# Peer-Project-Based Learning in CNC Simulation Programming Courses

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***Abstract*** **– The challenges of working with various dynamics and diverse job opportunities require students to have self-efficacy and creativity. Self-efficacy emphasizes courage in solving work challenges and creativity related to the supporting capacity of student innovation. This study aims to develop a peer-project-based learning (Peer PbL) model through model feasibility testing and model effectiveness testing. The research method uses a research and development approach by testing the model using an experimental method with a one-shot case study design. A total of 15 students were involved in this research, with the main topic discussion being CNC turning simulation. The results showed that the steps in the Peer-PbL model include team creation, providing challenges, preparing project plans, validating project suitability, doing projects, monitoring team performance, project presentations, and peer assessment.**

**Feasibility assessments from machine learning experts, learning technologists, evaluation experts, CNC professionals, and CAD/CAM professionals indicate strong rater results and correlations. The results of testing the effectiveness of the Peer-PbLmodel in implementing classroom conditions turned out to be able to increase self-efficacy and creativity before and after the Peer-PbL model. This research is a strategy for updating PbL as a learning model by CNC simulation and programming courses.**

***Keywords*** **– Peer-project-based learning, self-efficacy, creativity students, CNC simulation and programming.**

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## 1. Introduction

The demand for competence in the field of computer numerical control (CNC) shows an increase in line with the industry's efforts to achieve efficiency and innovation [1], [2], [3]. Efforts to produce competent CNC programmers must be made, one of which is by developing students' self-efficacy and creativity. Self-efficacy and creativity are seen as the drivers behind proficiency in CNC programming. Self-efficacy is defined as an individual's confidence in his or her ability to perform a task successfully [4]. Self-efficacy is not a prediction about behavior but what it believes can be done [5], [6]. Self-efficacy affects a person's behavior [7] and the environment in which a person interacts and is influenced by actions and conditions [8]. Self-efficacy affects task choice, effort, perseverance, and achievement [9]. Learners who feel confident will be better prepared, work harder, persevere longer when facing adversity, and reach higher levels [8].

A CNC programmer with high self – efficacy is more likely to solve complex challenges and adapt to rapidly evolving tehnological developments.

Creativity is one of the most critical skills in the 21st-century student toolkit and essential to vocational education and training (VET) [10], [11].

The term "creativity" encompasses a wide range of interpretations and definitions. However, at its core, creativity can be conceptualized as a construct that involves the capacity to generate new ideas [12], [13].

Creativity also plays an equally important role in CNC programming. The ability to think creatively allows students to design innovative solutions to solve problems and optimize CNC operations. Developing creativity is essential to be at the forefront of an industry that demands innovation [14], [15].

The peer project-based learning (Peer-PbL) model is a pedagogical approach developed from project-based learning (PbL). PbL increases student self-efficacy and creativity [16], [17]. The constructivist approach underlies the theoretical foundation of the Peer-PbL model, in which individuals build their knowledge through cognitive processes of assimilation and accommodation [18]. The Peer-PbL model generally refers to learning principles that support learners to actively participate in learning while cooperating through practical problems [19]. The project referred to here is a complex task given by each group to explore and complete each other [20]. The projects undertaken in Peer-PbL create collaborative learning dynamics and solve complex problems in a team [16]. Self-efficacy is fostered through students' fundamental contributions to the projects undertaken. In addition, Peer-PbL can stimulate student creativity by fostering various perspectives of ideas that can produce solutions and innovations.

This scientific research explores the potential of the Peer-PbL model in increasing the self-efficacy and creativity of students who participate in CNC learning. The research aims to develop a Peer-PbL model with supporting devices, syntax, and implementation time in accordance with simulation learning and CNC programming [21]. In addition, research is also directed to testing the effectiveness of the Peer-PbL model so that the practical needs of the model can be completed for users based on changes in self-efficacy and student creativity. By increasing self-efficacy and fostering the creativity of students involved in CNC programming, it becomes a provision for students to learn to make and accept project challenges based on student knowledge, experience, and creativity.

## 2. Research Method

This research uses research and development with test methods, namely experiments. The experimental design used was a one-shot case study [22] where before and after the application of the Peer-PbL model, research respondents measured their self-efficacy and creativity.

The research consists of two main stages: developing and testing the feasibility of the Peer-PbL model and its effectiveness in CNC simulation and programming lectures.

The first stage in research is to develop a Peer-PbL model. Development involves researchers and experts through brainstorming and focus group discussion (FGD). Experts involved in feasibility testing of Peer-PbL models include machine learning model experts, learning media experts, machine learning evaluation experts, CNC professionals, and CAD/CAM professionals. These experts provide assessments between raters with references, among others: (1) completeness of the Peer-PbL model device; (2) ease of use of Peer-PbL model devices; (3) Peer-PbL model construction/scheme; (4) the Peer-PbL model can improve student self-efficacy; and (5) the Peer-PbL model can improve student creativity. The Peer-PbL model that has been evaluated is then revised and adjusted to the learning in the CNC simulation and programming course.

