Study of Implementation of Project Based Learning in Mechanical Engineering Study Program of Vocational High School

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Abstract: This study aims to describe the implementation of project-based learning in Vocational High School (VHS) of Mechanical Engineering Expertise Competency in terms of planning, implementation, evaluation, and constraints. The study was carried out using qualitative descriptive methods. Research respondents were vocational teachers in the Mechanical Engineering Expertise Competency of the State VHS of Technology and Engineering in Malang City. The research data was collected using in-depth interview techniques, observation, and analysis of learning documents which were then analyzed qualitatively. The results show that vocational teachers have implemented PjBL both in terms of planning, implementation, and evaluation of learning. In projects planning the teachers have not involved the industries, the projects are relatively simple, so products of project cannot be utilized and not sold. The syntax of PjBL has not been seen in the implementation plan of learning but the implementation of practical learning at the workshop/laboratorium conducted by the teachers indicates the implementation of the PjBL syntax. Evaluation of learning outcomes in PjBL includes evaluation of processes and products. The main obstacle faced by teachers lies in determining the project, the preparation of the PjBL syntax, the limited practicum facilities in the school workshop/laboratorium, and the limited time for practicum.

1. Introduction

The national education system has a very complex challenge in preparing the quality of Human Resources that are able to compete in the global era. The role of education is very important in creating quality human resources, namely people who are intelligent, skilled, moral, democratic, and have the ability to compete. Development of quality human resources is needed in the face of competition in various fields of life, especially to compete in mastering and developing science and technology [1]. Vocational High School (VHS) is a secondary level education that prepares students with expertise and skills in a particular field to enter the workforce in the industry [2]. Therefore education in VHS must be carried out by adopting and or adapting the work processes that exist in the industry. In this context, one of the learning models contained in the Standard Process for Primary and Secondary Education [3] which is rightly applied in VHS is the project-based learning model (PjBL).
According to Han & Bhattacharya [4], PjBL is a learning strategy that involves students in complex activities, requiring several stages and relatively long duration, at least several meetings up to a full semester. The project focuses on creating a product, and generally directs students to choose and organize learning activities, conduct research, and synthesize information. Similar opinion was conveyed by Chiang & Lee [5] who considered PjBL as a learning approach where students were directed to respond to real-world questions or challenges through a long process of inquiry. The characteristics of PjBL are to develop students’ thinking skills, enable them to have creativity, encourage them to work together, and lead them to access information independently and to convey that information.

According to Zhang [6] the implementation of PjBL in vocational schools must reflect three basic components, namely project planning, project implementation, and project evaluation. Project planning is the main foundation in the implementation of PjBL and can be implemented by teachers in three forms of activities, namely (a) project selection, (b) project modification, and (c) project completion all of which must be oriented to projects in the industry. Project implementation in PjBL can be divided into three stages, namely (a) project introduction carried out at the beginning of learning to make preparations related to project activities, (b) sub-project implementation, namely the process of working on project parts based on the results of overall project analysis, and (c) integration of sub-projects, namely the process of assembling the entire portion of the project so that it becomes a complete product. Project evaluation consists of two steps, namely process evaluation and summative evaluation. Process evaluation is an evaluation of the project implementation process. While summative evaluation is an evaluation of the results of the project, namely the final product produced.

This study aims to describe: (1) PjBL planning, (2) PjBL implementation, (3) PjBL evaluation carried out by mechanical engineering vocational teachers; and (4) various obstacles in implementing PjBL experienced by mechanical engineering vocational teachers in VHS.

2. Method
This research was carried out using a qualitative approach with descriptive research design [7] which was intended to describe the results of research in the form of words as they were at the time the research was conducted. This research was conducted at the VHS State for Technology and Engineering in Malang City which has implemented PjBL as referred to in the Standard Process for Primary and Secondary Education [3]. Respondents who were chosen to be the key informants were vocational teachers of Mechanical Engineering Expertise Competency. Data collection was carried out using in-depth interview techniques, observation of learning activities, and analysis of learning device documents created by the teacher. The research data that has been collected is organized and sorted into units that can be managed, then determined the data patterns that are considered important to be studied and described. The validity of the research findings was done through source and methods triangulation [8].

3. Results
Four research results are obtained as follows. First, the teacher's planning in implementing PjBL shows that (1) the project planning carried out by the teachers does not involve the industry at all, but is only planned jointly by vocational teachers; (2) the project planned by the teacher is only in the form of a simple product whose manufacturing process is considered to be the most appropriate with certain skill competencies contained in only one subject; (3) the functioning and selling of products are not considered by the teacher in determining the project; (4) the project is presented by the teacher in the form of jobsheet which is only in the form of work drawings that must be done by students; and (5) the planning of PjBL learning strategies is implied in the form of selecting learning methods, formulating learning scenarios, and determining the assessment system in learning planning documents.

Second, the implementation of PjBL is described thoroughly in theoretical and practical learning with the following details: (1) theoretical and practical learning is provided in an integrated manner with theoretical subject matter given first and then followed by the provision of practical tasks in the form of simple projects in the jobsheet; (2) the methods used by teachers in theoretical learning are quite varied,
including lectures, question-answer, observation, and discussion; (3) practical learning begins with group formation, then sequentially followed by giving and explaining jobsheets by the teacher, formulating work steps, determining equipment (tools) to be used, and determining work safety by the students; (4) assessment of the completion of the jobsheet by the teacher, if it is not appropriate the student is asked to improve it and if it is appropriate the student is invited to do it; (5) the implementation of practice to carry out tasks/projects by students; and (6) during the practicum activities the teacher provides supervision and assistance to groups of students who have difficulties in tutorial in accordance with their respective problems. The PjBL operational procedure carried out on VHS can be described as follows.

