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Research paper

Mobile Technical Calculators with a Flipped Classroom for Sustainability Machining Process

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Abstract

This study has the primary objective in planning machining practices early on through the precision of machining parameter analysis with mobile technical calculators combined with the flipped classroom. This research will compare the calculations with manual and mobile phone devices and measure the effectiveness of the media concerning the three elements of sustainable development, i.e., economic, environmental, and social. The research used posttest-control design experiment design which was divided by random sampling. The sampling technique uses saturated sampling. Data collection using performance test, observation, and questionnaire. Data analysis using independent sample test. The results show the use of mobile technical calculator with a flipped classroom is more effective in generating the accuracy of analysis than manual analysis. The t-test results state that there is a difference if this media is applied in machining practice. Also, students' perspectives on the application of these auxiliary media analyzes have an increasing impact on sustainable machinery processes concerning elements in sustainable development.

Keywords: *mobile technical calculator, flipped classroom, machining parameters, sustainability machining process*

1. Introduction

The shift of the Millennium Development Goals (MDGs) to Education for Sustainable Development (ESD), which later developed into Sustainable Development Goals (SDGs), is a concrete step for the inhabitants of the earth to start thinking about life in the long-term [1], [2]. The destruction of nature, the scarcity of energy, the shrinking of clean water, the widespread crime, the extinction of living beings, the eroded nature of the material, and so on have led to a massive movement to overcome the global problems concerning the ages of the earth [3]. If it does not happen the worst possibility is that our children and grandchildren cannot enjoy the true nature of life that provides sustainable comfort, security, and sustainability.

SDGs have 17 noble goals that end in 2030 [4]. One of the roles discussed in this paper is that SDGs play an essential role in producing quality education [5] and contribute to the efficiency of material consumption in production [6], [7]. In the vocational field, ESD management models have evolved according to the characteristics of vocational education in each country [8]. Differences in work culture, job opportunities, demography, climate, workplace challenges, etc. make ESD move continuously and complement the functioning of each essential element. Sustainable development which is the coherence of three elements of the environment, social, and economic [1] is a strategy to consider in doing a work that is useful for three aspects. If it refers to technical education, the functions of these three elements have an enormous impact in practicums both in the laboratory and vocational workshops [9].

Vocational workshops are especially vulnerable to environmental damage, workplace hazards, and energy wastage and material consumption [10]. Many workshop managers are less concerned about the importance of governance that promotes sustainable development. The impacts resulted in the workshop becoming a dangerous place to practice not as a convenient means of learning vocational and provide services in the achievement of student competence to the maximum. Also, production workshops that have large machines and require meticulous work have spaces that must be neatly arranged, ergonomic, pay attention to the principles of occupational safety and health, and provide a sustainability series of production [11]. Production workshops in vocational schools with large machine capacity one of which can be found in engineering majors.

Vocational high school in Indonesia which has a production machine workshop is the competence of machining engineering expertise. This skill competency provides an opportunity for its graduates to work in the manufacturing industry, entrepreneurship to open a machining workshop, and to go to engineering college [12], [13]. The three graduate alternatives result in the competence of dynamic engineering techniques following the apparent needs of stakeholders. To achieve the expected competence of graduates, the competence of machining engineering skills is divided into two: basic and advanced competencies [14], [15]. Basic competence of machinery is the basic of students to study the mechanical technique, the introduction of tools, the use of measuring instrument, primary machining process, the use of safety and health equipment theoretically. Advanced competencies are provided for developing both conventional and non-conventional machining skills with complex types of work and the use of multi-tools in the production process.

Some facts found in the field that there is a waste of material use practices and damage to chisels and machine components because students are less careful in mastering the parameters of machinery.