The second research stage is to use CNC simulation and programming courses to test the effectiveness of Peer-PbL models. The study involved one class with 15 respondents. This study will measure the existing condition of the class first by distributing questionnaires on students' self-efficacy and creativity. Of course, this testing is carried out in the middle of the semester so that students already have sufficient provisions to participate in CNC simulation and programming lectures. Furthermore, researchers practice teaching CNC simulation and programming courses by paying attention to the steps in the Peer-PbL model. At the end of the learning outcomes, researchers distributed questionnaires again to measure the extent to which students' self-efficacy and creativity developed. Self-efficacy refers to students' abilities in self-assessment, self-assertiveness, and self-availability, while student creativity refers to students' flexibility, originality, elaboration, and fluency abilities.

The questionnaires arranged on both variables are based on the gradation of answers according to the self-assessment rubric.

Data analysis techniques in testing between stages vary. For the feasibility testing phase of the model, the data analysis technique uses rater feasibility variance analysis and interclass correlation coefficient (ICC). Decision techniques using Cohen's Kappa coefficient approach [23]. Meanwhile, the stage of testing the model's effectiveness begins with testing the normality and homogeneity of the data in order to find out the data obtained both at the beginning and end using the right statistical tools.

To determine the difference before and after applying the Peer-PbL model, it is necessary to analyze it with a T-test for correlated sample types [24].

## 3. Results and Discussion

This research uses a gradual solution by starting the model's design and feasibility testing to test the Peer-PbL model's effectiveness.

CNC simulation programming courses are appropriate in providing challenges for mechanical engineering students to develop self-efficacy and creativity.

### *3.1. Peer-PbL Model Development*

The Peer-PbL model consists of 8 foremost syntaxes: team creation, challenge, project plan preparation, project suitability validation, project creation, team performance monitoring, project presentation, and peer assessment. Each stage has the following detailed steps.

*Table 1. Syntax and Peer-PbL model activities in CNC programming simulation learning*

| Steps | Activities | Sub-activities | Times |
|---|---|---|---|
| Day 1 (300') | | | |
| 1. | Team creation | 1. Team building by lottery<br>2. Students coordinate according to their groups | 30' |
| 2. | Challenge giving | 3. Identify course learning outcomes<br>4. Build project challenges<br>5. Provide project challenges | 60' |
| 3. | Project plan preparation | 6. Sketch drawing<br>7. Working drawing creation<br>8. Preparation of work steps | 180' |
| 4. | Project conformity validation | 9. Job sheet review<br>10. Leave feedback and comments<br>11. Revise a job sheet | 30' |
| Day 2 (300') | | | |
| 5. | Project creation | 12. Preparation of practicum equipment and equipment<br>13. Preparation of programming simulations<br>14. Carry out the project manufacturing process<br>15. Product quality measurement | 180' |
| 6. | Team performance monitoring | 16. Monitoring the team's manufacturing process<br>17. Review the team's manufacturing products<br>18. Provide suggestions and comments to the team | 30' |
| 7. | Project presentation | 19. Presentation of each team<br>20. Feedback from other teams<br>21. Strengthening discussions by lecturers | 60' |
| 8. | Peer assessment | 22. Students assess all the work of each team<br>23. Lecturers assess all team activities<br>24. Project conclusion by lecturers | 30' |

Table 1 explains the efforts to effectively implement the CNC programming simulation course held for two meetings. The first meeting focused on preparing project challenges and strategies developed by the team, and the second meeting focused on project completion and presentation. The model has been agreed upon in a focus group discussion and constructively tested by machine learning model experts, learning media experts, machine learning evaluation experts, CNC professionals, and CAD / CAM experts.

The inter-rater analysis and validator consideration results produce Cronbach's Alpha value = 0.758. This value is still in the category of reliable enough for all model validators.

The results of the inter-rater analysis tabulation are listed in Table 2, and the Interclass Correlation Coefficient (ICC) score is in Table 3.

