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Effect of implementation demonstration method on students' understanding and practical skills in Milling Machine

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Abstract: Mechanical engineering education is crucial in providing students with the knowledge and skills to become competent professionals in the industrialized world. This learning process involves integrating theoretical knowledge and practical skills, and the demonstration method naturally helps combine both aspects. The demonstration method has proved promising in improving students' understanding and practical skills in Milling Machining Techniques. This study aims to improve the understanding and practical skills of Mechanical Engineering Class XI students at SMK Negeri 5 Padang, Indonesia by implementing the demonstration method. Using a quasi-experimental research design, the results showed that the demonstration method significantly improved students' understanding and skills. The evaluation by a team of validators also showed that the method was valid regarding materials, methods, and instruments. There was a difference and an increase in scores between the control and experimental classes. In the written comprehension test, the control class scored an average of 65, while the experimental class scored 80.62. In the practical skills test using the evaluation sheet, the control class achieved an average of 48.87, while the experimental class achieved an average of 74.78. This indicates a positive influence and change in the student's understanding and practical skills after implementing the demonstration method.

Keywords: *Engineering education; Learning method; Hard skills; Mechanical engineering*

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1. Introduction

Mechanical engineering education is crucial in equipping students with the necessary knowledge and skills to become competent professionals in the industry (Alabadan et al., 2020). One of the key challenges in learning mechanical engineering is to achieve optimal levels of student understanding and practical skills (Kuppuswamy & Mhakure, 2020). Mechanical engineering education should be more than just the delivery of information; it should be a holistic experience that combines theory with practice (Van den Beemt et al., 2020). Encouraging students to engage in challenging practical projects can help them overcome problems they encounter while learning (Hawari & Noor, 2020). Effective learning methods can be essential in achieving these learning goals (Ji, 2020). Learning mechanical engineering requires integrating theoretical knowledge and practical skills, and demonstration methods naturally facilitate this integration (Deng et al., 2020). While several studies have highlighted the effectiveness of demonstrations in improving concept understanding and practical skills, much research has not looked in depth at how this method can stimulate student creativity.

The demonstration method is a promising approach to improve students' understanding and practical skills in milling engineering subjects (Bhaskar et al., 2020;

Guo et al., 2020). Demonstrations facilitate the understanding of complex concepts and provide students with hands-on experience, allowing them to apply theory practically (Salame & Makki, 2021). Although this method is widely recognized, few studies have specifically investigated the effect of using demonstrations on students' creativity in learning milling machining techniques (Mourtzis et al., 2022). Creativity plays a crucial role in learning machining techniques, as innovation and unique solutions are often required to meet challenges in the industrialized world (Gajdzik & Wolniak, 2022). In this context, creativity includes not only the ability of students to find new solutions but also the ability to see and solve problems innovatively (Kardoyo et al., 2020). However, it should be noted that although creativity is recognized as a critical element of learning, the direct influence of the demonstration method on student creativity has not been fully established. It is essential to understand how demonstration methods in the context of milling machining techniques can catalyze student creativity (Soomro et al., 2023). In developing creativity, students are expected not only to be able to complete routine tasks but also to have the ability to think further, to see innovative potential in any situation, and to generate new ideas that can be applied in the real world.

This method allows students to experience first-hand the application of theoretical concepts in a practical context, opening the door to creative exploration (Onu et al., 2023). This process can enable students to hone their ability to create new solutions to engineering problems, improve their adaptability to change, and develop the innovative mindset required in the industry (Chatwattana et al., 2023; Kostov et al., 2022). In the context of learning milling technology, hands-on experience with machines and tools and interaction with lecturers through demonstration methods can be a trigger for students to go beyond conventional boundaries and create more efficient and effective solutions (Ożadowicz, 2020; Wang et al., 2023). Giving students the freedom to apply their knowledge creatively can stimulate confidence and intrinsic motivation, laying the foundation for measurable creativity (Conradty & Bogner, 2020).

Based on preliminary observations at SMK Negeri 5 Padang, Indonesia, especially the Mechanical Engineering class in the subject of Milling Machining Technique, the factor that causes the low value of students' learning outcomes and practical skills is the learning process that still uses conventional methods or one-way lectures so that students are less active and have difficulty in understanding the basic concepts of milling machining techniques such as types of Endmill, main movements and basic principles of milling machines. Thus, students become less excited and less motivated in the learning process, resulting in student learning outcomes that are less than optimal and not as expected (Hanif, 2020). Two factors affect student learning outcomes. The first factor is internal factors, which come from the students themselves. Meanwhile, the second factor is external factors, including parents, economy, family, teachers, and social environment (Maksum et al., 2021). Based on the literature review, the demonstration method in practical learning can improve students' understanding and practical skills (Inderanata & Sukardi, 2023; Shang, 2018). This study aims to test the effectiveness of the demonstration method in improving students' understanding and ability to operate milling machines.