The machining parameters play an important role in determining the quality of student practice outcomes [16]–[18]. The precision or dimensions of whether or not the product depends on how the student can know the material, the engine speed, the depth of the feed, the time, the type of chisel is used, and the selected cooling system [19]. Many students are less concerned about the preliminary practice plan by analyzing machining parameters and practice requirements with effective and efficient procedure standards. As a result, the material becomes imprecise, the engine components become damaged, and the chisel becomes quickly worn which impacts the time it takes in a single production process [20], [21].
Planning of machining work is the basis for determining the production process [22] adapted to the tools and machines used and the materials employed. Manually calculating machining parameters often gives errors in measurements. It is because of the nature of human knowledge in the analysis varies significantly in its ability according to the analytical power held by each student [23]. Dullness in calculation causes the production process to be less effective and efficient. Although the analysis of machining parameters can be done manually with the help of calculator and Microsoft Excel, it is still also found errors in the calculation process. The limitation of students' numeracy skills requires special software or online tools used to correctly calculate machining parameters that impact sustainability in an effective and efficient machining process.
There are now many specialized engineering calculators that are used to calculate machining parameters [24]. The app can be mobile and online. Both types have the same function though from several different vendors. The technological advancement of this machining analysis does not seem to be heard well by many students and vocational teachers in Indonesia. The lack of understanding of the software engineering calculator is due to the lack of use of smartphones accommodate the function of play store [25] provided for instructional media by teachers. If the teacher just never taught in such a way, then the student certainly does not know such information. Also, the use of an online version of the technical calculator that can be accessed by some vendors is not yet known by many teachers and students. The use of learning media is still rarely known unless applied in the environment of colleges who began to pay attention to the efficiency of the work by planning from the beginning through the online technique calculator.
The use of engineering calculators performed when the machining practicum can take a long time in addition to the students should prepare equipment and practice equipment, but students are also required to operate the technical calculator in the mobile version. The planning of the students can be done in a separate time or online interaction between teachers and students. The challenge of future learning is how to apply the MOOC to the efficiency and effectiveness of quality learning [26]–[28]. MOOC can be blended learning, hybrid learning, e-learning, flipped classroom, and other online learning [29]. When it comes to asynchronous learning, the interaction that emphasizes student-centered learning by demanding student independence is the use of the flipped classroom method [30], [31].
The flipped classroom is a kind of blended learning, but in its implementation, students learn online outside of school activities [32], [33] to hone their cognitive abilities [34]. Because of the flipped shape, the results of self-study at home according to the instructions of teachers brought to school according to the schedule of subjects for discussion. It means students experience two home and school learning processes that give their cognitive skills even stronger [35]. About the technical use of calculators, students first perform the analysis with the help of scientific calculator software available in the mobile as instructed by the teacher delivered through eLearning in Edmodo form. Teachers convey the problem through Edmodo where the problem is a job that will be done students in the future. By doing early analysis and checking the result of machining, parameter calculation gives students more ready to do machining process.
The success of the machining process of the students depends on the readiness of the students well planned. The meaning of continuous machining process as the impact of long-term activities of the use of technical calculator both from equipment and machinery wiring, efficient use of materials, determining the duration of work, and energy generated. For that reason, it is necessary to do planning research as the root of continuous development in the production process. This research will lead to the use of mobile technical calculators that are integrated into Edmodo in the form of the flipped classroom. This study compares the length and accuracy of machining parameter calculations in manual and mobile technical calculator and identifies whether there are differences in the changes between groups with the media or not. Also, this study will also measure students' perspective in using the mobile technical calculator against sustainable development elements.

2. Methods

A. Research Design

This study was included in this type of experiment with the dominant approach being quantitative [36], [37]. The experimental design used was posttest-only control design [38]. This design is used because it can produce differences based on the t-test of the use of mobile technical calculator with other classes that use the calculation of machining parameters manually. The group is divided into two groups A and B selected randomly by random lottery. Group A is the group that will be treated with a mobile technical calculator, while group B is a natural group (without software treatment). Here is a picture of the research design used.

Treatment	R	X	O_1
Comparison	R		O_2

R = random assignment
X = treatment with mobile technical calculators
O_1 = group A (experiment class)
O_2 = group B (control class)

Fig. 1. Experimental design in research

B. Research Setting

The sampling technique used in this experiment is saturated sampling [39] with population use as the data sample. The subjects of the study were class XI Vocational High School 2 of Yogyakarta with a total of 36 students. The division of the group is divided into two by drawing. The draw to distribute in two groups is A and B. Group A as experiment group and group B as a control group. The object of the research is the subjects of advanced machining process for the focus of the work is the practice of high-end lathe with the following design work.

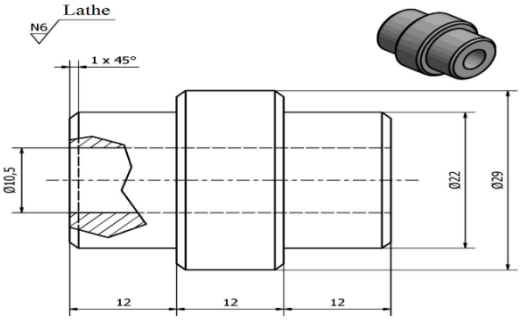


Fig. 2. Setting the problem for experimentation

The Jobsheet experiment shown in Fig. 2 using material from mild steel with diameter 40 mm and initial length 40 mm. The chisel used for the experiment is High-Speed Steel (HSS). The existence of job settings as experimentation material makes it easy to compare the efficiency of time and work process and effectiveness in determining spindle spin speed, feeding, and cutting speed.
Specifically for the experimental class, the use of engineering calculators is used by combining with Edmodo in the form of the

flipped classroom. The experimental setting is done to Group A to calculate first with mobile technical calculators before doing the practice, while the control class goes the usual learning. About Fig. 2, the two classes perform different ways of analysis.

