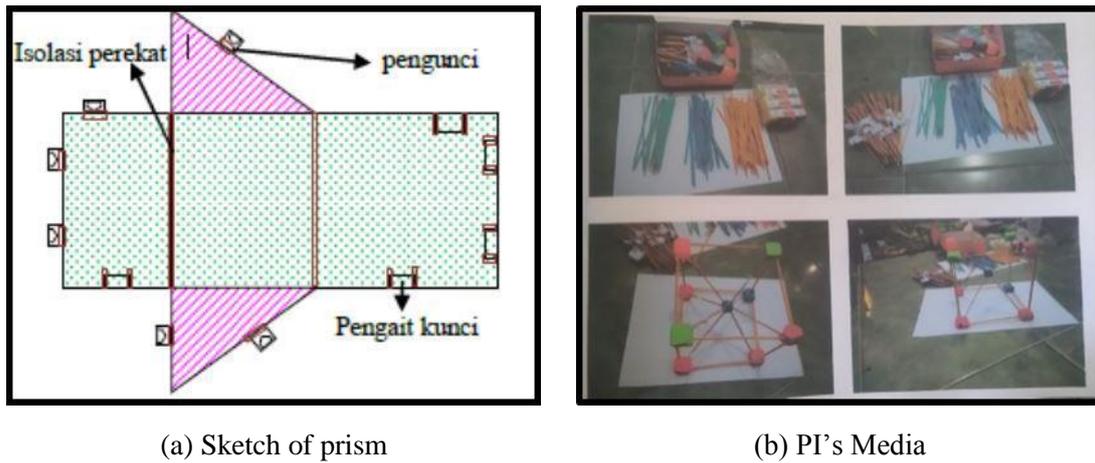


(b) Bar chart using paper beam

**Figure 2.** Mathematics manipulatives 2

### ***Results Examination***

In the fifth steps, each student was asked to present interactive and manipulative learning media. Learning media that have been made has increased significantly. In the aspect of flexibility, students can create a variety of learning media. For example, in the learning media used in the geometry material using paper media (Yulistyarini & Mahmudi, 2015) that formed the nets of solid figures using double-tape. In this study, the resulted geometry products were developed using bamboo rods as ribs and clay as the vertices. Student PI showed the novelty aspect was in a fair category because the student could adapt the cube framework using different tools and materials. The weakness of the media was the absence of the faces of the cube. The aspect of originality was in a good category because the learning media of solid figure was only a question card that was made to resemble wall magazines or crossword puzzles. It means that the wall magazines or crossword puzzles have increased creativity on aspects of excellent originality. The different between the design and the realization of the media can be seen in Figure 3.



(a) Sketch of prism

(b) PI's Media

**Figure 3.** Mathematics manipulatives 3

This phenomenon also can be seen in Figures 4 which show wall magazines and crossword puzzles adapting from previous research by changing the rules of crossword puzzles into issues of space geometry.



(a) Wall magazines

(b) Crossword puzzles

**Figure 4.** Mathematics manipulatives 4

Enhancement of student creativity through the making of manipulative learning media can be seen clearly from the existence of learning media on algebra, matrix, statistic, linear equation of one variable, and two linear equation system. It satisfies the excellent aspects of flexibility, originality, and novelty. It could happen because the learning media has not been available before. The various learning media that has not been available before can be seen in Figure 5.



(a) Stacko algebra to learn linear equation



(b) Cube of matrices to learn the type of matrices

**Figure 5.** Mathematics manipulatives 5

The improvement of student creativity through project-based learning is also seen based on the flexibility aspect. In this aspect, the learning media has made very interesting, diverse and used a variety of used materials (Tienken, 2010). Students can utilise in using materials as raw materials of learning media. Aspects of flexibility have been seen in various forms of learning media such as stacko, wall magazine concepts, scales, lottery game concept, monopoly, snake ladder, puzzle, pop-up book, a miniature of space geometry, graphics miniature, plot board, and an electrical circuit.

### ***Evaluation***

The final step of the implementation of project-based learning is the evaluation of the project in the form of an exhibition of learning media. The exhibition was organised by displaying various manipulative media from three different classes. Each student is in charge of assessing the media of other friend's media based on the assessment sheet provided by the researcher. The learning media exhibition lasted for five hours in a gallery. It enabled visitors to freely enter the gazebo and find out various kinds of mathematics learning media.

### **CONCLUSION**

Based on the description of the results of the implementation of project-based learning to improve the creativity of students, it can be concluded that there was an improvement of the student's creativity in completing the project of making mathematics learning media based on the aspects of flexibility which met very good category. It was evidenced by the change of learning media by comparing the storyboard with the final project result. Besides, the flexibility aspect was good based on the wide variety of learning media created on various mathematics learning materials of junior high schools. There was also an improvement of students' creativity in completing the project of

making the mathematics learning media based on the aspect of originality, though some students still developed learning media with the similar rules and form with the previous developed learning media. The last conclusion is an improvement of students' creativity in completing the project of making mathematics learning media based on novelty aspect meets the good category. It is because some of the manipulative media were original, though the rest of the others still adapted from the previous studies.

## ACKNOWLEDGEMENT

We thank the Directorate of Research and Community Service of the University of Muhammadiyah Malang who has provided the funding support for this research.

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