2. Methods

2.1 Subject and research procedures

The type of research carried out was quantitative research using an experimental approach (Miller et al., 2020). The experimental approach was chosen as the most appropriate method in this study because it is the best way to test research hypotheses about cause-and-effect relationships between variables that allow a researcher to observe and influence certain phenomena. The experimental method analyzes narrative data such as pool analysis (Miller et al., 2020). This research is quasi-experimental. The use of a post-test-only control design in this research design was carried out by dividing the research subjects into two classes, namely the experimental and control classes. (Rogers & Révész, 2019; Stratton, 2019).

This research was conducted in SMK Negeri 5 Padang, and the research subjects were selected using the stratified random sampling technique. As a result, a sample of 32 students of class XI TPM was obtained and divided into 16 students of class XI TPM 1 (Experiment class) and 16 students of class XI TPM 2 (control class). This research was implemented during an odd semester from July to December 2023. The flow of the research procedures is shown in Figure 1.

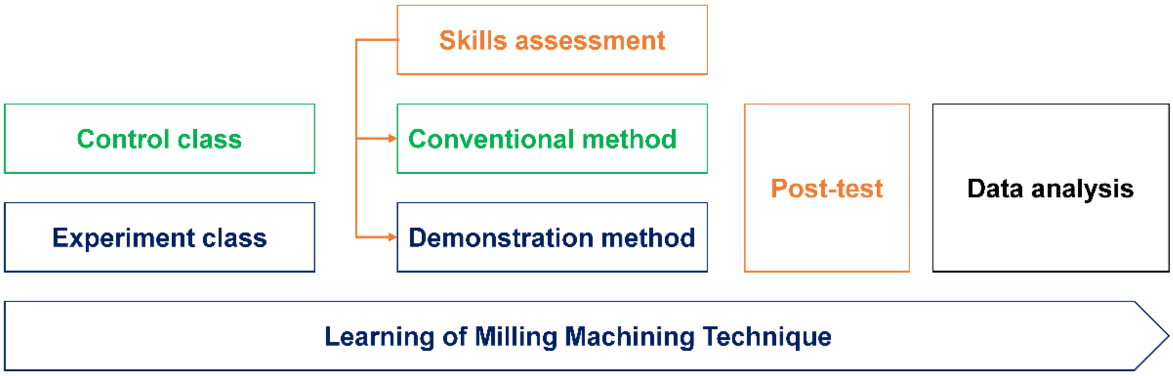


Figure 1: Research procedure

2.2 Data collection techniques and analysis methods

In this study, three variables were revealed in each learning class (experimental and control class): students' understanding of and skills in operating milling machines. The instruments and data analysis methods used for each variable are presented in Table 1.

Table 1: Instruments and data analysis

Variables	Data collection techniques	Instruments	Analysis data
Student understanding	Post-test	Achievement test	Descriptive analysis and T-test
Skills in operating Milling machines	Performance assessment	Rubric	Descriptive analysis and T-test

The achievement test tested Students' understanding at the end of the lesson (post-test). Before being used, the achievement test was tested on other classes (not on students in the experimental and control classes), with the number of questions before 40 items. The test results were analyzed using the Pearson product-moment correlation coefficient (Spearman, 1987). Based on the analysis results, 20 items were valid for use (Appendix 1). The reliability of the test items was analyzed using Cronbach's Alpha, with a test result value of 0.0771.

The rubric instrument for assessing the students' skills in operating the milling machine was validated by two experts, teachers, and lecturers who taught milling techniques. The results of the expert assessment were analyzed using the V-coefficient formula (Aiken, 1985). The analysis of the student assessment rubric gave a V-coefficient of 0.81, which means that this instrument can be used to assess students' skills in operating the milling machine. The assessment of the student's skills in operating the milling machine was carried out by a non-teaching teacher in the research class (experimental and control), so the assessment can be objective.

3. Results and discussion

3.1 Student's understanding

The results of the descriptive analysis of the student's comprehension data in the post-test activities are presented in Table 2. There were 16 students in each class (experimental and control). The average score of the students in the experimental class was also higher than in the control class; the average score of the students in the experimental class was 80.62, and in the control class, it was 65. The standard deviation in the control class (10.16) was higher than that in the experimental class (9.81), indicating a more significant variation in student scores in the control class, whereas it was more uniform in the experimental class. The highest score of the students in the experimental class was 100, and the lowest was 65, while in the control class, the highest score was 85, and the lowest was 45.

