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Implementation of the Navigator on Project Work Learning Model to Improve the Competence of CNC Machining Practices

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Abstract. This study was aimed to explain the implementation process of the Navigator on Project Work (NOPW) learning model and to measure its effectiveness in improving the learning outcomes of the CNC Machining course. The method used in this study was classroom action research (CAR). The subject of this study consisted of ten students from Master's Program of Mechanical Engineering Education, Post Graduate Sch, UNY in the academic year of 2017. The research design included four stages, namely planning, action, observation, and reflection. The findings revealed that: (1) The implementation of the NOPW learning model worked effectively according to the formulated syntax. To obtain optimal results, the implementation of NOPW required 4 to 5 cycles; (2) The NOPW learning model was effective in improving learning achievement or CNC machining competencies. This was indicated by the increase in the mean score of students' achievement (competency), i.e. the learning achievement in the first cycle, the second cycle, the third cycle, the fourth cycle, and the fifth cycle were 77, 44, 48, 83, and 100 respectively.

Keywords: learning, competence, CNC machining

1. Introduction

Rapid technological developments in the industry require the industry to have high-quality human resources. One of the industrial fields that is currently experiencing developments and switching from manual technology to automation technology is manufacturing industry. Manufacturing works with manual equipment and machinery has now started to switch to automatic machines for time efficiency and product quality improvement. The production of machine components was used to apply manual machining processes, but now most of the manufacturing industries have used Computer Numerically Controlled (CNC) based machining processes. The CNC-based machining process is the process most widely carried out by manufacturing industries to produce machine components from metal materials (Sentot, 2014: 1).

The progress of CNC-based machining process technology is very rapid, demanding 21st-century vocational educator candidates to always update their competence continuously. 21st-century teachers are required not only to be able to effectively teach and manage classroom activities but also should build effective relationships with students and the school community, using technology to support the improvement of the quality of teaching, as well as reflecting and improving the practice of continuous learning (Darling , 2006). Therefore the concept of long life education must be instilled in prospective vocational educators thus they have the ability to independently learn in the face of changes in

industrial technology. This is important because an educator who always improves abilities according to the needs of the industry can provide relevant and up to date learning for students.

Law Number 14 of 2005 concerning Teachers and Lecturers and the Ministry Regulation Number 17 of 2007 concerning Qualifications and Competency Standards Teachers also explain that professional teachers are required not only to have teaching skills as required by the standards of pedagogical competence, but teachers must also be able to develop professionalism continuously as stated in professional competence. Teachers must always learn, discuss, and exchange experiences with industry practitioners so that the teacher competency gap can be reduced. Therefore the concept of learning with colleagues must be instilled in prospective vocational educators from an early age. One effort that can be performed is to apply a learning model that allows students to actively study, familiarize discussions, and exchange knowledge among students to improve the students' learning activities.

Problems in the learning process of prospective vocational educators especially experienced by the students at the Master's Program of Mechanical Engineering Education, Post Graduate School, UNY, are related to competency gaps. This gap is resulted from different competencies between the students who have already learned the practice of CNC machining in the bachelor program courses, who understand the lecturers' explanations more quickly, and some other students who have never learned CNC machining practices. There are still many students who ask simple questions to lecturers due to limited understanding of CNC. This gap provides a domino effect that students feel less confident in practicing CNC machining. This study is intended to overcome this gap. The concept offered is learning by implementing the Navigator on Project Work (NOPW) learning model. This study will also measure the effectiveness of the model in improving learning achievement or CNC machining competencies of the students. The implementation of the NOPW learning model in this lecture is expected to encourage prospective vocational teachers to always discuss and exchange knowledge with their peers.

This learning model is based on an active cooperative learning approach. The technical implementation with the project work approach is in the form of guided practices by modifying the Student Team Achievement Division (STAD) to have a smaller group that consists of two people per group. One student becomes an operator (operator) and the other student becomes a guide (navigator). This learning model is expected to provide an active learning experience through direct practices and accelerate overcoming competency gaps, increase the spirit of cooperation and confidence of the students in practicing CNC Machining.

In this STAD type cooperative learning model, students are grouped into small groups called teams then the entire class is provided with a presentation on the subject matter. Students are then assessed with a test. Individual values are combined into team values. In this type of cooperative learning model even though students are tested individually, students are still encouraged to work together to improve the performance and achievements of their teams. The STAD learning model emphasizes group formation. The group will discuss to solve a problem.

Previous studies on the implementation of STAD learning reported a significant increase in students' competencies (Zenginobuz and Meral 2008; Bernaus and Gardner 2008). In addition, there are many empirical research findings that reveal the effectiveness of STAD in classroom learning. For example, STAD learning enhances students' soft skills and hard skills (Sinarwati, 2014), and increases pleasure as well as improves learning outcomes (Saptono & Soetjipto, 2016).

