Development of Cooperative Problem Based Learning Models in Engineering Mechanics Learning

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ABSTRACT
This research is motivated by the observed low learning ability of students in the Engineering Mechanics course. Consequently, a Cooperative Problem-Based Learning (CPBL) model was developed with the aim of enhancing students' learning abilities in Engineering Mechanics. The CPBL model is a synergistic integration of two established learning models, namely Cooperative Learning (CL) and Problem-Based Learning (PBL). The research follows the development procedure outlined by Borg and Gall, modified into four stages: (1) initial research and information gathering; (2) planning, initial product development, and expert validation; (3) initial field trials and subsequent revisions; and (4) main field trials and final revisions.Verification of the CPBL model products involves Forum Group Discussions and validation by relevant experts in the field of engineering education. The results of the validity tests indicate that all CPBL model products are deemed valid and suitable for implementation in teaching Engineering Mechanics. The CPBL model underwent trials with Civil Engineering students at FT UNP, who were enrolled in the Engineering Mechanics course. The research findings demonstrate that the CPBL model is both valid and practical for teaching Engineering Mechanics. With valid and practical criteria, the CPBL model can be effectively implemented in Engineering Mechanics learning.

Keywords: *Cooperative Learning, Problem Based Learning, CPBL, Learning Outcomes, Engineering Mechanics*

1. INTRODUCTION

The rapid evolution of technology in response to the challenges presented by the 21st-century job market poses a significant issue for the field of education. Addressing this challenge requires an educational system capable of producing competent and reliable human resources (HR) [1]. Within an educational organization, effective human resource management and development are essential to achieving overarching goals. Elevating human resource performance is anticipated to yield a positive impact on educational performance, facilitating the institution in fulfilling its role within society and the professional realm [2].

Education is an inseparable part of the process of preparing quality, strong and competent human resources. Through education, quality potential workers are produced so that they are more productive and able to compete with other countries. Increasing human resource capacity and skills for the young generation of prospective workers is the responsibility of the world of education, both through formal and non-formal education channels which can complement each other, support and enrich each other [3]. Educational institutions must equip their graduates with a variety of more general skills, including life and career skills, learning and innovation skills, as well as skills in using information, media and technology [4].

The 21st century learning skills that students must have are called the 7Cs, namely: (1) Critical thinking and problem solving; (2) Creativity and innovation; (3) Collaboration, teamwork, and leadership; (4) Cross-cultural understanding; (5) Communications, information, and media literacy; (6) Computing and ICT literacy; (7) Career and learning self-reliance [5]. In entering the 21st century, students must have critical thinking skills, be creative, innovative, productive, be able to solve problems, have high work motivation, be able to collaborate and communicate, be skilled in using technology and information and have religious responsibility [6]. Increase The quality of education is the responsibility of all parties involved, including lecturers. Lecturers are required to take various approaches with

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certain learning models in each course they teach in order to provide various learning abilities [7].

Based on observations made through pre-survey questionnaires and interviews with several students regarding the Engineering Mechanics learning process in the Department of Civil Engineering, UNP, several problems were found, such as the lack of packaging learning in an interesting and fun model. In general, lecturers still use conventional models in teaching Engineering Mechanics. Learning tends to be dominated by lecturers, meaning that learning is still centered on lecturers (teacher centered learning). Lecturers often deliver teaching material as is, so that learning becomes boring and does not attract student interest.

Based on a survey of the ability to learn Engineering Mechanics in the last three years, there are still many students who have not obtained satisfactory results, in fact, each year it tends to decline. This low learning ability may be caused byMost students are not interested in arithmetic learning and need a lot of understanding and practice to master it. Students are less aware that Engineering Mechanics is the most basic learning that must be mastered. Apart from that, many students' attitude towards attending lectures is still not serious and they are less active in seeking other learning sources. Students' study habits tend to rely on the activeness of lecturers and are less able to learn actively and independently.

Engineering Mechanics is one of the skills courses that students in the Civil Engineering study program must master. Engineering Mechanics is the science of calculating the strength of building structures [8]. This course is a basic science for other structure courses. Students are required, apart from being able to analyze structural strength, to also be able to be involved in implementing infrastructure development projects in the construction industry. This is related to the competencies required in SKKNI, namely producing graduates who are able to face real conditions in the field.

