

Virtual Activities on Mathematics with Project Based Learning

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Abstract. Mathematics learning with project based learning required students to do something activities that produced a product in order to reach level understanding of a mathematical concept. Activities carried out by students during learning could trained higher order thinking skills and improved students' skill. Mathematics learning curriculum recommended project based learning as a learning model that has the ability to improve students' competencies in cognitive, affective and psychomotor. When face-to-face learning, the teacher could directly observed students' activities, in order contrast to distance learning. Needed one innovation in technology that was able to record all virtual activities that students did during learning. The research method that used was literature study. First, the researcher defined about project based learning. The next step based on literature review was analysis activities carried out during mathematics learning with project based learning.

Keywords: virtual activities · mathematics · project based learning

1 Introduction

Mathematics learning process was aim to develop students' abilities in cognitive, affective and psychomotor. Implementation of learning required a learning model that supported students' activities in developing these three domains. So the learning process as a whole gave birth to good personal qualities of attitudes, knowledge and skills [1]. In the 2013 Curriculum, mentioned that knowledge was achieved through the activities of knowing, understanding, applying, analyzing, evaluating, and creating and applying a scientific approach in the implementation of learning. To support the implementation of the 2013 curriculum, needed learning plan that could directed students to carry out the learning process through activities that involved experience in understanding the concept. Through experience, students were able to connect their concepts to be able to develop mathematical thinking skills in finding new knowledge. To support the development of students' mathematical abilities both individual and groups, it was highly recommended to use learning that produced work in the form of problem solving and increasing student activity in the learning process, it was the Project Based Learning (PjBL) model. Learning with PjBL was able to fully develop students' ideas and skills, and exercise responsibility, independence and discipline. The development of these skills was important for successing in solving problems that would be encountered in everyday life [2]. Learning with PjBL provided opportunities for students to plan and determine how to solve problems, so it trained discipline and independence of the students.

Learning that could trained independence and responsibility started by training students made plans, completed strategies and carried out all plans according to the time they had made. To be able to carry out activities that had been planned, students needed to connect their basic knowledge. This knowledge processed and resulted the new knowledge that was carried out individual or groups. This activity was able to develop a cooperative attitude and the ability to think, because in determining action to processing and producing new concepts that were needed accountable explanation. As mentioned by [3] PjBL was able to encourage students to learn subjects independently and be aware, responsible and reflect on their learning. Through PjBL learning activities, students could simultaneously develop cognitive abilities and practiced their basic abilities to train and developed psychomotor abilities.

Learning with PjBL provided opportunities for teachers to continue the reflection on project developments and provided stimulus to students to be active and creative to develop their basic abilities in obtaining the right new concepts. In the learning process, the teacher provided feedback which was an important part of learning with PjBL because students were asked to reflect on the feedback that provided and made improvements to the work they had completed [4]. PjBL learning could be done by investigating and constructing problems, researching solutions, planning, presenting, providing feedback, and revising plans, then presenting [5].

In face-to-face learning the teacher could directly saw the development of student abilities and controlled student activities in completing projects, students who had less contribution could be motivated to participate in the implementation of learning with PjBL. The problem right now was how if learning with PjBL was carried out online, the teacher must still controlled the progress of the project, controlled the development of abilities and controlled the process of student activities carried out online by the students. The control was done so the planning, completion strategies and processes produced products that were carried out by students rightly and correctly. A technology was needed that was able to help teachers saw all virtual activities carried out by students collaboratively and these activities were recorded. As mentioned by [6] that collaboration through technological tools could created connections between classrooms around the world. This study reviewed the relevant literature on the definition of PjBL by looking at internationally relevant studies, and then analyzed and determined activities carried out in offline learning using PjBL so it was found the virtual activities that could be done using PjBL in online learning.