*Table 2. Analysis of variance for inter-rater eligibility scores*

| | | Sum of Squares | df | Mean Square | F | Itself |
|---|---|---|---|---|---|---|
| Between Rater | | 2.640 | 4 | .660 | | |
| Within Rater | Between Items | .240 | 4 | .060 | .375 | .823 |
| | Residual | 2.560 | 16 | .160 | | |
| | Total | 2.800 | 20 | .140 | | |
| Total | | 5.440 | 24 | .227 | | |

*Table 3. Results analysis of Interclass correlation coefficient (ICC)*

| **Intraclass Correlation** | | **95% Confidence Interval** | | **F Test with True Value 0** | | | |
|---|---|---|---|---|---|---|---|
| | | **Lower Bound** | **Upper Bound** | **Value** | **df1** | **df2** | **Itself** |
| Single Measures | .385a | .021 | .874 | 4.125 | 4 | 16 | .017 |

The results of validation between raters show that both the ANOVA significance value (Table 2) and the > sig value and intraclass correlation values of 0.385 (Table 3) are included in the appropriate categorization. This strong support [25] because the model developed by the researcher is equipped with a clear and complete Peer-PbL model guidebook and steps.

### *3.2. Testing the Effectiveness of Peer-PbL models*

Through the use of single class testing of the effectiveness of Peer-PbL models is done. Effectiveness testing using simulation learning outcomes and CNC turning programming. Figure 1 below is a documentation of the model deployment.

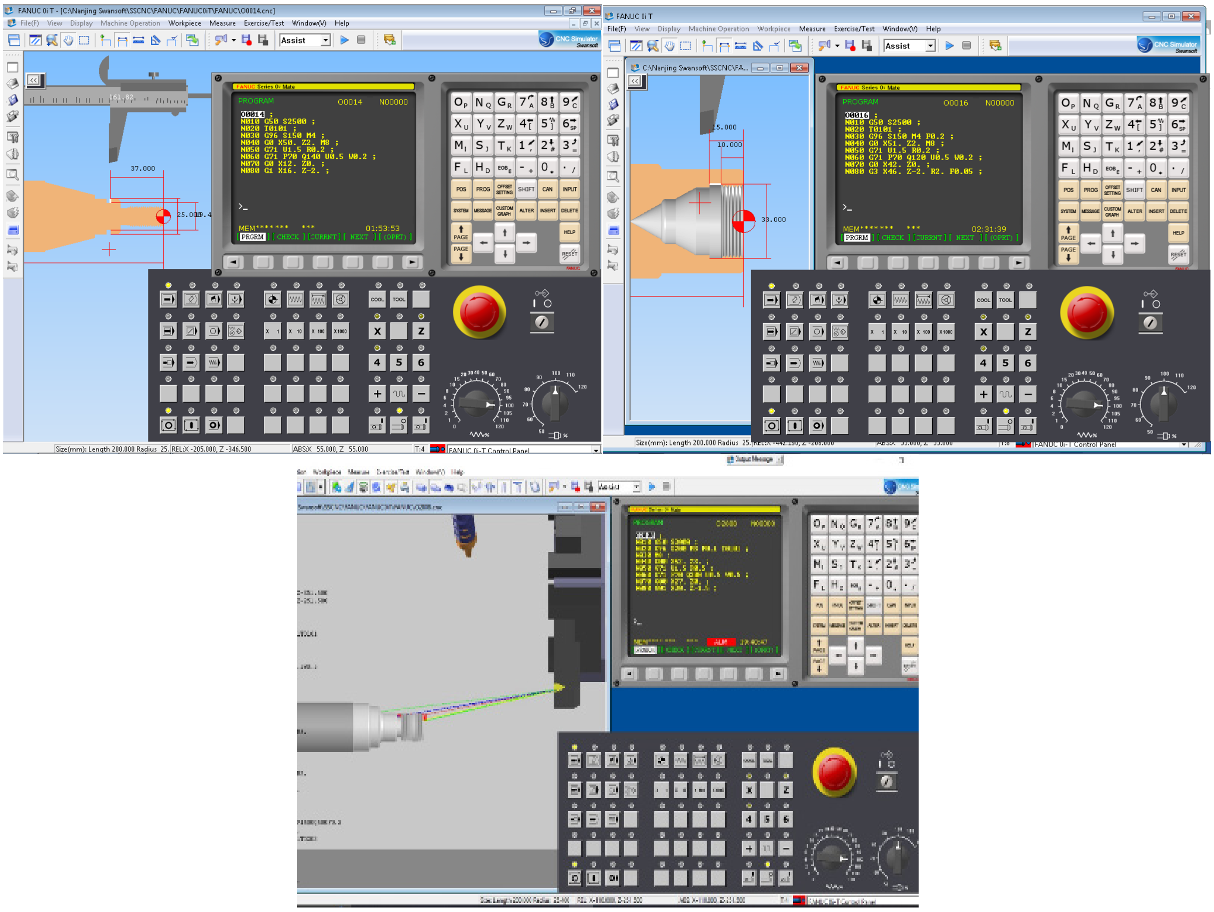
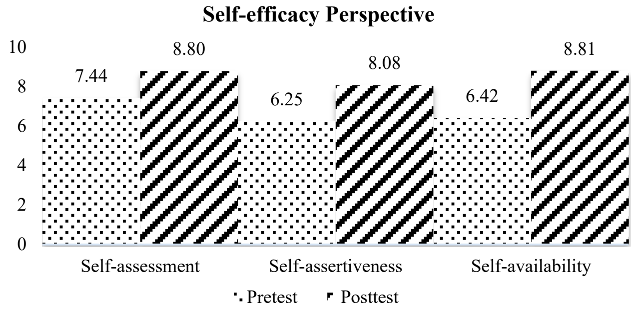


*Figure 1. Results of Peer-PbL model trials on CNC turning simulation and programming learning outcomes*

Questionnaires were distributed to determine the initial ability of self-physicalization and creativity of students.

