The influence of engineering students numerical reasoning on the academic achievement of Computer Numerical Control (CNC) course

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Abstract. The research aimed to examine the relationship between numerical reasoning abilities and academic achievement in CNC (Computer Numerical Control) course and the contribution of numerical reasoning of CNC course. This study employed a survey method with correlational causal relationships. The stratified random sampling proportional technique is employed with 30 engineering students. The results of the study show the significant relationship between numerical reasoning and academic achievement of CNC course with \( r = 0.76 \). The two coefficients are terminated by independent variables (predictors of X) for changes in the dependent variable (Y criterion) of \( R^2 = 57.8\% \). The results show that there is a positive relationship between the two variables. Therefore, the learning experiences should provide the opportunities for students to develop their numerical reasoning.

1. Introduction
At present almost all manufacturing plants are in dire need of Computerized Numerical Control (CNC) personnel, who are trained. This need will increase sharply in the future [1]. Therefore, training is important in the Department of Mechanical Engineering, because almost all fields of work such as engineering managers, skilled worker constructors, organizations, and others are faced with this technology in various fields, for example: As a constructor must be able to know the possibilities of production, new plans can be realized. As skilled workers must be able to know and program the CNC (Computerized Numerical Control) system.

It is undeniable that the quality of the industrial sector is largely determined by the quality of human resources in it. In other words, it is human ability that determines the sophistication of equipment and methods and new ways in the industry. Along with the development of science and machinery that has penetrated every industry in Indonesia, the new tools and methods are becoming increasingly complicated. Therefore, human ability is also required to be able to overcome that complexity.

One of the human abilities that is needed by the industrial sector, especially in the field of machinery technology, is how vocational students can solve the engineering problems that arise in the industry
well. The need for personnel who are able to solve such problems is increasingly urgent, because in the future the problems that arise will increase, both in terms of quality and quantity.

In teaching CNC lecturers practice extra time and energy to carry out teaching activities. In certain subjects related to numerical reasoning such as mathematics, calculus, engineering mechanics, engine dynamics, statics lift and so on, it is necessary to inform students about schematization of the mindset in detail, so that it is easy for students to follow.

To achieve this, there needs to be success in education, success can be seen in the basic concepts of assessment and teaching-learning processes, where the process has a number of components that are interconnected with each other. In this case it means that the success of certain learning achievements will be influenced by the basic knowledge obtained previously. Ausebel called Learning Transfer [2]. Learning transfer is the influence of another learning atmosphere. The first transfer of learning will affect the material being studied, the second will affect learning habits, learning strategies, and general skills acquired from previous learning.

The problem of learning transfer is the problem that will be solved through this research, by applying the contribution of Numerical reasoning to abilities in CNC (Computerized Numerical Control) practice. The researcher suspects whether there is a relationship between numerical reasoning and ability in CNC practice (Computerized Numerical Control)? Is there a positive relationship between Numerical reasoning and the results of learning the CNC Machine practice?

1.1. Numerical reasoning ability
The term reasoning ability in this study leads to capability as a result of student learning during teaching. The term is learning capability [3]. In numerical reasoning contains three learning capabilities, namely ability, intellectual, and cognitive strategy.

Intellectual ability is also called procedural knowledge, namely student capability which enables them to control their environment symbolically by using symbols of language and mathematics. This ability contains the activity of applying rules / formulas in the problem-solving process. Thus, a problem cannot be solved without knowledge of a rule that contains a link between concepts in mathematical formulations. The third learning capability in the form of cognitive strategy is the ability of students to manage themselves to carry out the process of learning and thinking. Students who have high ability in cognitive strategies are more independent in learning and thinking. As a result, they have their own thoughts in dealing with and solving problems.

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The ability to synthesize is the ability to manage and combine material to obtain new structures to solve problems. Finally, evaluation ability means the ability of students to make decisions. Both quantitatively and qualitatively so that problems can be solved properly.

Numerical Reasoning tests consist of numbers that are certain to form a series [5]. Broadly speaking, numerical reasoning still strongly emphasizes cognitive abilities, namely in reasoning and logical abilities in mathematics. For CNC Machine Practice it is emphasized in cognitive abilities in addition to psychomotor abilities. Numerous acquired cognitive abilities and numeric and mechanical abilities. In practice the CNC machine also requires information about, object area, angles, surface bias, blanket area and all of them are in numerical reasoning ability, and emphasized on psychomotor abilities, besides that accuracy is also needed to support precision in making a Work Unit. In addition, skills in practice also should not leave their affective, attitude and cognitive aspects.
Furthermore, and the description above, we can see the relationship between ability in numerical reasoning and the success of CNC Machine practice. In other words, there is a significant contribution between numerical reasoning ability and the practice of CNC machines.

