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STRENGTHENING CONCEPTS OF MATERIAL MECHANICS THROUGH THE USE OF PARTICIPATORY LEARNING MODEL

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Abstract

The ability to design material mechanics, for example in designing a machine construction, is a basic competency of an engineer. This ability is an integrative ability from various sciences such as engineering mechanics, advanced mathematics, and engineering materials. This research aims to improve mastery of the concept of material mechanics through participatory learning. The method used is experimental by implementing participatory steps, namely participatory activities including determining the required syllabus, project results, and cognitive mastery (assignments, quizzes, mid-semester exams, and final semester exams). The resulting data is qualitative. The results showed increased student participation in learning activities. Students show participation in carrying out learning as evidenced by an increase in mastery of material mechanics design concepts.

Keywords: Competency, Mastery of concepts, Material mechanics, Participatory learning, Project.

1. Introduction

To improve and advance the understanding of the concept of material strength, a learning process will be implemented that involves students in learning. Participatory learning can be interpreted as a way for teachers to involve students in learning exercises that include three stages, namely the preparation stage, program implementation, and program assessment [1]. Participatory learning creates an environment for active participation that focuses on peers, models facilitative teaching, and encourages the development of new knowledge about instruction [2]. The involvement of educators in participatory learning has a role as an assistant, motivator, and guide for students in learning activities [3]. In carrying out this learning, students will be involved in material planning, especially checking the strength of the material. It is hoped that the results of this study can measure students' understanding and mastery of concepts in terms of calculating the strength of materials/constructions. This study aims to see the implications of participatory learning on students' mastery of concepts regarding the calculation of material/structural mechanics. This study was chosen and became one of the interesting topics (see Fig. 1). Detailed information for obtaining this data is described elsewhere [4-6].

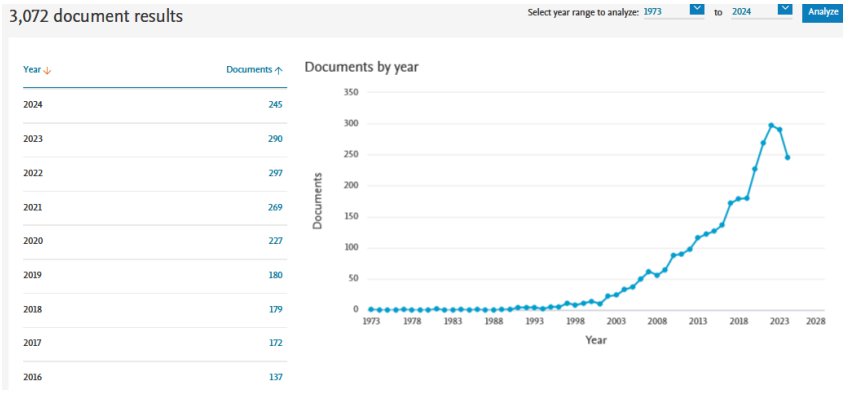

Fig. 1. Research trends in Scopus using keyword "participatory learning model".

2. Method

The research approach used in this research is qualitative. This data was obtained from instruments and direct observations given to students in the form of activities which include:

(i) The questionnaire items are designed to assess aspects such as enjoyment in learning, learning gaps, and problem-solving abilities [7].

(ii) Participatory Activities: Activity data is an activity that refers to the implementation of lectures in formulating the syllabus through group discussion activities, presentations, discussions and work demonstrations [8].

(iii) Project Results: Project data is generated from project activities that study various types of frame construction, create frame construction results/drawings, analyse frame strength calculations, create reports on the

results of frame strength calculations, and create graphic designs for report content according to group assignments [9].

(iv) Cognitive/Knowledge (Tasks): Reportable tasks range from simple tasks to more complex tasks consisting of: (i) observation reports; (ii) creating graphic designs; (iii) creating descriptions/drawings of frame construction; (iv) virtual observation reports [10].

(v) Cognitive/Knowledge (Quizzes): Quizzes are carried out in the form of quiz activities including simulations, questions and answers, puzzles, quizzes, etc.

(vi) Cognitive/Knowledge (Mid-Semester Exam): The report form for filling out the Mid-Semester Exam is to write down the type and form of the questions, for example, 10 multiple choice question tests, and 5 essay question tests.

(vii) Cognitive/Knowledge (End of Semester Exam): Report sheet to fill in the End of Semester Exam with multiple choice and essay questions with 30 and 5 questions respectively. Measuring criteria for participatory activities were determined by tasks as shown in Table 1. Meanwhile, the measurement of activities in task project activities is shown in Table 2.

Table 1. Grid of participatory activities.

Group number (5 students/group)	Activity theme	Criteria for learning success
1	Presentation and discussion on how to determine the force on a rod and the types of force.	Can use methods for determining the force and type of force on each rod Can calculate the force and type of force on each rod
2	Presentation and discussion about the stresses that occur in each member of the frame	Can calculate the amount of stress and type of stress on each rod.
3	Presentation and discussion on determining the size and type of profile	Can calculate safe profile sizes for frame construction.

Table 2. Project outcome activities.

Group number (5 students/group)	Activity theme	Criteria for learning success
1	Tensile testing practicum	1. Make specimens as standard testing material
2	Impact testing practicum	
3	Compressive testing practicum	2. Create a report. 3. Interpret test result data

For cognitive achievement (in the form of assignments) each student will be given the task of making a book report which includes material: Types of frame construction, how to determine the style and types of forces. The first step in participatory activities, students are involved in determining the lecture syllabus. Based on students' personal needs in understanding the concept of material mechanics

and based on a review of competence in designing structures. Meanwhile, other achievements in cognitive mastery are in the form of Quizzes, mid-tests, and final tests in the form of questions with material that includes book reports.