Engineering Mechanics is a science that discusses immovable or static forces, with a state of movement equal to zero. This occurs when all the forces that load the structure and the support reaction forces cover each other, so that all forces are balanced [8]. Engineering Mechanics is also called the science of balance of forces. Engineering Mechanics is basically a development of physics, explaining everyday natural events related to the forces at work [9].

For Answering the problems above requires efforts to change the continuous learning process towards a better one that can increase students' reasoning power, creativity and critical thinking by implementing appropriate learning models. Lecturers are expected to be able to mix the learning process with innovative learning models by placing students not as objects but learning subjects. They are expected to be able to explore knowledge concretely and independently. The ability to determine the right learning model will have an impact on student learning success and the achievement of learning goals [10]. Lecturers are expected to be able to deliver teaching material appropriately and pleasantly without causing boredom so that students understand the teaching material more easily, are more creative and innovative.

Based on backgroundwas developedCooperative Problem Based Learning model(CPBL) with the hope of improving student learning outcomes in the Engineering Mechanics course and creating meaningful learning.The CPBL model developed in this research is a combination of Cooperative Learning (CL) and Problem Based Learning (CPBL) models.

The CL model is a group learning model for collaborating to construct knowledge and each student has a contribution to their group. CL is learning that requires working together in groups to achieve joint learning goals [11]. This learning model pays attention to individual learning so that each member is involved in contributing to group work. In groups, students are directed to work together to communicate with each other to solve a problem. This model directly hones students' collaboration, communication and problem solving and critical thinking skills in learning.

CL is one of the simplest learning methods, and is the best model to start with for educators who are new to using a cooperative approach [12]. CL uses small groups with heterogeneous members of 4-5 people. This model places greater emphasis on student participation attitudes in order to develop cognitive and affective potential [13].

PBL is a designed learning modelas a context for students to learn critically and be skilled insolve the problemand obtain essential knowledge and concepts from the teaching material studied. In this case, students are involved in investigations for problem solving that integrate skills in sharing teaching material content.PBL is a learning model that presents various authentic and meaningful problematic situations to students which can function as a springboard for investigation and investigation [14]. PBLdesigned primarily to help students develop their thinking skills, problem solving skills and intellectual skills. PBL can be an alternative that can be used to develop mathematical learning abilities. The PBL model offers the potential to help students develop flexible understanding and lifelong learning skills [15].

The CPBL model developed is a learning model designed based on procedures and work standards from a combination of two learning models. CPBL ModelThis is expected to be a challenging learning model for students to learn and work together in study groups to find solutions to real problems in life [16].Through this model, students are more active in constructing their own knowledge, starting learning when faced with a problem, then representing it in an idea expressed in the form of pictures, tables, diagrams, mathematical equations, or others.Through this learning model, it is possible to improve students' mathematical learning abilities in the

Engineering Mechanics course and be able to improve their learning outcomes.

2. METHODS

The type of research conducted in this study falls under the category of Research and Development (R&D). The development method employed is a systematic approach used to explore, create, and test a product with the primary goal of ensuring that the resulting product possesses high scientific value and can be deemed reliable [17] [18]. This research was carried out within the Department of Civil Engineering at the Faculty of Engineering, UNP, involving five teaching lecturers and twenty students as research subjects. Descriptive analysis was employed as the data analysis technique.The research adhered to the development procedures outlined by Borg and Gall, modified into four stages: (1) initial research and information gathering; (2) model planning; (3) model development and expert validation; and (4) field trials and subsequent revisions [19]. The research and development process of the CPBL model is depicted in Figure 1.

For produce learning products carried out product trials. Product trials are intended to collect data on the quality of CPBL products. This trial is a series of product implementation, evaluation and revision of the CPBL model that will be developed. The purpose of this product trial is to test the developed CPBL model meets the criteria of validity and practicality. Test Preliminary trials were conducted on experts to determine the construct validity and content validity of the CPBL model. The experts (experts) who were the subjects of the trials were civil engineering experts, learning model experts, research methods experts, and vocational education experts.