C. Data Collecting

The data collection in this experimentation uses performance tests, observations, and questionnaires. The performance test is used in the assessment of students' machining results according to the temporary job used based on the observation and measurement of the product. The instrument used refers to a series of holistic assessments that include assessment of preparations, processes, and products [40]. Preparation assessment includes student observation in preparation of equipment and work equipment, preparing machining parameters, preparing work steps, and performing running maintenance. Process assessment includes observation of student practice in the process of the lathe, the use of measuring instruments, precision in applying machining parameters, applying lathe based on work steps that have been prepared, and the use of safety equipment. The product assessment is measuring the student's practice product and taking into account the time required for the completion of the product. The collected data will be the information between groups A and B in applying machining practices. Also, this study will disseminate questionnaires to samples in Group A related to the use of technical calculators with flipped classroom impact on sustainability machining process. The indicator used refers to the three elements of sustainable development whose results can lead to economic, environmental, and social [41].

D. Data Analysis

Quantitative data analysis on this experimentation using descriptive statistics. This research is a real experiment with sample randomization system, so it is not necessary to test homogeneity because it is not applied pretest. Furthermore, the tested data is performed data normality for the use of statistical tools used. After that, data analysis was continued by performing a t-test to determine whether there was a difference in the use of mobile technical calculators with a flipped classroom with non-experimental class. Data analysis is also used to calculate the percentage of efficiency value generated in the application of the treatment. For the questionnaire data, the researcher calculates the percentage of student perception in the use of mobile technical calculators with a flipped classroom distributed in group A.

3. Result and Discussion

A. Justification of Mobile Technical Calculator

Justification of the use of mobile technical calculator using one example of the vendor used is Turning Calculator (TC). In TC requires several parameters [17], [18], [42] to be filled include diameter, cutting length, cutting speed, spindle speed, feed per revolution, feed per minute, and so on. Completion of the value of each variable will result in the time required for the work. Here is an example in the application of mobile technical calculator with the lengthening information extending from Ø 40 mm to Ø 29 mm with 40 mm lathe length.

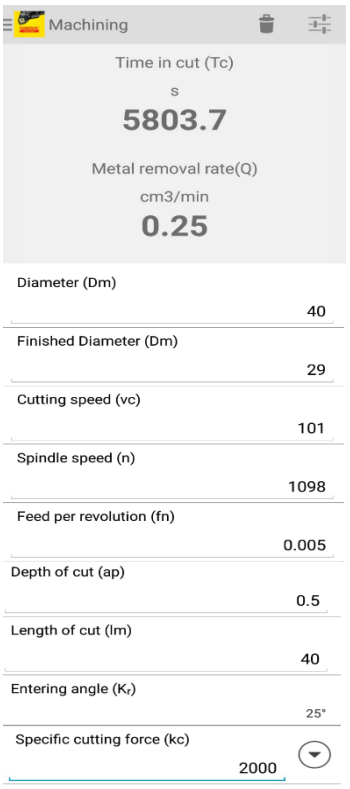


Fig. 3. Display of mobile turning calculator

B. Mobile Technical Calculator combined Flipped Classroom with Edmodo

The learning of the lathing practice done by group A is done online with an asynchronous system which means the students are required to learn independently according to the instructions of the teacher [31], [43]. Provision of scheduled materials and jobs to be undertaken at subsequent meetings may be accessible to students with the aim of providing an opportunity for students to try to design machining parameters. Preparing for earlier calculations of machine parameters provides an opportunity to calculate precisely the greater. Also, the impact that may be produced next is the efficiency and effectiveness of the production process. Here's how the presentation of the task of calculating machine parameters using a flipped classroom with Edmodo.