Third, the evaluation is always carried out by the teacher at the end of each lesson that includes evaluation of processes and products. The process evaluation is carried out by the teacher in the form of (1) observing the work process of students from the beginning to the end of the practicum; and (2) the teacher asks students to tell the successes, failures, and or problems faced by students. Product evaluation is carried out at the end of the learning episode which is marked by the completion of the entire task/project by the students. The product evaluation is done by the teacher by (1) asking students to assess the workpiece produced by measuring each dimension, writing the results on the assessment sheet given by the teacher, comparing the size produced with the requested size and tolerance, and giving a score according to range of scores set by the teacher. Sometimes the teacher also asks the group to cross-evaluate the workpiece of other groups. According to the teacher it was intended that students learn to assess objectively and be able to appreciate the work of others; and (2) the teacher directly assesses all work items produced by each group of students by measuring and comparing them with the specified size, including the level of refinement, then giving a score according to the rubric that has been determined. The final score used by the teacher is the result of its own assessment, while the results of the student assessment are only used as a form of their involvement process so that the learning is more meaningful.

Fourth, the constraints felt by teachers in implementing PBL are (1) difficulties in determining projects that must involve the industry, (2) difficulties in determining the correct implementation strategy of PjBL, (3) limited practical facilities, and (4) limited allocation of practicum time.

DISCUSSION
The learning planning made by the teachers in implementing PjBL includes two important things, namely project planning that is realized in the form of work drawings on jobsheet, and planning of learning strategies which includes method selection, formulation of learning scenarios, and determining the evaluation system. This is in line with the Process Standards for Primary and Secondary Education [3] which explains that the planning of the learning process must include the Syllabus and the Learning Implementation Plan. The planning is also in accordance with Wena's opinion [9] which states that in order for the project-based learning process to take place optimally, learning planning must be systematically arranged with steps (1) formulating learning objectives or projects, (2) analyzing the characteristics of students, (3) formulating learning strategies, (4) creating worksheets (jobsheet), (5) designing learning resource needs, and (6) designing evaluation tools.

Projects planned by the teacher with characteristics in the form of simple workpieces that are developed based on certain basic competencies from certain subjects, do not have certain functions and are not selling well in line with the findings of Sudjimat & Romlie [10]. The exclusion of the industrial world in project planning by teachers is not in accordance with Zhang's opinion [6] which makes the industry a source of project planning for vocational schools. Learning strategies that are designed are also not fully in accordance with the PjBL syntax as suggested by experts (see [9], [11], [12]). This happens because the learning scenario created by the teacher emphasizes more on the scientific approach that includes observing, asking, exploring, associating, and communicating. However, the results of observations on the implementation of practical learning show that the learning strategies implemented by the teacher have similarities with the PjBL syntax, namely (1) forming groups, (2) explaining project tasks, (3) assigning students to formulate the work process, (4) asking students to work on project, and (5) assessing project results. This is in accordance with Sani's opinion [14] which states that PjBL involves students in designing, creating, and displaying products.

In implementing PjBL, the teachers have conducted assessments in three aspects, namely cognitive, affective, and skills/practical. Cognitive assessment is intended to assess students' mastery of learning theory. While the assessment of attitudes and skills is given related to practical learning in the workshop. The assessment of the practicum is in line with Zhang's opinion [6] which states that project evaluation includes an assessment of the process and the final product.

The main obstacle faced by teachers in implementing PjBL is the difficulty of involving the industry in determining the project. This happens because the industries oriented is business and profits so they have not entrusted their products to work on VHS. Constraints related to the difficulty of the teachers in determining the correct PjBL learning strategy are mainly due to the low understanding of the teachers about the PjBL syntax as recognized by most sample teachers. Besides that, it is also due to errors in the syllabus received by teachers that make the scientific approach as a learning procedure [11]. Related to the lack of fulfillment of practical facilities, this is in accordance with Sani's opinion [13] which states that some of the weaknesses of PjBL are related to the need for inadequate facilities, equipment and materials. Finally, the constraints associated with the limited time for learning activities are also in accordance with Sani's opinion [13] which states that the amount of time needed to solve problems and or produce products in PjBL is also one of the obstacles that occur in VHS.

4. Conclusion

First, PjBL planning on VHS Machining Engineering Skills Competencies has the characteristics of (1) projects in the form of simple workpieces that are adapted to the formulation of basic competencies in certain subjects without regard to aspects of functionality and sales of products produced; (2) the project is only formulated by teachers without involving the industry; (3) the project is presented in the form of working drawings on the jobsheet; and (4) PjBL syntax is not explicitly stated in the learning design but is implicitly illustrated in the method selection, scenario formulation, and determination of the assessment system. Second, the implementation of PjBL is reflected in practicum learning which begins with the formation of student groups which are sequentially followed by project assignments and explanations in the form of job sheets, formulation of work steps, determination of equipment (tools) to be used, and formulation of work safety by students; and the implementation of practice to carry out
tasks/projects by students under the supervision of the teacher. Third, evaluation of learning outcomes in PjBL is carried out on aspects of attitudes, skills, and knowledge. Knowledge assessment is carried out with written tests in theory learning, attitude assessment is carried out during the practicum process, and skills assessment is carried out by assessing the products (workpieces) produced by students. Fourth, the main obstacle experienced by vocational teachers in implementing PjBL lies in the difficulty of involving the industries in determining the projects, the difficulty in determining the PjBL syntax, the limited practicum facilities, and the limited time for regular practicums.

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