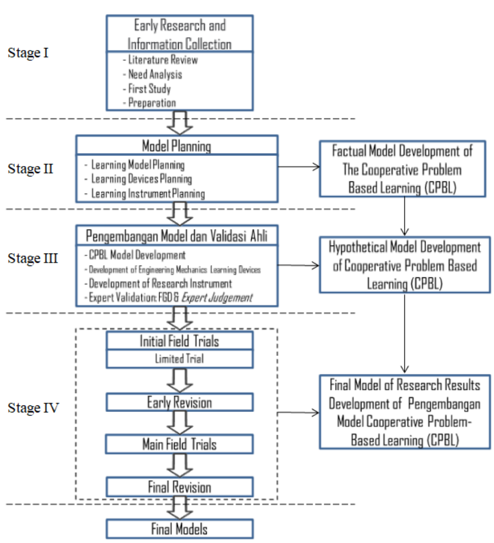

Figure 1. CPBL Model Research and Development Procedures

To determine the construct validity of the CPBL model and its tools, the Kendall W test, commonly called the Kendall Concordance coefficient, is used. This test is carried out to determine whether there is alignment or compatibility of judgments between each expert regarding the construct validity of the model being developed [20]. The Kendall Concordance coefficient significance test was carried out with the help of the SPSS version 17 program.

To find out the validity of the CPBL model and its tools, the Aiken's V test is used. Based on the findings of an evaluation of an item's degree of representation of the construct being assessed by a panel of experts, Aiken develops the Aiken's V formula to get the content-validity coefficient [21].

To determine the practicality of the CPBL model, it was obtained through a questionnaire in the form of responses or opinions from lecturers and students. Alternative answers to some of the statements given by the respondents were provided with a score with the following criteria: 5 = very good, 4 = good, 3 = enough, 2 = poor, and 1 = very poor. Determination of the average score obtained by adding up the values obtained from many indicators. Next, giving a practicality value with the formula [22]:

$$FV = \frac{SO}{MS} \times 100\%$$

Information:
FV = Final Value
SO = Score Obtained
MS = Maximum Score

The practicality category of the CPBL model in Engineering Mechanics learning can be seen in Table 1 [23].

Table 1. Practicality Category

Achievement Rate (%)	Category
81 - 100	Very practical
61 - 80	Practical
41 - 60	Practical enough
21 - 40	Less practical
0 - 20	Not practical

3. RESULTS AND DISCUSSION

3.1. Initial Research and Information Gathering Stage

On This stage begins with conducting a preliminary study of the problem under study. The preliminary study in this research is a review of the relevant literature. Need analysis is the stage of gathering information, especially related to the lectures in Statics that have been going on so far, studies on the implementation of CPBL learning that have been carried out in other fields, as well as the constraints experienced by students in attending classes in Statics. This stage is intended to carry out a needs analysis for the CPBL model to be developed.

In this initial stage, an exploratory approach was employed to investigate various aspects. The exploration encompassed both qualitative and quantitative data. Qualitative data included information on Engineering Mechanics learning and the CPBL model. On the other hand, quantitative data, derived from preliminary trials, focused predominantly on aspects related to Engineering Mechanics lectures. These included workload, attractiveness, difficulties encountered in learning Engineering Mechanics, the dynamics between lecturers and students, as well as an assessment of the existing curriculum and statics course tools that have been utilized thus far.

The research undertaken in this stage comprehensively explored the entire engineering mechanics learning process, scrutinizing aspects ranging from input to process and output. The insights obtained from each facet of this investigation will form the foundational basis for the subsequent development of a CPBL model that is intended to be both valid and practical. The forthcoming model development phase will adhere to the planned procedures, integrating the knowledge and findings acquired during the exploratory phase. This approach ensures a systematic and informed development process, aligning with the identified needs and challenges revealed in the initial stages of the research."

In addition to data collection through literature study, this research also involved field studies, employing surveys and interviews with both teachers and students. These field studies aimed to gain a deeper understanding of the real-life circumstances surrounding the education of engineering mechanics. The participants included several lecturers with expertise in education and learning, as well as those specifically teaching Engineering Mechanics courses. Through this activity, a comprehensive profile of the Engineering Mechanics course was generated. This profile encompassed essential elements that would serve as the foundation for developing the CPBL model. The insights gathered from the field studies contributed valuable information about the practical aspects of engineering mechanics education, ensuring that the subsequent development of the CPBL model would be well-informed and closely aligned with the specific context of the Department of Civil Engineering at FT UNP.

Field study is a survey research activity that aims to: (1) collect information related to the implementation of Engineering Mechanics learning and what components have been used in learning; (2) find out the shortcomings and obstacles in the implementation of learning that has occurred so far; (3) get student responses to Engineering Mechanics learning; and (4) get responses from the lecturers in the Engineering Mechanics course regarding the scope of material, time, learning facilities, and learning models that have been carried out.