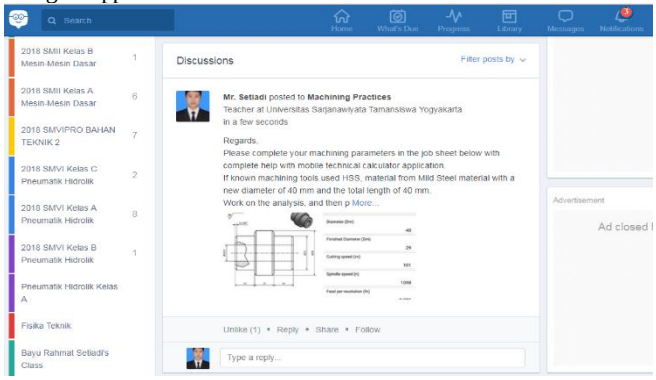


Fig. 4. Learning flipped classroom with Edmodo

C. The accuracy of manual analysis with technical calculators

The difference between manual analysis calculations and mobile technical calculators can be seen with the results of the analysis of each student. Students who counted manually were done before the practice whereas students using mobile technical calculator had been given far away because of using flipped system learning. All students collect the timing analysis to calculate the time required in one production process. With the same variable constants (use of HSS and mild steel) is expected to measure the same result. The following is the distribution of the accuracy of the results of each student's calculations.

Based on Fig. Five it can be seen that there are 80% of students residing in the ellipse who respond appropriately in the analysis of machining parameters with the help of flipped classroom and mobile technical calculators, only 13.33% of which answer accurate, comprehensive analysis with a manual. These results indicate that the role of calculator-based software provides accurate analysis values compared with manual analysis. Errors in manual calculation give the respondent ignore the parameter analysis. If this simple error is left, it will undoubtedly have an impact on the next production process which requires the scores to fill the machining parameters. When planning is structured, then the subsequent good impact is the efficiency of time, work, and use of materials or tools [44], [45].

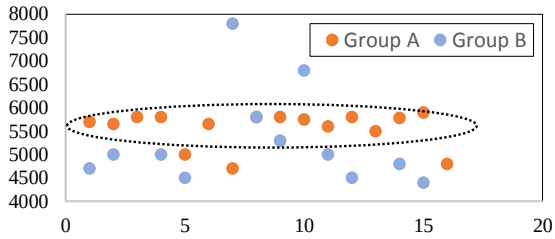


Fig. 5. Accurate analysis of machining parameters with manual and mobile technical calculator

If linked in the element of sustainable development, then the use of mobile technical calculators and flipped classroom can provide high economic value by showing the efficiency of time, work, and the use of materials and tools. Also, it provides an insight into the practice of environmentally-friendly machinery where practices designed by students from the outset with proper analysis can provide the workload of machine and tool operations to be light by the specifications. If it exceeds its working capacity, it will inevitably produce environmental pollution both over coolant waste, noise, and increase the working room temperature. The use of such media will undoubtedly provide a social value to students wherein starting future machining practices they will be accustomed to working by applying the principles of careful planning to produce high-efficiency value in the work process. This habit will continue to be attached to the students so that it becomes a sustainable lifestyle [46].

D. Differences in results between groups

The next step is to practice the grouping of both groups A and B. Differences in group results are seen in the preparation, process, and product of students [47] based on a holistic assessment in the form of observation and measurement. To find out how big the value graph of each student can be seen in Fig. 6 below.

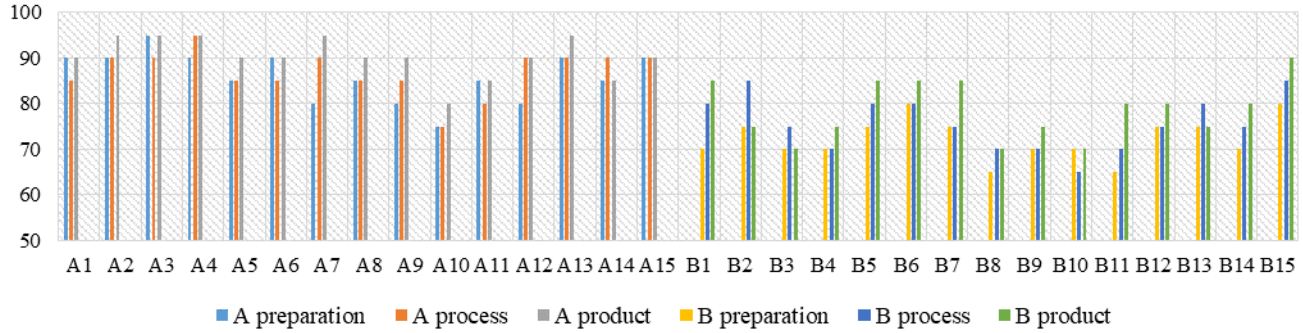


Fig. 6: Comparison of scores between groups A and B

Based on the tabulation in Fig. 6 indicates that there is a visual difference in values on the graph. Preparation by Group A has an average of 86, a process with an average of 87, and a rolling practice product with an average of 90.33. For group B, the preparation performed has an average value of 72.33 while the value of the lathe process is 75.67 and the value of the practice product is 78.67. Based on these results there is a difference between the use of mobile technical calculators with a flipped classroom in machining practice with manual machining parameter analysis.

