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Project Planning Characteristics In Project-Based Learning On Mechanical Engineering Study Program

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***Abstract*— Project planning is one of the key stages in project-based learning. This study aims to describe the characteristics of project planning undertaken by mechanical engineering teachers for the implementation of project-based learning. The samples of the research were mechanical engineering teachers of Mechanical Engineering Study Program from eleven vocational high schools in East Java. Data were collected through questionnaires and interviews, and analyzed by qualitative descriptive and percentage techniques. The results show (1) the complexity of projects planned by teachers varies greatly from simple to complex categories, depending on the variables that the teacher considers; (2) few teachers have involved small industries or other stakeholders and students in project planning; and (3) the involvement of industries or stakeholders in project planning is limited only as a product orderer either in the form of working drawings, descriptions of desired products, as well as exposure to real problems it faces. The conclusion of this study is that the characteristics of the project complexity planned by the teachers in implementing project-based learning models depend on whether or not there are industry involvement and the many variables of the products they are considering.**

Keywords*— *characteristic; project planning; project-based learning; mechanical engineering.

I. INTRODUCTION

Project-Based Learning (PjBL) is a learning strategy that involves learners in complex activities, requiring several stages and relatively long duration, at least several meetings up to a full semester [1]. The project focuses on creating a product, and generally directs learners to select and organise learning activities, conduct research, and synthesise information. In the context of learning mechanical engineering in vocational education, PJBL is interpreted as a learning model that provides opportunities for learners to learn through project activities in the laboratory that begins with teacher guiding questions, then briefing learners to explore learning resources, make learning plans for project creation, and practice collaborative and cooperative learning attitudes in solving contextual problems [2]. There is no standard for defining projects in PjBL, but the terms of the project are made/agreed upon in any particular program [3]. In this context Aalborg University [3] defines projects as complex activities requiring analysis (problem analysis), to be planned and managed, involving novelties, tasks or complex problems; and must be completed on a predetermined schedule. On a small scale, the project has only scope in a discipline course, while on a larger scale the project is multidisciplinary, involving not only a variety of different disciplines but also involving several professional personnel and teams [4]. This shows that it is not easy to determine the right project for a lesson.

In engineering courses, Al-Sharif [5] categorizes projects into four groups, namely (a) practical projects, ie projects that are practical and require the availability of laboratories, such as the job of designing simple electronic circuits, designing mechanical systems used to calibrate tools, or testing of measuring instruments; (b) visit/survey project, ie a project involving learners to conduct a visit or survey, then make a report on a visit to the industry to observe the pneumatic and hydraulic systems, or visits to research institutes/laboratory testing of technical materials; (c) programming projects, ie projects involving the creation of programming codes of software used in engineering; and (d) theoretical projects, a project aimed at enhancing the understanding of learners in-depth through research activities and the preparation of reports.

According to Zhang [6], project planning can be done through three steps, namely (a) project selection, (b) project modification, and (c) completion of the project. Project selection must come from actual projects or businesses to condition learners to experience job/tasks in real terms in their field. Thus, teachers should conduct a survey directly to the industry to search for topics relevant to the field of students. Modification of projects originating from the industry is usually done if the project belongs to a large-scale project. In this context, project modification should be

done by taking into account project time and school hours. While project planning obtained from the completion of the project is intended if the project obtained from the industry is still classified on a relatively large scale, while lessons are available in a limited semester then the project can be taken from part of the big project. In other words, to organise lesson schedules and control the effectiveness of learning, teachers should organise/break the project into subprojects based on the work process, and each sub-project should show a relatively complete work process.

This study aims to describe the project characteristics planned by engineer engine teachers for project-based learning including (1) project complexity, (2) industries engagement, (3) students engagement, and (4) examples of project planning results along with their characteristics.

II. METHOD

This study aims to describe the project characteristics planned by engineer engine teachers for project-based learning including (1) project complexity, (2) industries engagement, (3) students engagement, and (4) examples of project planning results along with their characteristics.

III. RESULT

Characteristics of the project in the implementation of PjBL on Mechanical Engineering Study Program of Vocational High School can be identified into four as follows. First, the project used by teachers in the form of simple work objects to complex that has a specific function and marketable. The complexity of the project depends on how teachers decide or plan projects that their students must work on. The more things considered and the more parties involved by the teacher, the more complex project will be, and vice versa. In this context, most teachers (63.33%) state that project planning is based on the following: (a) the suitability of the project with the competencies that the students must master, (b) the usefulness of the project to the community at large, (c) the project's usefulness to meet the needs of the school, (d) the usefulness of the project according to the needs of the partner industries, (e) the availability of materials and equipment at the school, and (f) the consideration of whether or not the products are sold to the community, both internal and external schools. Related to the complexity of the project, most teachers (63.33%) explained that the planned project is complex because it takes into account many things. In contrast, a small percentage of teachers (36.67%) stated that in project planning it is based solely on the suitability of the project with the competencies that students must master, the availability of materials, and the availability of equipment in the school alone without considering the usefulness of certain parties so that the planned project is classified simple.