2 Method

This research was conducted in the form of a literature review from previous research related to learning using the PjBL model in mathematics learning. This literature review was then developed to find learning activities with PjBL online. This research referred

to the previous article related to learning activities with PjBL. The following steps were taken to see student activities in learning with PjBL, were: (1) Analyzing the definition of learning with PjBL, (2) Synthesizing some information about the work that had been done to determine learning activities directly using PjBL, (3) analyzing activities that could be done in online mathematics learning using PjBL, and (4) making conclusion for this research.

3 Results and Discussion

3.1 The Definition of Project Based Learning (PjBL)

PjBL was project-based learning and student-centered learning strategy [7]. PjBL learning was a form of learning that involved students in a project and directed students to find solutions with different viewpoints or perspectives and used classic problems and used basic concepts as a way of solving them [8]. Learning began with small learning communities and projects led by students themselves [9]. Student-centered learning through project activities could provided experience in understanding mathematical concepts, knowledge and skills acquired by working through problem solving over a period of time. So the experience gained by students could last a long time and the knowledge in the form of mathematical concepts obtained becomes meaningful as a form of understanding. [10] Russell said that learning experience was needed, and this experience tended to be less available to students in learning mathematics. PjBL learning provided learning experiences through projects and shared knowledge between students and one another through group work. Learning with PjBL defined based on previous researched could be seen in Table 1.

Learning with PjBL was a learning method that designed the learning process with projects. Projects gave by the teacher provided learning experiences to students and increased the effectiveness of learning with PjBL [11]. Projects could be made in the form of a portfolio assessment because the portfolio contained an assessment of activities, learning progress and learning goals [12]. A portfolio could be a collection of students' work and reflections during the learning process. This project-based learning required innovation and technological tools used to interact, distribute, store and handle data. So

| Author | Mathema tical Ability | Student as Learning Center | Started from Problem | Produced the Product | Used the Technology | Group Work |
|--------------------|-----------------------------|----------------------------------|----------------------------|----------------------------|------------------------|---------------|
| Branch (2015) | | | | | | |
| Ubuz (2019) | | | | | | |
| Owens (2020) | | | | | | |
| Han (2015) | | | | | | |
| Evans (2017) | | | | | | |
| Gulbahar (2006) | V | | | | | |

Table 1. Definition of Project Based Learning from Previous Research

the projects produced by students really provided experience in the process of gaining knowledge.

Learning using PjBL nowadays involved technology, especially in the 21st century. Project-based learning improved students' thinking and skills [13]. The teacher had a role to be able to integrate the used of technology in teaching to improve students' thinking skills [14]. The used of technology by students and teachers had now became a necessity because it could be used to improve the performance of an effective teaching and learning process. PjBL learning that used technology would be able to increase the interaction between teachers and students in learning. The teacher's ability to facilitate students in using technology in mathematics learning was able to increase student activity in creating and making new knowledge discoveries. Many applications and software that could be used in mathematics learning. Teachers could facilitated students to complete projects with the helped of technology, thus teachers had helped developing students' skills in using technology in learning. Mentioned by [11] that it took students who were able to explore skills in using technology for readiness to live and work in the 21st century.

In activities based on PjBL, learning started by being faced with real problems that must be collaborative [15]. Collaborative activities could be carried out in discovery activities, students could shared information with each other in solving problems in groups. Collaboration could also be done with the help of technology. Technology helped in collaborative activities by providing a communication tool to build trust between parties that could be very different [16]. The learning process that involved students directly in finding knowledge was very helpful in improving students' mathematical abilities. Mathematical abilities included mathematical communication skills, reasoning skills, problem skills, and critical thinking skills. PjBL by providing opportunities for students to effectively foster them so the students' communication skills came out [15]. Collaboration between students also played a role in increasing students' knowledge in thinking and solving problems [17]. Experiences that allowed students to carry out collaboration and communication skills, as well as cultivate critical thinking and problem skills needed to lead to real-world situations [18].