Furthermore, after applying the Peer-PbL model, a re-questionnaire related to student self-efficacy and creativity was distributed.

Based on descriptive statistical analysis for each research indicator in each variable, a histogram of the difference in the before and after values of each indicator is shown in Figure 1.



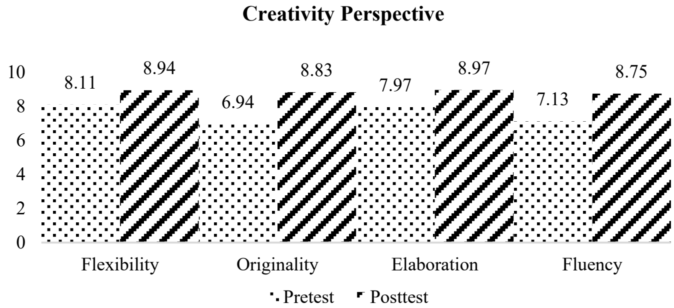




*Figure 2. Histogram indicators (a) self-efficacy, and (b) creativity*

Figure 2 shows an improvement in each research indicator before and after. The mean score for the pretest value on the self-efficacy variable was 6.70, with a standard deviation of 5.102, and the mean score for the posttest was 8.56, with a standard deviation of 2.569. These results show an increase in the mean score, but the resulting data distribution begins to cluster at a specific value. Meanwhile, the mean score for the pretest value on the creativity variable is 7.54 with a standard deviation of 1.486, and the mean score for the posttest is 8.56 with a standard deviation of 1.486. Similarly, to self-efficacy variables, mean values point to specific value groups. If you look at the results of the four-survey data, students' self-efficacy is still lower than their creativity.

The classes used in this study were more prominent in the initial state of creativity, which was better than self-efficacy.

The results of data analysis pre and post-application of the Peer-PbL model began with testing data normality and continued testing differences using paired sample T-test. The results of normality data, both pretest and posttest for each self-efficacy and creativity variable, were declared normal. Through the Kolmogorov-Smirnov and Shapiro-Wilk approaches, the resulting value is pretesting self-efficacy = 0.281; posttest self-efficacy = 0.102; pretest creativity = 0.289; and posttest creativity = 0.153. The four normality analysis results are above the significance value of 5%. With these results, the statistical tools used are parametric. Based on interval data, the T-test paired test can be used as a reference for analysis. Table 4 reveals the different test results between the pretest and posttest.

*Table 4. Different tests before and after the application of the Peer-PBL model on self-efficacy and creativity*

| | Paired Differences | Mean | Std. Deviation | 95% Confidence Interval of the Difference Lower | 95% Confidence Interval of the Difference Upper | t | df | Sig. (2-tailed) |
|---|---|---|---|---|---|---|---|---|
| Pair 1 | Pretest Self Efficacy - Posttest Self Efficacy | -15.000 | 5.141 | -17.847 | -12.153 | -11.301 | 14 | .000 |
| Pair 2 | Pretest Creativity - Posttest Creativity | -7.867 | 4.389 | -10.297 | -5.436 | -6.941 | 14 | .000 |

The before and after difference analysis results in Table 4 above show that the Peer-PbL model has provided significant changes in self-efficacy and creativity. This happens because students are very enthusiastic when they are given job challenges. The challenges of the work provide confidence, courage to face risks, and creativity in solving problems [26]. Students also consider ideas collaboratively when compiling a challenge and provide flexibility in completing their work [27].

## 4. Conclusion

Comprehensive research on developing Peer-PbL models as a finding of learning scientific novelty in CNC programming simulation has great potential to be developed. The results showed that the development of the Peer-PbL model has eight main syntaxes that users must encounter. The syntax includes team creation, challenge giving, project plan preparation, project suitability validation, project creation, team performance monitoring, project presentation, and peer assessment. They were developing Peer-PbL models through a feasibility assessment mechanism by expert validators with rater values and good correlations to support the effectiveness testing stage. The results of effectiveness testing stated significant differences for students based on the perspective of self-efficacy and creativity. The two leading research indicators studied are challenges for practicum learning lecturers to innovate and provide quality challenges to students so that there is novelty and development of project-based learning.

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