To know whether there is a difference of influence between giving treatment with no hence can be tested prerequisite normality test. Based on the analysis of Normality test with Kolmogorov-Smirnov found that group A is normally distributed with a significance value of 0.121 and group B is normally distributed with a significance value of 0.171. It means that the use of parametric statistics in the different test can be continued by performing independent sample test. The results of independent sample t-test with SPSS are as follows.

Table 1: Independent Sample Test Between Group A And B

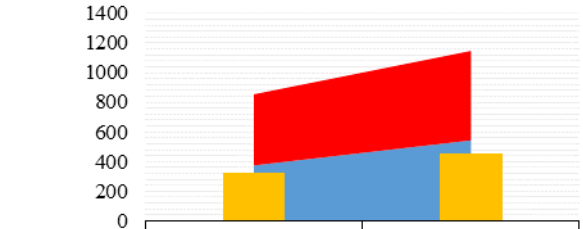
		Levene's Test for Equality of Variances		**t-test for Equality of Means**						
		F	***Sig.***	***t***	***df***	***Sig. (2-tailed)***	***Mean Difference***	***Std. Error Difference***	***95% Confidence Interval of the Difference***	
									Lower	***Upper***
Value	Equal variances assumed	1,110	,301	7,287	28	,000	36,667	5,032	26,360	46,974
	Equal variances not assumed			7,287	27,454	,000	36,667	5,032	26,351	46,983

Based on the results in Table 1 shows that there is a significant difference between the applications of mobile technical calculators by flipped classroom with manual analysis of machining parameters. Sig value. (2-tailed) <0.05 proves that the use of mobile technical calculators with flipped classroom can provide significant changes to students' practice results. Also, the presence of these calculators provides an opportunity for students to practice machinery sustainably to become a commitment of students to prioritize planning as a foundation in the process of continuous machining [48], [49].

E. Analysis of mobile technical calculator with a flipped classroom against three elements of sustainable development

The next research activity is to analyze the perspective of using mobile technical calculator with a flipped classroom on three elements of sustainable development. The questionnaire was given to group A by giving before and after treatment. With

consideration of economic principles, environment, and social, students are asked for their opinion in the form of a Likert questionnaire. The results of the tabulation of data as follows.



	Pre-treatment	Post-treatment
Environment	480	604
Economic	375	544
Social	324	455

Fig. 7. The perspective of students before and after being given treatment that affects the elements of sustainable development

Referring to Fig. Seven shows that there are three elements of sustainable development concerning economic, environmental, and social principles. The positive impression of students on the acceptance of mobile technical calculators is a sign that machining practices can be combined with information technology tools. Given these results, the paradigm shifts that proper planning will have a future sustainable impact. Such an understanding should be given to the students that in carrying out a sustainable machinery process it is necessary to consider these three aspects.

The application of elements in sustainable development can be made with small things through the utilization of existing technology media. Advances in information technology began to touch on the machining process. The e-learning approach in practical learning needs to be applied once it can build stronger student cognitive [32]. Applying the flipped classroom allows students to master information early and deepen their knowledge to apply when learning in the classroom. Vocational learning practice cannot be separated from the cognitive learning process. Require knowledge in mastering machining parameters to give students more ready in doing machining process. By estimating the time and process of work with some machining variables, the machining practice results in quality and precision according to the job sheet direction.

4. Conclusion

This study has several findings that provide an application of machining technology to practical learning in vocational. The use of mobile technical calculator with flipped classroom gives an important role in practice planning. Through the calculation automatically with the application can good accuracy of analysis than manual. With careful planning, the production process in machining provides accurate, precise, and qualified results. The results of this study also provide information that the use of mobile calculator technical in planning machining practices able to provide efficiency and effectiveness in work. Also, the use of such media has a positive impact on the three elements of sustainable development that includes economic, environmental, and social values. It means the use of mobile technical calculators with a flipped classroom is capable of supporting a sustainable machining process.

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