Effectiveness of Project-Oriented Problem-Based Learning (POPBL) in Manufacturing Product Design for Vocational Higher Education

ABSTRACT

This study aimed to investigate the effectiveness of the Problem-Oriented Project-Based Learning (POPBL) model in teaching manufacturing product design in vocational higher education at Makassar ATI Polytechnic. The research involved 15 students for a limited trial and 35 students for an extended trial. The study used questionnaires, pre-test and post-test cognitive tests, and parametric statistical tests to evaluate the effectiveness of the POPBL model. The results showed that the POPBL model was effective, with an average very agree response of 80% in the limited trial and 92% in the extended trial. The average posttest scores were 64.80 and 78.97 in the limited and extended trials, respectively, which were significantly higher than the pretest scores. The parametric statistical test using the t-test also showed that the POPBL model was effective in both the limited and extended trials. Based on these results, it can be concluded that the POPBL model is an effective approach to teaching manufacturing product design in vocational higher education.

Keywords: *effectiveness, POPBL, design, student response, cognitive test.*

INTRODUCTION

In Indonesia, the term vocational education for secondary education is SMK/MAK and vocational education for higher education is academy, high school, polytechnic, institute, and university. Juridically, this is stated in Law No. 20 of 2003 concerning the National Education System Article 15 which states that vocational education is a secondary education that prepares students primarily to work in certain fields. Then vocational education is higher education that prepares learners to have jobs with certain applied expertise, maximum equivalent to undergraduate programmes. In general, the main objective of vocational and vocational education is to prepare learners who are skilled for work. The vocational education pathway is primarily directed at equipping learners with the skills, competencies and technical expertise required in performing certain jobs (Mujiyono, 2018)

Vocational education, also known as vocational higher education, is currently important in Indonesia because the country needs a technologically proficient, flexible, and skilled workforce that aligns with the highly dynamic world of work, both as employees and entrepreneurs (Hambali et al., 2020). Vocational education in Indonesia is required to develop local wisdom, fulfill national education standards, and align with the needs and characteristics of the country (Slamet, 2017).

Competence in vocational higher education can be achieved through a curriculum that focuses on theoretical courses and specializes in practical courses. The curriculum is structured to improve students' learning experience by strengthening their motivation to learn and work, work habits, teamwork, collaboration skills, communication skills, creativity, critical thinking, use of new technology, leadership, self-discipline, decision-making, and other hard and soft skills competencies. Learning in vocational higher education provides a hands-on experience that results in a product or work.

Mastery of student competence in manufacturing product design is highly relevant to the achievement of higher vocational education competencies in the Diploma III program in the field of manufacturing technology. Achieving this competency involves students' ability to create preliminary designs for individual components that form a simple system. By mastering this competency, students are expected to possess the knowledge to explain the stages of the mechanical design process and make good and safe design decisions.

However, there are still students who do not understand the concept of design thoroughly. This issue has been observed in the Agro Industrial Manufacturing Engineering Study Programme, as evidenced by the average score of 24 classes, which is relatively low (59.17 or equivalent to a C grade). The cause of this problem can be attributed to several factors, such as the teaching methods used by some lecturers, which involve a larger portion of lectures with little time spent on discussions. Additionally, some lecturers only provide a general and basic introduction to the course material, leading students to seek their own references on the internet without effective guidance from their instructors. This has resulted in some students facing difficulties and being unable to complete assignments, leading to unsatisfactory grades and even failure. Similar opinions have been expressed by Purnomo & Ilyas (2019), who argue that learning that promotes independent learning and knowledge construction is still lacking. The conventional teaching and learning process in many schools has not included the application of problem-oriented project-based learning. In the classroom, students are conditioned only to listen, memorize, and ask questions.

To address these issues, it is essential to incorporate problem-oriented project-based learning into the curriculum, as suggested by research. This approach encourages students to engage in real-world problems, develop critical thinking skills, and collaborate on projects, ultimately leading to a more comprehensive understanding of the design process.

Several learning models are commonly applied to improve students' skills and learning outcomes, one of which is Problem-Oriented Project-Based Learning (POPBL). POPBL integrates Project-Based Learning (PjBL) and Problem-Based Learning (PBL) to foster students' learning based on problems and enable them to solve problems through projects. Mastery of concepts and skills is crucial in supporting students' learning and improving the quality of education. In science and engineering, for example, learning is not limited to concepts but also requires concrete activities to ensure students' knowledge. This makes the teacher-centered approach less appropriate for learning that requires student activeness. The learning process can implement a model that not only adds student activities outside the classroom or parallel to project work but also embeds activities as an integrated part of the overall team-based project (Moesby, 2006

The combination of two learning models, PBL and PjBL, called POPBL is expected to be used as an alternative student-centred learning model through learning a project in addressing problems that exist around them (Ibrahim & Halim, 2013; Meehan, Lawlor, & McLoone, 2014; Wan Nor Fadzilah et al., 2016; Yasin & Rahman, 2011). POPBL seeks to foster students' ability to learn actively, think critically, and solve problems through a learning process that focuses on practical tasks. It also encourages students to conduct group discussions. POPBL provides new learning experiences for students through real conditions when students create projects.