The variation in project conformity with the competencies that students must master can be classified into five as follows (a) the project is formulated in the form of a product (workpiece) resulting from one pair of basic competencies (i.e. BC3/coginitive skills and BC4/technical skills) of certain course (13.33%); (b) the project was formulated as a product produced from several pairs of BC from one course only (23.33%); (c) the project is formulated as a product formulated from several pairs of BC from several subjects in the same competency (20.00%); (d) the project was formulated in the form of a product produced from several pairs of BC from several subjects across the competency of expertise from the same skill program (13.33%); and (e) the project is formulated in the form of a product produced from several pairs of BC from several courses across the skill program (23.33%).

Second, with regard to industries involvement in project planning it is known that half of the mechanical engineering teachers (53.33%) state that industries or partner institutions have never been involved; while 16.67% of teachers stated that the project the students do is an order from the industries in the form of working drawings; and 30.00% of other teachers stated that the industries were involved to validate the prototype of the products it ordered that had been developed by teachers. Third, related to students involvement in project planning that will be used in learning, a small percentage of teachers (23,33%) stated always involving students, while most of the teachers (76,67%) stated never involving students.

Fourth, some examples of projects resulting from the planning process as described in the first to third items can be described as follows.

1. Simple category projects are resulting from the analysis of one pair of BCs in a particular subject. For example, in Lathe Machining Course, the project can be a straight axle, a multilevel shaft, tapered lathe, threaded lathe, and the like. In Frais Machining Course the project could be to create a cube shape, create a groove, make straight gears, and the like.
2. Medium category projects are resulting from the analysis of multiple pairs of BCs in one particular subject. For example, the project task is in the form of making snei holders in Lathe Machining Course, and the manufacture of a holder (jig) for pipe drilling in Frais Machining Course.
3. Medium category projects are resulting from the analysis of multiple pairs of cross-learning BCs within a competency skill. For example, the combination of BCs in Lathe Machining and Frais Machining Courses resulted in the project task of making drilling pipe jigs equipped with a pipe-sized axle to be drilled.
4. The complex category project in the form of orders from stakeholders is expressed in the form of desirable product descriptions. In this context exemplified one order from the Department of Hygiene and Gardening in the form of garbage chopper machine. Project planning is carried out by a team of mechanical engineering teachers of SMAW Welding Course, Manufacturing Drawing Course and Machining Course. Their planning produces a sketch of a garbage chopper machine as desired by the stakeholder. Furthermore, the teacher of

Manufacturing Drawing Course instructs the students to draw the machine sketches into three-dimensional drawings and working drawings. In that context means project planning has involved three elements, namely teachers, stakeholders, and students. If the work drawings are followed up in the form of project work by the students of the SMAW Welding Course and Lathe Machining Course, then the product will be produced.

5. The complex category project in the form of excellent school products. In one of the Vocational High School Samples found that the school has a flagship program in the form of an electric bicycle named the school bike. School bike planning is classified more complex than the previous category projects so that it involves teachers from three competency expertise, namely Welding, Machining, and Automotive. The sketch drawing produced by the teachers then followed up by the teacher of the Manufacturing Drawing Course by assigning the students to draw into three-dimensional drawings and working drawings. In this context, project planning has involved three elements as well, namely teachers, students, and school management as stakeholders. Furthermore, the work drawings are distributed to the students of SMAW Welding, Machining, Autotronic, and Body & Repair Courses to be done in teams so that the product is produced.
6. A complex category project is a special tool for solving real problems in the community. This project planning starts from the request of the citizen, that is the owner of the car workshop, to one of the Vocational High School in Malang City to be made a special tool that can be used to remove certain components without causing damage to the sensor system contained in the parts. The case was handled by a CNC machining teacher. After careful attention to the case/problem then the teacher assigned a group of students to observe, measure, and make sketches according to the shape of the tool that will be made with its sizes. The students were then asked to transform their observations into CNC programs and simulate them. If the program is considered feasible by the teacher, then the students are asked to execute the program for making the desired special tool. If the results are not as expected, then the students are required to improve the program until a special tool is created that can be used to remove the component as desired. Such project planning has involved the students in full and the teachers are more functioning as facilitators.