To maximize the learning model development process in this study, a needs analysis was carried out for students and lecturers. A needs analysis was carried out with the aim of answering the needs for the development of the CPBL model in Engineering Mechanics learning. The instrument used in the needs analysis is a questionnaire. This questionnaire is used to determine the need for the development of the CPBL model in Engineering Mechanics learning. A needs analysis questionnaire for students was given to 33 students who were taking the Engineering Mechanics course. A Likert scale with 40 statement items that fall into the categories of strongly agree, agree, undecided, disagree, and disagree makes up this score. A needs analysis questionnaire for lecturers was given to 5 lecturers in the Engineering Mechanics course. This survey comprises sixteen Likert-scale statement items that fall into the following categories: strongly agree, agree, undecided, disagree, and disagree. The level of achievement of respondents in analyzing student needs regarding the development of the CPBL model can be seen in Table 2.

Table 2. Level of Achievement of Needs Analysis Respondents

No.	Needs Analysis	Score Max	Score Acqusition	TCR (%)	Category
1.	Learning Preparation	825	633	76.73	Need
2.	Learning Information	825	631	76.48	Need
3.	Implementation of Learning	1650	1239	75.09	Need
4.	Learning Materials and Models	1155	868	75.15	Need
5.	Tutoring	495	349	70.51	Need
6.	Group task	825	643	77.94	Need
7.	Assessment of Learning Outcomes	825	630	76.36	Need
	Average Student Needs	6616	4993	75.47	Need
	Average Lecturer Needs	480	416	86.67	Need

From the results of the analysis, it was obtained that the level of achievement of student respondents on average 75.47% needed Engineering Mechanics learning using the CPBL model. Likewise, the level of achievement of the lecturers who teach the subject shows that an average of 86.67% requires the CPBL model in Engineering Mechanics learning.

3.2. Model Planning Stage

In the planning stage, the steps for developing the CPBL model were prepared based on the results of the initial research phase and factual findings in the field, as follows: (1) considering and choosing a learning model; (2) designing an Engineering Mechanics learning model; (3) identify engineering mechanics learning activities and develop engineering mechanics learning management strategies; and (4) developing the material organizing structure and management pattern of Engineering Mechanics learning with the planned CPBL model.

The model planning stage was carried out based on the results of preliminary studies and factual findings in the field, including: (1) CPBL model design in Engineering Mechanics learning; (2) learning device design, consisting of Semester Learning Plans (RPS), Learning Program

Units (SAP), Engineering Mechanics textbooks; and (3) research instrument design.

The CPBL model planning scheme in Engineering Mechanics learning can be seen in Figure 2.

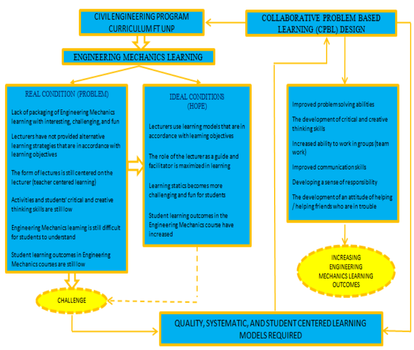

Figure 2. CPBL Model Planning Scheme in Learning Engineering Mechanics

3.3. Model Development Stage and Expert Validation

This stages, initial product development was carried out, namely the initial design of the CPBL model, learning device design, and research instrument design. So, in this stage a conceptual CPBL model, RPS and SAP, Engineering Mechanics teaching materials in the form of a manuscript, and research instruments are produced.

The CPBL conceptual model scheme developed can be seen in Figure 3.

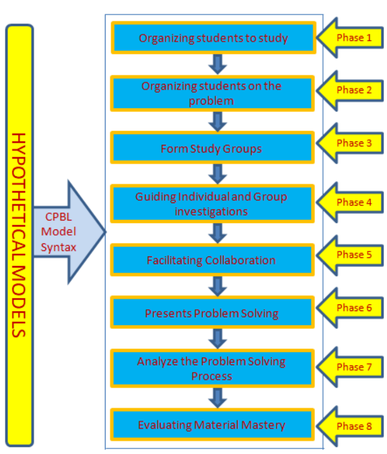

Figure 3. Schematic of CPBL Conceptual Model of Development Results

Validation experts carried out in this stage, including: (1) validation of the conceptual CPBL model through Focus Group Discussion (FGD); (2) model device validation, consisting of RPS and SAP, Engineering Mechanics teaching materials; and (3) validation of research instruments, consisting of an Engineering Mechanics learning achievement test and a questionnaire on the responses of subject lecturers on the practicality of the CPBL model, and a questionnaire on student responses on the practicality of the CPBL model.

