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Scaffolding Learning in Teaching Applied Mathematics: A Review in Engineering Polytechnic Education

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Abstract

Teaching mathematics plays an ultimate role in engineering polytechnic education which mathematics is one of the fundamentals of any science and engineering. Therefore a better understanding on mathematics concepts supports valuable contribution to students in mastering concepts of engineering and the implementation. Considering the important role of mathematics does not mean that teaching mathematics is less challenge since students' motivation is not adequate enough to encourage learning. This leads to low academic achievement. Therefore, teachers need to develop a teaching approach which facilitate student to increase motivation as well as academic achievement. To reach the purposes of the teaching, teaching mathematic in Shipbuilding State Polytechnic of Surabaya use scaffolding learning which gives not only path for students to learn mathematic step by step, but also means to solve problems related to science and engineering.

I. Introduction

Mathematics is one of the fundamentals of any science and engineering. Therefore teaching mathematics plays a crucial role, especially in engineering vocational education which will lead to other concept of engineering and the implementation. In general, the vision of Indonesian mathematics education states that mathematics education is devoted to understanding mathematical concepts and ideas which are then applied in routine and non-routine problem solving through reasoning, communication, and connection development inside mathematics and outside mathematics itself [1]. Students are expected to be able to use mathematics and mathematical thinking, both in daily life learn and also learning science subjects [2].

Furthermore, it is stated that the main purpose of teaching mathematics is to enable students to solve problems in daily life. Mathematics teaching is mentioned by the social constructivist paradigm for the teaching-learning process in which students actively construct meaning as they participate in increasingly substantial ways in the re-enactment of established mathematical practices [3]. The mathematical problem solving ability itself is not only a goal in mathematics learning, but also something that is very meaningful in daily life [4], and in the world of work; being a problem-solver can provide benefits. Therefore learning should be developed to educate students to be able to realize and solve the problems that they face. In short, it can be said that teaching mathematics is projected to develop thinking competency.

On the other hand, the requirement of high quality graduates pushes the institution and the teachers to encourage students to develop their problem solving competency along with their technical skills. The current requirement for polytechnic graduates is not limited to perform

skilful jobs as they have used half of their learning time at campus with developing hard skills. Another half of their time is allocated to develop other skills to build their professionalism, including their ability to solve problems logically and scientifically.

Current situation of applied teaching of mathematics at higher vocational education institution still has many problems. It is often that students may face difficulty to imagine and understand the concept. Yet the mathematics concepts become the basis to understand the science and engineering concepts. The condition is getting worse due to lack of students' learning motivation. Negative stigma on mathematics and learning mathematics which told that mathematics is always difficult to learn and to master has discouraged learners to study mathematics.

Considering the essential role of mathematics in developing thinking and engineering skills, the teachers are urged to increase learning motivation and mathematics achievement. The present teachers change the role in teaching as it changes from 'showing and telling' to responsive guidance in developing pupils' own thinking. Cultivation of students' interest in learning mathematics in the process of teaching can establish students' confidence effectively which in turn it is possible to increase learning motivation and academic achievement. The teachers are required to give a range of support for pupils' thought constructions, in a way that develops individual thinking as well as leading to the generation of mathematically valid understandings. Teachers work to establish classroom practices in which patterns of instruction are established to support this learning.

This is a conceptual paper to answer two research questions, which are: how is mathematics teaching increasing students' motivation and academic achievement? and, how is scaffolding approach facilitating learning mathematics in vocational education?

II. The importance to develop motivation

The discussion in this section is devoted to give emphasize on how motivation in mathematics learning is crucial since mathematics learning is considered a difficult lesson to learn. Furthermore, the subject is one of several subjects which got negative stigma from society. The difficulty in the subject faced by learners and the negative stigma make motivation of learning mathematic low. In turn, it makes academic achievement low considerably.

Mathematics teaching of higher vocational colleges emphasizes students as subjects. In the process of teaching, teachers should pay attention to the point that students are subjects of teaching and teachers only play the role of leading people and partners. Teacher appropriate guidance is expected to arouse students' interest in study. Nevertheless, there are alternatives to grow interest to mathematics.

III. Reasons to connect mathematics with other subjects

Actually, connecting mathematics with other subjects is also potential to increase interest in learning mathematics since students may have practice or experience to implement mathematics into real areas of science and engineering. It is started from the increasing curiosity when the true learning is learning that proposes human problems in relation to the world. By learning mathematics, students are trained to solve routine problems or operations to gain knowledge and help them solve problems with stimulus questions which bring students a sense of belonging to mathematics, understanding, and independent thinking [5].

The reasons to connect mathematics with other subjects in engineering vocational education are crucial since understanding concepts underlays development of hands-on skills. The objective of students learning mathematics at higher vocational colleges is different from that of students at undergraduate colleges. In detail, students at higher vocational colleges mainly direct at using mathematical knowledge to solve problems in life by learning mathematics, which requires that the mathematical knowledge learned by them must serve daily life. Teachers must explain not only the generation and development of mathematical concepts but also the implementation in learners' specialties in the process of teaching. The approach is in line with what G Polia's sugesstion, an American educator, who deems that the most effective way to learn all things is to discover them by ourselves. This has similar meaning with the sentence 'interest is the best teacher' because both of them emphasize students should discover problems in the process of teaching and lay stress on importance of problem-solving. About

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mathematics teaching, lay stress on a famous scholar also said mathematics not only needed theoretical learning but also should carry out continuous observation and do experiments. The process of discovery gives path to connect mathematic with other subject.