Table 2: Descriptive analysis of student's understanding

Statistics	Experiment class	Control class
Students number	16	16
Average	80.62	65
Std. Deviation	9.81	10.16
Max. Score	100	85
Min. Score	65	45

The students' post-test scores were normally distributed and homogeneous based on the prerequisite test results. Normality analysis using Kolmogorov Smirnov test using SPSS software. Table 3 shows students' post-test scores in the experimental class [Sig.: 0.051; K-S: 0.213] and in the control class [Sig.=0.200; K-S= 0.125]. This homogeneity test uses Levene's test with calculations performed by SPSS; if the significance value of the data is greater than 0.05, then the data can be said to be homogeneous. Based on the results of homogeneity analysis using Levene's test, students' post-test scores are not significantly different from the population [Sig.= 0.915; Levene's Statistic = 0.012]. Based on the normality and homogeneity test results, the post-test data that tests students' understanding can be continued by conducting an independent sample T-test.

Table 3: Normality and homogeneity test of students' understanding scores

Class	Normality		Homogeneity	
	Sig.	Statistics (K-S)	Sig.	Levene's Statistic
Experiment	0.051	0.213	0.915	0.012
Control	0.200	0.125		

The analysis results using T-test on students' post-test score data are presented in Table 4. Based on the results of data analysis using the T-test, it was found that there was a significant difference between the experimental class and the control class [t = 4.424; Sig. (2-tailed) < 0.05 = 0.000].

Table 4: Independent Sample T-test of student understanding assessment results

	F	Sig.	t	df	Sig. (2-tailed)
Equal variances assumed	0.012	0.915	4.424	30	0.000
Equal variances are not assumed.			4.424	29.962	0.000

3.2 Skills in operating Milling Machine

This practical activity and assessment were carried out on both experimental (Demonstration method) and control (conventional method) classes, with slightly different jobs but the same practical objective of assessing students' skills in the milling machine operation. A descriptive analysis of students' practical skill scores in both classes is presented in Table 5. The average score of students' ability to operate the milling machine in the experimental class was 74.78, and the score of students in the control class was 48.87. This shows that the student's ability to operate the milling machine in the experiment class is higher than that of the control class. However, in the experiment class, the standard deviation of student scores is higher (17.77) than in the control class (12.18); this indicates that the difference in the distance of student scores in the experiment class is higher than in the control class. The highest student score in the experiment class was 95, while in the control class was 68.67. The lowest student score in the experiment class was 43.33, and in the control class was 30.00.

Table 5: Descriptive analysis of student's skills in operational Milling Machine

Statistics	Experiment class	Control class
Students number	16	16
Average	74.78	48.87
Std. Deviation	17.77	12.18
Max. Score	95	68.67
Min. Score	43.33	30.00

Furthermore, prerequisite tests (normality and homogeneity) analyzed the students' scores, as shown in Table 6. The normality test of the class value of the skills to operate the Milling Machine of students in the experimental class [Sig.: 0.174; K-S: 0.180] and in the control class [Sig.= 0.021; K-S = 0.232]. This shows that the values in both classes are normally distributed. The homogeneity test of the values of the experiment and control classes [Sig.= 0.104; Levene's Statistic = 2.819], indicates that the value of student skills in operating the Milling Machine is homogeneous. Based on the prerequisite tests that have been carried out, it is found that the data on the value of students' skills in operating the Milling Machine can be continued to do the independent sample T-test.

Table 6: Test of normality and homogeneity of ability to operate the Milling Machine

Class	Normality		Homogeneity	
	Sig.	Statistics (K-S)	Sig.	Levene's Statistic
Experiment	0.174	0.180	0.104	2.819
Control	0.021	0.232		

The analysis results using a T-test on the data of students' skills in operating the milling machine are presented in Table 4. Based on the results of data analysis using the T-test, it is found that there is a significant difference between the experimental class and the control class [t = 4.810; Sig. (2-tailed) <0.05= 0.000].