2. Methods

This study is action research focused on classroom situations or often called classroom action research. This method is selected based on the following considerations: (1) research problems and objectives based on a number of information and observations, and (2) research problems and objectives based on reflective, collaborative and participatory actions in the classroom situation in the learning implementation. This study was carried out collaboratively with two observers. The first observer is a member of team teaching in the implementation of the learning process in the classroom, and the other is a video shooting operator. The subjects of this study consisted of ten students from the Master's Program of Mechanical Engineering Education, Post Graduate School, UNY in the academic year of 2017. This class action research was carried out on March 16 to June 16, 2018.

This study used a class action research model developed by Suharsimi Arikunto (2008: 16). This research model was selected because if there was a deficiency at the beginning of the action, then the improvement could be done in the next cycle until the problem could be solved. This class action research model consists of four stages, namely (1) planning / plan, (2) action / do, (3) observation / seeing, and (4) reflection. These four stages are referred to as one cycle. Therefore, in this context, the cycle is defined as a round of activities consisting of planning, action, observation, and reflection. Data analysis in this study used descriptive statistical analysis. The success of this classroom action research can be measured by an increase in learning or competency achievements with indicators that students can complete a project with a score of 100, and students' activities reach a minimum of 95%.

3. Results and Discussion

Pre-action activities are carried out before conducting the study, namely observation during learning activities in CNC Machining courses in the Master's Program of Mechanical Engineering Education, Post Graduate School, UNY in the academic year of 2017. The first observation was conducted on March 15, 2018. Observations showed that there was a CNC competence gap related to the initial understanding of each student. This condition occurred because students came from various S1 education backgrounds and different previous experiences. This indicated by the results of interviews that around 60% of students had never received Basic CNC Machining materials. As a result, the majority of students could not meet the expected basic competencies. Based on the results of the observation and interviews, a class action research was planned.

The implementation of the NOPW learning model was carried out in 5 cycles. Learning outcomes or competencies can be seen in Figure 1, while students' learning activities in the implementation of NOPW can be seen in Figure 2.

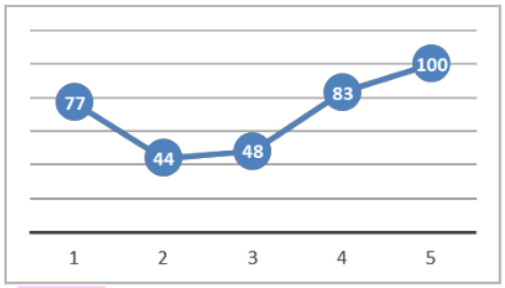

Figure 1. Learning Achievement in Each Cycle

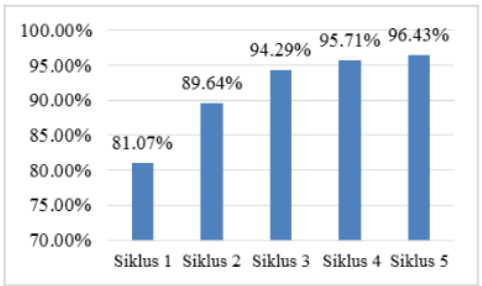

Figure 2. Students' Activities in Each Cycle

In cycle 1, the mean score of the first job learning achievement was 77. The achievement of this learning was good, although it was still far from the success criteria of 100. The first job learning achievement was quite good, this happened because the first job was in the form of simulation and was still basic with a low level of difficulties thus students complete the first job easily.

The implementation of the action in the cycle 1 referred to the NOPW learning model as the set syntax. The action was applied to CNC machining courses. Learning activities had proceeded according to the plan. From the results of the observation, it was found that the activity of students in the first cycle was 81.07%. Detailed activities can be seen in Table 1.

Table 1. Students' Activities in Cycle 1

No	Activity	Students' Activities (%)	Category
1	Opening	88	Very high
2	Lectures on supporting theories for practices	77	High
3	Grouping (2 students in each group)	100	Very high
4	Discussion (preparation, procedures & CNC program)	60	Low
5	Presentation of discussion results	77	High
6	Practice (operator-navigator model)	98	Very high
7	Assessment and evaluation	67	High
8	Closing	73	High
	Average	81.07	Very high

Table 1 shows that overall students' activity in cycle 1 is 81.07% categorized as very high. However, if it is examined in more detail, the new discussion activities are 60%, or still in the low category. The results of cycle 1 were discussed during the reflection stage. The results of the discussion at the reflection stage noted that there was only one group that could discuss intensively to work on the worksheet while the other groups were still passive and less confident. They asked directly to the lecturers more than discussing with groups or asking other groups. This means that discussion with friends was still not optimal. Even some students still focused on their own work. The results of the reflection were used as the basis for improvement in cycle 2.

Implementation of the actions in cycle 2 was conducted according to the plan. The average learning achievement in cycle 2 was 44. This result was lower than the learning achievement in cycle 1. This could happen because the second job was real and more complex. The fact was, along with the increasing learning activities, it was actually inversely proportional to the achievement of students' learning. The results of the observation showed that the activity of students in cycle 2 achieved significant improvement with the percentage of 89.64%. Detailed students' activities in cycle 2 can be seen in Table 2.