Activities in learning were determined by students through the selection of strategies used to solve problems. Students were directly involved in planning projects and did exploration repeatedly to find mathematical concepts [7]. Projects were selected by students according to their interests, and could be of various types, to be explored by a specific group of students [8]. Student-centered learning provided opportunities for students to learn responsibly and independently to choose the right strategy in solving problems. Student activities in solving problems were different, sourced of inspiration were based on the relationship between their knowledge and real life [17].

In conclusion, project-based learning could be defined as a learning model that was carried out by providing a problem that could be a real-world problem, to be solved by students through activities that were designed by students by involving the basic knowledge and skills that they had previously to produce the final product as a project. which could be shown by developing students' mathematical abilities.

3.2 Activity in Offline Learning Using PjBL

Students in the project-based learning process could carried out activities independently or collaborating in groups. Activities carried out by students required controlling from the teacher, so the teachers were required to have the ability to create challenges for students, opportunities to practice, meaningful assessment and feedback and practice development [19]. Learning with PjBL was designed to provide opportunities for students to work independently and collaboratively, as well as provided opportunities for feedback [20]. Planning in formulating strategies and the process of solving problems submitted to students to produce products required controlling from the teacher so the processes and results obtained by students were correct. The process that students chose was a key element of problem solving, the teacher supervised every decision and provided direction to students during the learning process [2]. When students seeking for solutions to these problems, teachers directed students' knowledge and adapted it to individual needs so PjBL provided significant opportunities for meaningful feedback to students and teachers [5]. This condition illustrated that when students receive feedback, teachers had the opportunity to develop innovations and their contributions to projects designed by students and ultimately helped increasing activities in learning. Activities in offline learning using PiBL based on previous research could be seen in Table 2.

Planning activities here were students compiling a schedule and process of activities. The teacher had a role in directing students to produce creative scenarios, and assessing the scenarios and content chosen by students, if they were deemed not feasible, the teacher directed students to redesign so the planning is produced with a constructivist processed [12]. Activities carried out in PiBL learning involved students in investigations, discussing in groups to refine questions, debated ideas, designed, collected data and analyzed data, drew conclusions, communicated ideas and findings to others in teacher direction and guidance [21]. As time goes by, the processed to produce products leaded students to actively use their basic mathematical knowledge to work skillfully with others, appreciated the strengths of their different colleagues and be able to build their own understanding through problems that were solved in groups [22]. Learning activities with PjBL trained students to be able to develop independently through freedom of activity, designing and determining problem solving strategies carried out in groups, thus enabling students to develop their knowledge. The teacher provided feedback that could lead students to reflect and expanded and generated new knowledge for students [21].

Activities in offline learning with PjBL, all activities carried out by students were continuously monitored with teacher guidance and direction. This was meant so the strategy or process chosen by the students was rightly and correctly. Activities could also be started with real world problems, students worked together in groups to share information and respect each other to achieve group goals. Collaboration in group work and contextual problems that reflected students' real-world experiences were needed in learning with PjBL [7]. The process carried out in learning with PjBL provided experience of the communication processing and the ability to represent new concepts with basic knowledge that was owned [23]. It could be concluded that activities in offline learning with PjBL were student-centered but the teacher still directed and guided them so the new knowledge obtained was correct. For online learning with PjBL, the activities

| Table 2. Activities in Online Learning using r [D | Table 2. | Activities in | Offline Lo | earning | using | PiBL |
|--|----------|---------------|------------|---------|-------|------|
|--|----------|---------------|------------|---------|-------|------|