Validation this conceptual model is carried out by experts (expert judgment) in the field of education, experts in the field of learning, experts in the field of evaluation/assessment, and experts in the field of Engineering Mechanics. These experts were purposively selected based on their competence and experience in the field related to the learning model being developed. The results of the CPBL model validation by experts can be seen in Table 3.

Table 3. CPBL Model Validation Results

No.	Validator Assessment	Skor maks	∑s	Aiken's V	Note
1.	CPBL Model Construction	400	360	0.9	Valid
2.	CPBL Model Contents	240	218	0.908	Valid
3.	RPS and SAP	940	830	0.883	Valid
4.	Mechanics Textbook	680	590	0.868	Valid
5.	Lecturer's Guidebook	420	360	0.857	Valid
6.	Student Handbook	440	382	0.868	Valid
7.	Learning Outcome Assessment	352	336	0.955	Valid
8.	Research Instrument	128	108	0.844	Valid

The results of the CPBL model construction validity test in Engineering Mechanics learning obtained an average Aiken's V value of 0.900. Overall for all statement items are in the classification above 0.80. Based on the validity value classification criteria where $0.80<V\leq1.00$: very high, it can be interpreted that all items of CPBL model construction validation by experts are declared valid and feasible to be tested.

The results of the content validity test of the CPBL model in Engineering Mechanics learning obtained an average Aiken's V value of 0.908. Overall for all statement items are in the classification above 0.80. Based on the validity value classification criteria where $0.80<V\leq1.00$: very high, it can be interpreted that all CPBL model content validation items by experts are declared valid and feasible to be tested.

Validation was carried out by experts on RPS and SAP covering several aspects, namely content, construction, and language. There are 4 experts involved as validators. the results of the RPS and SAP validity tests obtained an average Aiken's V value of 0.883. Overall for all statement items are in the classification above 0.80. Based on the validity value classification criteria where $0.80<V\leq1.00$: very high, it can be interpreted that all RPS and SAP validation items by experts are declared valid and feasible to be tested.

Validation was carried out by experts on Engineering Mechanics textbooks covering several aspects, namely content, construction, and language. There are 4 experts involved as validators. The results of the validity test of Engineering Mechanics textbooks obtained an average Aiken's V value of 0.868. Overall for all statement items are in the classification above 0.80. Based on the validity value classification criteria where 0.80<V≤ 1.00: very high, it can be interpreted that all the validation items of Engineering Mechanics textbooks by experts are declared valid and feasible to be tested.

Validation was carried out by experts (experts) on the lecturer's handbook covering several aspects, namely content, construction, and language. There are 4 experts involved as validators. The results of the validity test of the lecturer's guidebook obtained an average Aiken's V value of 0.857. Overall for all statement items are in the classification above 0.80. Based on the classification criteria for the validity value where 0.80 <V≤ 1.00: very high, it can be interpreted that all validation items for the lecturer manual by experts are declared valid and feasible to be tested.

Validation was carried out by experts (experts) on the student manual covering several aspects, namely content, construction, and language. There are 4 experts involved as validators. The results of the validity test of the student manual obtained an average Aiken's V value of 0.868. Overall for all statement items are in the classification above 0.80. Based on the criteria for classifying the validity value where 0.80<V≤1.00: very high, it can be interpreted that all validation items for the student guidebook by experts are declared valid and feasible to be tested.

Validation was carried out by experts on the student manual covering several aspects, namely content, construction, and language. There are 4 experts involved as validators. the results of the validity test of the learning outcomes assessment instrument obtained an average Aiken's V value of 0.955. Overall for all statement items are in the classification above 0.80. Based on the classification criteria for the validity value where 0.80<V≤1.00: very high, it can be interpreted that all validation items for the assessment of learning outcomes by experts are declared valid and feasible to be tested.

Validation was carried out by experts on research instruments including construction aspects. The experts involved as validators are 2 people. The results of the research instrument validity test obtained an average Aiken's V value of 0.844. Overall for all statement items are in the classification above 0.80. Based on the validity value classification criteria where 0.80<V≤1.00: very high, it can be interpreted that all research instrument validation items by experts are declared valid and feasible to be tested.