Table 7: Independent Sample T-test of students' skill scores in operating a Milling Machine

	F	Sig.	t	df	Sig. (2-tailed)
Equal variances assumed	2.819	0.104	4.810	30	0.000
Equal variances are not assumed.			4.810	26.553	0.000

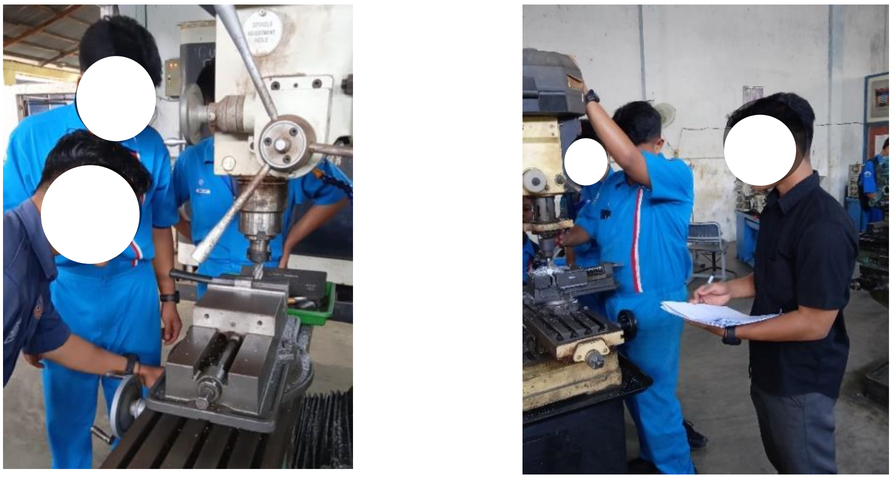
3.3 Differences in students' learning activities from both classes

Experimental classes, where demonstration learning methods are employed, are compared with control classes that utilize conventional learning methods based on students' levels of understanding and practical skills; there are, of course, significant differences both in the use of learning methods and in the results of the assessment of students' learning activities. The researchers chose the demonstration method as a solution to the problems faced by the students because this method relies on an object to be demonstrated or observed, as the researchers did in the material about cutting tools on the milling machine, namely by providing examples in the form of tools both with available tools and showing the shape of the cutting knife and the results to direct examples on the practical tools to be used, besides that the researchers also provided illustrations of images on the blackboard as support. This object will be the main factor in the learning process because the object presented will stimulate the minds of the students to be able to create ideas and illustrations directly in the minds of the students so that during the practice the minds of the students will be more open in channeling their skills and abilities during the practice.

(a) (b)

Figure 2: a) Demonstration learning method process (b) Conventional learning method process

In the control group, there were differences due to conventional learning activities that only used the lecture method, such as explaining the material of the Milling Machine cutting tools, and then students were asked to memorize the material to do questions and answers. This method runs less optimally because students will have enough difficulty reading the beginning if they do not get good supporting media. Consequently, the results of students' understanding and practical skills using conventional learning methods are categorized as low. This difference can also be seen in the results of the hypothesis test analysis and the average value of classes using the demonstration method and classes using conventional learning methods.



(a) (b)

Figure 3. (a) Process of experimental class practice activities (b) Process of control class practice activities

The demonstration method allows students to see and interact directly with the process being taught better to understand the techniques and procedures in the placement. By watching the teacher operate the Milling Machine, students can gain a strong visual understanding of what is expected in the placement. In addition, the demonstration method allows the teacher to directly guide the students as they perform the skills being taught, so the teacher can provide immediate feedback to correct student mistakes quickly. It also allows students to be actively involved in learning as they can see and do for themselves, which enhances their understanding. Demonstrations also help explain complex concepts to students more efficiently, as the teacher can clearly illustrate how theoretical concepts are applied in practice. Hands-on assistance also reduces the risk of accidents to students. The teacher can act if there are things that will cause accidents to the students.

4. Conclusion

Based on the study results, there is a significant difference in the student's understanding and skills in operating a milling machine between the experimental class using the demonstration method and the control class using the conventional method. The demonstration method involves the teacher giving the students direct examples of operating a milling machine. This demonstration includes steps such as showing how a professional operator operates a milling machine, explaining the purpose of each step, allowing students to try the exercise under the teacher's guidance, giving feedback by asking students what they have done, and instructing the whole class to do the exercise under the teacher's guidance.

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Declarations

Author contribution

Robby Eliga Putra: Formulate a research design and concept, collect, analyse and interpret data, and writing - Original Draft. Eko Indrawan: Research methodology, investigation, analyse and interpret data. Aprilla Fortuna: Visualization, writing - review and editing

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Competing interest

The authors declare no conflict of interest in this research and publication.

Ethical Clearance

This research has received permission from the institution where the research was conducted and the research subject has agreed to be a sample in this study.

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