3. Results and Discussion

Based on Table 3, in general, the activity achievements of each student are depicted. Starting from discussions on determining the syllabus and during presentations and group discussions on each assigned material. The project that is the student's assignment is to carry out practical testing of material strength. Based on Table 4, almost all members in the group show activities according to the task. This is reflected in the results of the criteria determined in the practicum project activities.

The form of the quiz given in the activity step is an independent question-and-answer simulation. Each student is invited to answer the questions given. The quiz results were done from the 15 students. The achievement of student activities in increasing knowledge (quis) is in a good category. Mid-semester exams are given to measure students' knowledge in the middle of the semester. New lecture material is provided at 50% of the total provided.

Table 3. Results of achievement of participatory activities.

Group number (5 students/group)	Activity theme	Criteria for learning success
1	Discussion on how to determine the magnitude of force and type of force on a member of a construction.	1. The group is quite skilled in explaining how to determine the magnitude of force and type of force on the rod of a construction. 2. Members in the group show a role in discussion and presentation activities.
2	Presentation and discussion on selecting bar/profile dimensions in a construction.	1. In general, all members show the ability to answer/discuss the selection of the dimensions of the rods used and can provide an explanation of the selection table for the dimensions of the rods/profiles. 2. All group members show participation in the discussion.
3	Presentation and discussion on deflection deformation.	All group members can explain the meaning of deflection and deflection angle and can calculate the amount of deflection that occurs using the double integral method.
4	Presentation and discussion of statically indeterminate constructions.	1. The group can differentiate certain constructions from statically indeterminate constructions. 2. The group can explain how to solve statically uncertain Levels 1 and 2.

Table 4. Results of activities on the project.

Group number (5 students/group)	Activity theme	Criteria for learning success
1	Hardness testing practicum	1. The group can study the manual and make a standard specimen. 2. The group carries out the correct testing steps. 3. The group makes a complete practicum report.
2	Tensile testing practicum	1. The group studies the ASTM tensile test book and makes its specimens. 2. The group explains the Tensile test steps. 3. The group interprets the Tensile test result data
3	Impact testing practicum	1. The group makes impact test specimens. 2. The group carries out the correct test steps. 3. The group can interpret the test result data.
4	Compressive testing practicum	1. The group studies the manual of the compression testing machine. 2. The group can analyse the compression test results data and make a report.
5	Flexural testing practicum	1. The group studies the manual of the flexural testing machine. 2. The group can analyse the flexural test data and make a report.

Activity measurement activities by looking at cognitive improvement (Final Semester Examination) are carried out after all other activities are declared to have taken place. Cognitive enhancement activities (from the final test) are very good. The presence of instructions and guidance from lecturers can increase student activity in lectures [3]. Lecturer involvement in participatory learning can act as an assistant, encourager, and guide for students in learning activities [10, 11]. Thus, in this learning, there is interaction between lecturers and students in discussing learning material. The implication of encouragement and guidance for students will increase the interaction and participation of the students themselves [12, 13]. A clear guidance process will increase student participation. Participation is a person's mental and emotional inclusion in a group situation that encourages them to develop their thinking and feeling power to achieve goals, together being responsible for these goals [14]. Based on the tasks given in Table 1, there is a relationship between tasks and student participation. Students' participatory activities in the learning process can improve mastery of the concepts of material mechanics being studied.

Based on Table 2, if students are faced with a problem and need direction to solve it, they will easily implement their participation potential. Students' active participation in learning is realized in the form of physical, mental, and emotional activity in responding [15]. The response given by students can be seen through something physical, it can also be invisible, such as analysing something, thinking about something, or looking for an answer to a problem. Implementation

of participation will result in several benefits such as being able to make better decisions (because of the many contributions of thought), greater acceptance of the orders given, and a feeling of being needed [16]. Giving assignments in the form of projects is also able to give birth to creative ideas in determining solutions faced by students [17].

Students' active participation in learning causes individuals to do something to understand the subject matter with full confidence and try to complete the practical questions and assignments given by the teacher, asking the teacher about material that is not understood [18, 19]. Be enthusiastic and collaborate in group assignments, express opinions to solve a problem, ask questions, and respond to other people's opinions about learning problems [16]. Apart from that, try to find concepts in completing the results of thoughts and discoveries verbally or in appearance as well as enthusiasm in teaching and learning activities [19]. Participation is needed in learning; students must be active in participating in learning. There is no learning if there is no activity [20]. That is why activity is a very important principle in learning interactions. Participatory learning can arouse citizens' motivation to learn to be independent [18, 12]. Participatory learning strategies require students to be active in planning, implementing, and evaluating so that they can improve their ability to master the concepts of the material they are studying [7, 9, 21]. Finally, this study adds new information as reported elsewhere [22-26].

4. Conclusion

The research results show that student participation increases in learning activities. This can be seen in carrying out discussions on determining the learning syllabus and carrying out assigned project tasks. With increasing student participation, it shows an increase in mastery of the concept of material mechanics. Data that there is an increase in mastery of these concepts can be seen when working on knowledge assignments in the form of quizzes, Mid-Semester Exams, and Final Semester Exams.

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