| · · · · · · | |
|-----------------|---|
| Author(s) | Activities in Learning Using PjBL |
| Branch (2015) | Student facing on problems and challenges Collaborating to solve problems Using communication skill, raising critical thinking and solutions to problems ability in real world situation Using technology to develop thinking ability and producing products. |
| Ubuz (2019) | Introducing question that leading to problems Determining project groups (3–4 students) Determining group task: making plan, determining the solving strategy and guidance from teacher. Student participated in solving the problems, investigating and discussing Producing products Presenting the final product |
| Owens (2020) | Providing early questions that leading to problems Project activities began with small groups Discussing and working together to determine how to solve and solutions to problems The teacher observed the process and facilitated each group as needed Completing the products Presenting the final product in class Communicating the final product through online in several classes between countries |
| Han (2015) | Teacher explained project and activities that would did by students Students designed project activities Students discussed and worked active together solving the problems. Teacher designed assessment |
| Evans (2017) | Students in groups discussed to make planning and scheduling activities guided by teacher Student determined the topic (project) and strategies to solve self-problems Completing the project with teacher's guidance and presented it. |
| Gulbahar (2006) | Designing the project Students chose the strategies to finish the project Students finished the project by teacher guidance Teacher gave feedback (revision) to the project that produced by students Finishing final product |

carried out were the same as activities carried out in offline learning with PjBL. The important thing that must be considered was that the teacher knew all the activities carried out, for that in online learning, applications and software were needed that could help the teacher knew all the activities and strategies chosen by students. One application

that could be used to control student virtual activities were using geogebra and google documents.

3.3 Activity in Offline Learning Using PjBL

One of the important elements of PiBL learning was the choice of assignments that were able to direct students to have ideas and arguments, beside that the important things that must be considered were what the teacher did, the questions they asked and the communication they provided to students must produced activities that leaded students to form critical reasoning [24]. Virtual activities at PjBL could be built by teachers using technology. Interaction could used virtual technology to collaborate in small groups that facilitated online discussions, where teachers remain passive observers in the learning process and facilitated according to student needed [15]. So the teachers could saved virtual activities carried out by students, teachers could used the online geogebra application. In this application the teacher could save the activities that students did because all the steps that students took were recorded in the database. Geogebra equipped students to actively study independently, solved problems and processed data [25]. For example in the quadratic functions chapter. Finding concepts through projects could be done with the Geogebra application, students who learned to make various quadratic functions, and situations of the relationship between values a, b and c, root values, peak points and discriminant values through the geogebra online application. All virtual activities carried out by students were recorded in the database. The following was an example of an online geogebra application, could be seen in Fig. 1.

Each values a, b, and c on quadratic functions that formed by student recorded in the database. So the teacher could observed all of the virtual activities that did by the students.

The Geogebra Online application helped teachers found out all virtual activities that students did in finding concepts, so the teachers could directed and controlled the development of students' abilities in acquiring new knowledge. In online learning with PjBL, the role of the teacher as a facilitator could be maximally carried out, because all activities carried out by students were observed. Collaboration in groups could be done online using google documents. Students and groups could collectively fill in the findings that have been made on the geogebra application to conclude the concepts that had been found. So in the google document each group member could simultaneously fill in data, and the teacher could observed the activities carried out online, also the facilitator function could be carried out directly by the teacher during the process of obtaining the concept. The following is an example of a virtual activity sheet via google document that could be directly observed by the teacher.

In online learning with PjBL, students could still worked together in producing new knowledge. Geogebra allowed students to learn concepts visually better, students would shared with friends to generalize what they achieved in a collaborative learning environment [22]. It could be concluded that online learning with PjBL could be done using geogebra applications and google documents, where all virtual activities carried out by students were recorded and could be directly observed by the teacher. Teachers could directed the development of new knowledge that would be shaped by students rightly and correctly.



Fig. 1. Graphs of Quadratic Functions on Geogebra Application

4 Conclusion

Learning with PjBL was a learning model by giving problems as basic activities to produce a final product with the help of knowledge and skills. Activities in learning with PjBL began with determining products, planning and processes, producing products and publications. For virtual activities in learning with PjBL, it was carried out with the geogebra application and google documents so all virtual activities were recorded and could be observed by the teacher.

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