The trial of the CPBL model in learning Statics on a limited scale of 4 students showed a gain score at each meeting. There is an increase in Engineering Mechanics learning outcomes obtained by students starting from the first, second, and third meetings. The increase in learning outcomes during these 3 meetings indicated that the CPBL model was quite effective in teaching Engineering Mechanics. The increase in student learning outcomes on a limited scale during the trial of the CPBL model in Engineering Mechanics learning can be seen in Table 4.

Table 4. Improved Student Learning Outcomes in Trials CPBL Model Limited Scale

No	Meeting	Average value
1	I	56
2	II	72
3	III	84

Source: Results of Data Processing

From the increase in student learning outcomes during the CPBL model trial in Engineering Mechanics learning for a limited scale in Table 2, it can be explained that there is a significant gain score at each meeting. Figure 4 shows the increase in student learning outcomes in a limited scale trial. These results indicate that the CPBL model in Engineering Mechanics learning developed in this study is quite effective and can be implemented in a wider scale trial.

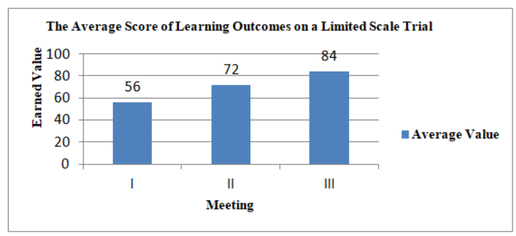

Figure 4. Diagram of Increasing Student Learning Outcomes in a Limited Scale Trial

Consistency of positive trend in learning outcomes implies that the CPBL model successfully contributed to enhancing the students' understanding and proficiency in the subject matter. The gain scores obtained at each meeting highlight the progressive impact of the CPBL model on the students' academic performance. These findings provide compelling evidence of the model's efficacy in facilitating the learning process for Engineering Mechanics and suggest its potential as an effective pedagogical approach in this educational context.

The increase in student learning outcomes on a broader scale during the trial of the CPBL model in Engineering Mechanics learning can be seen in Table 5 and a graph of the increase in Engineering Mechanics learning outcomes can be seen in Figure 5.

Table 5. Improving Student Learning Outcomes in a Wider Scale Trial of the CPBL Model

No	Meeting	Average value
1.	I	60
2.	II	69
3.	III	74
4.	IV	75
5.	V	78
6.	VI	80

Source: Results of Data Processing

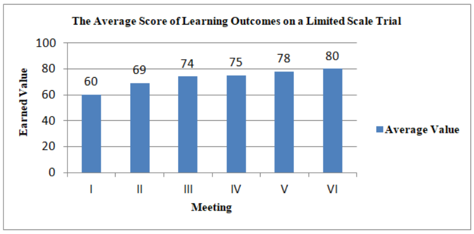

Figure 5. Diagram of Increasing Student Learning Outcomes in a Wider Scale Trial

4. CONCLUSION

Based on the results of the CPBL model development research in Engineering Mechanics learning, several conclusions can be drawn as follows:

First, model CPBL in learning Engineering Mechanicshas been validated by experts relevant to this research field. The results of the validity test showed that all products of the CPBL model, such as CPBL model books, lecturer handbooks, student handbooks, and textbooks Engineering Mechanics, as well as learning outcomes assessment instruments Engineering Mechanics declared valid by all experts with an Aiken's V score above the average.

Second, based on practicality test resultsit is proven that the CPBL model in Engineering Mechanics learning is very practical to use. This can be seen from the acquisition of a fairly high percentage of average scores from lecturers' and students' assessments of the practicality of the CPBL model.

The results of this CPBL model development research have the following implications:

First, this CPBL model is proven to be valid and practical to apply in learning Statics in vocational education. This learning model has many advantages, one of which can create a more lively classroom atmosphere and make students more active in participating in learning activities. Besides being able to improve student learning outcomes in Engineering Mechanics learning, this learning model can also improve generic skills for students including critical thinking skills, problem solving abilities, teamwork skills, communication skills, having a sense of responsibility, and mutual respect. and appreciate.

Second, the CPBL model developed can assist lecturers in organizing the Engineering Mechanics learning process to help students become more active and creative and understand learning material more quickly. The CPBL model can improve the quality of the learning process, because through problem-based learning it makes the problem a starting point or anchor that guides lectures and cooperative learning emphasizes strong collaboration between students, student-lecturers, and student-learning materials.

Third, the results of this study can be used as a reference and inspiration for the emergence of new ideas related to the development of Engineering Mechanics learning models and other learning forimproving the learning strategy that has been carried out so far so that it can further improve the quality of learning in the future.

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