IV. DISCUSSION

The findings of the research indicate that the characteristics of the project used by teachers of Mechanical Engineering Study Program are all in the form of making or creating certain workpieces. This is consistent with the project characteristics for mechanical engineering as described by Han & Bhattacharya [1] who call it the term creation of a product. When viewed from the category of projects created by Al-Sharif [5], the projects used by teachers are classified as practical projects, ie projects in the form of workpieces done in laboratories or workshops in school. While projects that are classified as visit/survey projects, programming projects, and theoretical projecs are not found at all. This indicates that the right project for the Mechanical Engineering Study Program is a project of making workpieces.

The characteristics of the workpiece as a form of the project used in Engineering Skills Program can be divided into two types, namely (1) workpiece that has no specific function so that can not be utilized in everyday life; and (2) workpieces that have certain functions that can be utilized in everyday life. The workpiece belonging to the first type is more accurately referred to as a workpiece for mere practice in order to deliver the students to master basic competencies as contained in the curriculum [9, 10]. Lessons that use such projects are more accurately described as Pre-PjBL, which is learning that has not yet fully used a project-based approach. Sudjimat [9] calls such learning as a competency-based training, ie learning that prioritizes the achievement of basic competencies and does not consider the usefulness of the products it produces. The workpiece belonging to the second type is a work piece that has a specific function and can be used in everyday life. Such learning is referred to as production-based training, which in addition is directed to achieving the basic competencies in the curriculum is also expected that the resulting workpiece can be utilized optimally for the purposes of everyday life [11].

In terms of the project planning process, two major classifications are found, namely (1) some teachers do not involve industries and students at all, and (2) others involve industries and students in different capacities. The first classification is often found in the school which has only one Expertise Competency, namely Mechanical Engineering. In general, the projects they use can be divided into two, namely (a) the project (workpiece) developed by the teachers of a particular lesson, and (b) the project (workpiece) developed by the teachers of several lessons of the Machining Expertise, for example, teachers of Lathe Machining and Frais Machining. Generally the workpiace belonging to the group (a) are more for mere practice and do not have certain functions that can be utilized in everyday life. While the workpiace produced from cross-lessons, belonging to the group (b), has a certain function although its utilization in daily life can not be maximized.

Project planning implemented by teachers involving industry or stakeholders can be classified into two, namely (a) as a product orderer in the form of working drawings, and (b) as subscribers of products in the form of desirable product descriptions. In the first category, the involvement of industry or stakeholders is only limited to consultative, ie the teachers only consult the drawings of work received, even if necessary. While in the second category, the involvement of industry or stakeholders is more intensive again, that is invited discussion about the clarity of the product he wants. After the product design is completed, the industris or stakeholders are also asked for feedback on the product design results related to product performance, size, materials used, and capacity. Project planning involving the industries qualifies as PJBL in accordance with Zhang's opinion [6] although not always done in three ways as a

whole, ie project selection, project modification, and project completion. In this context, project planning undertaken by teachers is more appropriately referred to as project selection in accordance with industries desires.

A very typical project planning characteristic is found in one of the State Vocational High School in Pasuruan, where teachers from cross-lessons and cross-skill competencies from different skills programs jointly plan projects that are the school's flagship product. The flagship product is School Bike, which is Electric Bicycle for the transportation of its students which is relatively cheap and environmentally friendly. Such project planning characteristics can also be interpreted as project planning involving stakeholders as referred to by Zhang [6]. The project planning is unique in terms of the involvement of teachers and students. The School Bike Planning has involved teachers from the competency of welding, machining, mechatronics engineering, and automotive body & repair, as well as the students of manufacturing drawing lesson with different portions.

Project planning involving students more optimally occurs in the project of making a special tool for car repair shop. The characteristic of the project is in accordance with the opinion of Aalborg University [6] which defines the project as a complex activity requiring problem analysis, to be planned and managed, and involves new things. Such project characteristics are classified as practical projects and programming projects [5], thus improving students' problem-solving skills. Back [12] calls a project that demands students work to identify problems as projects that can actually lead to active student-centered learning. Compared to previous complex categorized projects, the special tool-making project is more practical because it involves only one course, the CNC Machining.

V. CONCLUSION

First, the planned project complexity of teachers of the Mechanical Engineering Study Program can be stretched from simple categorized projects to complex categorized projects. The complexity of the project depends on the many things that teachers consider in planning. However, most of the projects planned by teachers are classified as practical projects. Secondly, few teachers have involved small industries in project planning, where the industry is only a product orderer so that project planning made by teachers is based on the order of the industry. Third, few teachers have involved students in project planning, especially at the stage of drawing the product into a three-dimensional drawing and working drawing. Student involvement is also more optimal, ie observing and analyzing the real problems that schools receive from stakeholders to make the project. Fourth, project planning that considers only the basic competence aspects in one or more lessons only produces projects that are characterized by simple and easy workmanship. While project planning involving industry and considering the usability aspect as well as the selling-it can produce a project with complex characteristic and more complicated its manufacture.

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