IV. Scaffolding teaching

Scaffolding can be defined as ‘‘the process that enables a child or novice to solve a problem, carry out a task, or achieve a goal which would be beyond his unassisted efforts’’ [6]. It was characterized as an interactive system of exchange in which the tutor operates with an implicit theory of the learner’s acts in order to recruit his attention, reduces degrees of freedom in the task to manageable limits, maintains ‘direction’ in the problem solving, marks critical features, controls frustration and demonstrates solutions when the learner can recognize them.

The study of this process originates in research on how mothers help children learn language and play games. The metaphor hints at a temporary construction that is used to erect or support a building. It can be removed once the building is finished. In this reading, what is supported is a student’s construction of knowledge or skill. Another way to interpret the metaphor is that the temporary scaffolding structure helps people to do work they would not be able to do without that support structure. Within educational research, the concept of scaffolding has gained popularity over the past decades. One of its attractions is that the concept hints at what is considered good teaching, namely ‘‘the active and sensitive involvement of a teacher in students’ learning’’. The concept has been broadened to include collaborative learning [7], peer scaffolding, and whole-class settings. The importance of design has also come into the picture, and supporting artefacts have become conceptualised as scaffolds [8]. Although originating in the context of problem solving (e.g.,building a pyramid), it took some time for the concept of scaffolding to find its place in mathematics education.

Most studies emphasize what Williams and Baxter [9] call analytic scaffolding, so content-related understanding. This includes generally formulated content such as problem solving, mathematical thinking, inquiry and modelling, but also more specific learning goals, such as arithmetic, algebra, geometry, probability, statistics, calculus and number theory.

The approach is beneficial for two reasons: students need of extra support and the effectiveness. Several studies focus on students with some disadvantage (e.g., low-achieving, low social-economic status, disengaged) because they need extra support. It was pointed out that the learning processes of these students include many regressions next to their progressions. This implies that the diagnosis of such students’ learning needs to be ongoing. Teacher cannot assume that once they have diagnosed a student as being able to do something independently, they remain in that state. It further points to a condition that has not received proper attention in the scaffolding literature: Students may be resistant to support. Another advice Broza and Kolikant [10] give is to provide ample opportunities for low-achieving students to think mathematically. Teachers are often inclined to minimize such situations to avoid failure. Thus there is a tension between on the one hand promoting students’ self-esteem and on the other hand helping them progress to higher levels. Furthermore, with low-achieving students it may be even more important to engage them [11]. Hence, much more attention to social-emotional aspects of learning should be given, not only in teacher– student but also in parent–child interaction.

Several strategies can be effective across a wide range of age and domains. They report promising qualitative or observational results that provide proof of principle. Only a few have experimental results that show the effectiveness of their approach

Originally, scaffolding was an analytic concept used to understand the interaction between child

and adult. Different features and functions were identified of an interesting phenomenon that naturalistically occurs and that scholars including Bruner and Wood liked to see in education too. Thus it gradually became a prescriptive concept, something that educators tried to realize deliberately in educational settings, which also asks for evaluation of the effectiveness of such approaches. In the original definitions, the concept of scaffolding includes the handover to independence, fading or transfer of responsibility. Without these happening, there would be no ground to characterize the observed phenomenon as scaffolding.

V. Applied Teaching of Mathematics

Directing at problems to carry out teaching is a core of applied teaching of mathematics. In detail, 'problem' is the most important, which requires students should quantitative opinions to observe and analyze mathematical phenomena and find ways to solve problems, and emphasizes that students should start with exiting knowledge and use knowledge points that they have learned to give experimental summarization of mathematics. It can be said that mathematical activities are established based on students' existing knowledge.

Current situations of applied teaching of mathematics at higher vocational colleges require a series of development. Teachers should have sufficient cognition about application mathematics. This affects to modern teaching modes which support students to accept knowledge actively to a large extent. This results in the situation that classroom teaching is less depressing and full of vitality and energy. Teachers give a broad chance to ask questions when they have something that they cannot comprehend. As a result, students' enthusiasm for learning is affected seriously.

Applied teaching of mathematic should be the solution of conflicts between college teaching and professional learning. Cultivation of students mainly target future employment. Thus, mathematics teaching should use practicability as a principle in the process of teaching and improve students' learning quality constantly when teaching is enhanced. While finishing theoretical courses, students show much talent and can solve mathematical problems by theoretical knowledge that they have mastered. However, students' practical level needs to be improved.

The teaching principle emphasizes the combination of mathematical practice and theory. On the one hand, applied teaching of mathematics at higher vocational colleges can facilitate students to learn and master theoretical knowledge. On the other hand, it can solve conflicts in students' practical work effectively. At the same time, students can understand the subject mathematics profoundly by practice. In addition to mastering basic learning methods and theories, corresponding teaching knowledge may be supplemented in the process of practice to make them form a complementary relationship.

VI. Conclusion

The teaching of academic and vocational subjects draws upon contrasting traditions. For vocational education one of the major influences has been the close association with the apprenticeship model of learning, in which the teacher demonstrates skills for students to replicate until they achieve competence in a 'community of practice'. Teachers may take a range of roles within vocational workshops and classrooms which the emphasis is on developing competency within a community rather than acquiring knowledge only. Scaffolding approach is considered practicable and effective to solve problems and conquer challenges in teaching mathematics in higher vocational education.

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