2. Methodology
This study used a survey method. Because through the method can be obtained information relating to symptoms at the time the research was conducted [6]. The design used is correlational design. With this design, we will see the extent to which one variable has another variable relationship. The strength of the relationship can be seen through the correlation coefficient [7].

The variables examined in the study consisted of one independent variable and one dependent variable.
- Free Variable (X): Numerical Reasoning
- Bound Variables (Y): Learning Outcomes CNC machine practice

The study population was all students of the Mechanical Engineering Department. Sampling is a student of Mechanical Engineering, who has followed the practice of CNC machines. Determination of the sample is done by Proportional Stratified Random.

While collecting data, the instrument used for numerical reasoning ability data obtained by using numerical reasoning instruments in the form of a questionnaire developed by Jim Barrett and Geoff Williams [4]. Whereas to obtain CNC machine learning results obtained from the documentation of the Mechanical Engineering Department.

3. Results and discussion
To test how much the relationship of numerical reasoning to CNC machine learning achievement is used Pearson Correlation, with the help of SPSS 10.00 for a window computer. To get convenience in analyzing and interpreting the data above, the data can be seen in the following table:

![Correlations Table](image)

**Figure 1.** Summary of correlation test calculations.

Based on the table, the correlation between numerical reasoning and the learning outcomes of CNC $r = 0.76$. Tests carried out by two tails with the case is 30. The criteria, if the significance is below or equal to 0.05, $H_a$ is accepted. When compared to the table, the size of the table with $n = 30$ on the 5% error is $r_{table} = 0.296$. And at 1% error is $r_{table} = 0.409$. This means $0.76 > 0.409 > 0.296$. So, it can be concluded that there is a positive relationship between numerical reasoning and learning achievement in CNC machine practice. Thus, the data obtained from the sample can be generalized to the population where the sample is taken or the data reflects the state of the population.
To find out the percentage effect of the independent variable (predictor) on changes in the dependent variable, it can be seen in the following table.

| Model Summary | Change Statistics |
|---------------|-------------------|
| Model         | R     | R Square | Std. Error of the Estimate | R Square Change | df1 | df 2 | Sig. F Change |
| 1             | .760a | .578     | 4.4318                        | .578            | 1   | 28   | .000          |

a. Predictors: (Constant), PRAKTEK CNC

Figure 2. Summary of the large model coefficients for the termination of predictors.

From the table above, R Square (terminated coefficient) is 0.578 or 57.8%. This means that the amount of the coefficient terminated by the independent variable (predictor of X) on the changes in the dependent variable (Y criterion) is 57.8% while the remaining 42.2% is influenced by other variables besides the independent variable.

3.1. Discussion

From the results of this study the things that can be found is that there is a positive relationship between numerical reasoning and CNC machine practice learning. Numerical reasoning contributes significantly to CNC machine learning achievement by 57.8%. In this case the lecturer of CNC machine practice must consider the characteristics of students in teaching, especially for students who lack numerical reasoning.

It supports the studies of Amstrong [8], Williams [9], Brooks & Pui [4], Ciampa et al. [10]. It reveals analytical scoring and high numerical aptitude play significant influence on the students’ academic performance. It implies that mechanical engineering education-designers should create a curriculum ensuring the students have a sufficient numeric aptitude level to apply mathematics, engineering science, and technology principles necessary for analyzing, modeling, and solving engineering problems. It is important not only for the teaching-learning purpose, but also for ensuring the students’ better future career.

4. Conclusion

Based on the research that has been done, conclusions can be drawn: First, there is a positive and significant relationship between numerical reasoning and CNC machine practice learning outcomes of r count = 0.76. Second, the magnitude of the terminated coefficient (contribution) of the independent variable (predictor X) on the change in the dependent variable (y criterion) is R square (coefficient terminated) = 0.578 or 57.8%. While the remaining 42.2% is influenced by other variables.

4.1. Implications

Reasoning is the highest ability in the intellectual ability, both according to Gagne and Bloom as revealed in the study of theory. Attempts to give problems to students can be taken delivery of questions that contain problems related to mathematical fields, so that numerical reasoning will increase. Besides that, the issue of numerical reasoning to students can be revealed in the form of case submission. While in CNC machine practice, giving problems about making workpiece programs, lecturers can refer to programming examples contained in the CNC handbook, or can also make their own according to the material specified. Thus, the problems presented already contain quite a lot of variables so that students only complete the part of the variable that has not yet emerged, then the variables can be done through
logic thinking that is aided by certain mathematical formulations. practical problem. Thus, the effort that needs to be made to implement CNC practice exercises leads to how to prepare practical training material that can adapt it to field conditions and the world of work.

Based on the conclusions and implications above, it is suggested as follows:

• In general, it can be suggested that in teaching CNC machine practice courses, it should apply a specific teaching strategy, which can produce students' ability to learn CNC machines.

• More specifically, it should consider the characteristics of students in teaching, especially for students who lack numerical reasoning.

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