Table 2. Students' Activities in Cycle 2

No	Activity	Students' Activities (%)	Category
1	Opening	90	Very high
2	Lectures on supporting theories for practices	77	Tinggi
3	Grouping (2 students in each group)	85	Very high
4	Discussion (preparation, procedures & CNC program)	67	High
5	Presentation of discussion results	83	Very high
6	Practice (operator-navigator model)	100	Very high
7	Assessment and evaluation	100	Very high
8	Closing	100	Very high
	Average	89.64	Very high

Table 2 shows that overall student activity is 89.64%, including in the very high category. However, the number of new discussion activities increased slightly to 67%, and this figure was still far from the success criteria. This deficiency was used in the reflection stage. The results of the reflection with observers stated that there were some students who were still less active in the discussion, resulting in communication and collaboration in the groups did not run effectively. On the other hand, most groups experienced an increase in activities and were quite enthusiastic. In this second cycle action, some students started asking friends in other groups. The results of the achievement of learning and reflection were then used as materials for the improvement planning in cycle 3.

Implementation of the action in cycle 3 was performed according to the plan. The average learning achievement in cycle 3 was 48, slightly increased from cycle 2. These results indicated an increase in learning outcomes. This result was still far from the success criteria and categorized in the low category. Observation showed that students' activity in the cycle 3 experienced a significant increase compared to cycle 2, which was 94.27%. Detailed student activities can be seen in Table 3.

Table 3. Students' Activities in Cycle 3

No	Activity	Students' Activities (%)	Category
1	Opening	100	Very high
2	Lectures on supporting theories for practices	93	Very high
3	Grouping (2 students in each group)	90	Very high
4	Discussion (preparation, procedures & CNC program)	80	Very high
5	Presentation of discussion results	80	Very high
6	Practice (operator-navigator model)	98	Very high
7	Assessment and evaluation	100	Very high
8	Closing	100	Very high
	Average	94.29	Very high

Table 3 shows that overall student activity is 94.29% and is in the very high category. This shows that students' activities almost reach the success criteria. The results of the reflection stated that in this cycle, discussion activities were improved. There were no students who asked other groups or lecturers. All students focused on discussions in their respective groups. Nevertheless, the NOPW learning model continued in cycle 4.

The implementation of actions in cycle 4 was conducted according to the plan. The average learning achievement in cycle 4 was 83. This results showed that there was an improvement in very extraordinary learning achievement. These results were categorized into a very high category and were closed to the success criteria. Observations showed that students' activity in cycle 4 experienced an increase, which is 95.71%. Detailed student activities can be seen in Table 4.

Table 4. Students' Activities in Cycle 4

No	Activity	Students' Activities (%)	Category
1	Opening	100	Very high
2	Lectures on supporting theories for practices	90	Very high
3	Grouping (2 students in each group)	100	Very high
4	Discussion (preparation, procedures & CNC program)	83	Very high
5	Presentation of discussion results	87	Very high
6	Practice (operator-navigator model)	100	Very high

7	Assessment and evaluation	100	Very high
8	Closing	100	Very high
	Average	95.71	Very high

Table 4 shows that overall students' activity is categorized into the very high category. This shows that students' activities almost reach the success criteria. The results of the reflection stated that in this cycle, discussions were performed effectively. There was good communication between each student in one group and no students asked other groups or lecturers. Nevertheless, the implementation of NOPW continued into cycle 5 to ensure the acquisition of these results.

The average learning achievement in cycle 5 was 100. All job practices were completed correctly by all of the students. This result showed that it reached the success criteria. Observation showed that students' activity in the cycle 5 experienced a slight increase to 96.43%. Detailed student activities can be seen in Table 5.

Table 5. Students' Activities in Cycle 5

No	Activity	Students' Activities (%)	Category
1	Opening	100	Very high
2	Lectures on supporting theories for practices	90	Very high
3	Grouping (2 students in each group)	100	Very high
4	Discussion (preparation, procedures & CNC program)	90	Very high
5	Presentation of discussion results	87	Very high
6	Practice (operator-navigator model)	100	Very high
7	Assessment and evaluation	100	Very high
8	Closing	100	Very high
	Average	96.43	Very high

Table 5 shows that overall students' activity is categorized into very high. This showed that the students' activities from cycle 3 to 5 seem stagnant and close to the success criteria. The results of the reflection stated that in this cycle, discussion activities were carried out effectively. Good communication occurred between students in group discussions.

4. Conclusions

The implementation of the NOPW learning model worked satisfactorily as expected. NOPW implementation optimally required 4 to 5 cycles. The NOPW learning model was effective in improving learning achievement or CNC Machining competencies of the students in the Master's Program of Mechanical Engineering Education. These findings indicated the NOPW learning model contributes positive effects on the students' CNC Machining competence. Therefore the stakeholders need to suggest the lecturers to apply the NOPW learning model, especially for practical subjects. The operator-navigator pattern applied in the NOPW learning model besides improves practical competence, it also creates a culture of questioning and discussion in order to solve the problem or the tasks. The culture of positive peer learning and the courage to express opinions are also prompted.

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