According to Ramdani (2018), the POPBL model is only applicable to topics that involve creating a project at the end of the learning activity. This is because the learning model aims to solve problems by analyzing the problem and the product of problem-solving. The result of the POPBL learning model is a product that serves as a solution to the problem raised as a project theme. However, the POPBL model has limitations, such as the lack of time allocated, which can affect the project results and students' understanding of the learning theme. Teachers who guide students using the POPBL model must understand how the learning model works and possess extensive knowledge to handle unexpected student questions. The POPBL framework applied in the RPS should be customized and use more resources to form systematic stages in learning activities through the POPBL method (Kolmos & Graaf, 2007, in Lehmann, 2018).

The novelty of this study lies in its focus on the effectiveness of the Problem-Oriented Project-Based Learning (POPBL) model in teaching manufacturing product design in vocational higher education at Makassar ATI Polytechnic. The study used a combination of questionnaires, pre-test and post-test cognitive tests, and parametric statistical tests to evaluate the effectiveness of the POPBL model. The results showed that the POPBL model was effective in both the limited and extended trials, with an average very agree response of 80% and 92% in the limited and extended trials, respectively. The average posttest scores were significantly higher than the pretest scores, and the parametric statistical test using the t-test also showed that the POPBL model was effective in both trials. This study provides valuable insights into the effectiveness of the POPBL model in teaching manufacturing product design in vocational higher education, which can be useful for educators and policymakers in developing similar programs in the future.

METHOD

The product of this research is a POPBL model based on manufacturing product design. The research design utilized two product trials, namely limited trials and extended trials. Product trials were conducted to evaluate the effectiveness of the learning model by comparing it to the predetermined criteria. Effectiveness data was obtained from student responses and student learning outcomes tests, which were then analyzed using a statistical test, specifically the t-test.

Indicators of the learning model are considered effective if:

1. The positive response of students in learning is at least more than or equal to 80% (≥80%) of the total number of students.
2. The achievement of the expected student learning outcomes competency test is at least 75% of the number of students achieving a final score of at least 71 or equivalent to a grade B (score range: 0-100).

3. There is a significant difference in the achievement of student learning outcomes before and after the application of the learning model.

By meeting these criteria, the POPBL model has been deemed effective in enhancing students' learning experiences and outcomes in manufacturing product design.

This research was conducted at the Makassar ATI Polytechnic and involved Semester II students of the Agro Industrial Manufacturing Engineering Study Programme in the 2022/2023 academic year. The sample consisted of 15 students for the limited trial and 35 students for the extended trial. The instruments used in this study were questionnaires, pre-test, and post-test cognitive tests.

RESULTS

Limited trial

Student response to learning

The results of the analysis of student responses to learning in the limited trial are presented in Table 1.

Table 1.Presents the results of the student response to learning during the limited trial

No.	Aspects Assessed	Response				%
		NA	LA	A	VA	
A	Attitude in the Learning Process	0	0	13	2	78
B	Knowledge in the Learning Process	0	0	13	2	78
C	Skills in the Learning Process	0	0	12	3	80
D	Activity in the Learning Process	0	0	11	4	82
	Total Average	0	0	12	3	80

Description:
NA : Not Agreed   A : Agreed
LS : Less Agreed   VA : Very Agreed

Based on the data in Table 1, the following observations can be made:

- 78% of students responded strongly agreeing that the POPBL model based on manufacturing product design can improve attitudes during the learning process, such as students' punctuality, enthusiasm, active participation in lectures, and the development of critical thinking skills in identifying problems.
- 78% of students gave a strongly agreeing response to the POPBL model based on the design of manufactured products, indicating that it can improve aspects of student knowledge, including increased understanding of learning materials, the ability to identify and solve problems through appropriate technology-based production tools, and relevant lecture materials.
- 80% of students gave a very agreeing response to the POPBL model based on the design of manufactured products, indicating that students were skilled in creating final product designs through projects, writing project reports, and possessing good social skills in discussions.
- 82% of students gave a very agreeable response in terms of activities in the learning process, with students generally considering the learning process to take place in a conducive and pleasant atmosphere, and the lecturer effectively managing the class, explaining the course material, and motivating students.

Thus, the overall results show that, on average, 80% of students gave a very agreeable response to learning activities using the POPBL model based on manufacturing product design.

Based on the description of student responses to learning, it was found that the POPBL model based on manufacturing product design met the effectiveness criteria (≥80%) according to student responses in the limited trial.

Results of student cognitive tests on limited trials

The results of students' cognitive tests in the limited trial were measured by administering a pretest before the application of the POPBL model based on manufacturing product design and a posttest after the application of the model. The pretest and posttest tests aimed to assess if there was an increase in student learning outcomes by using the POPBL model based on manufacturing product design. The achievement of learning outcomes competencies in the limited trial, using pretest and posttest, is depicted in the bar chart in Figure 1.

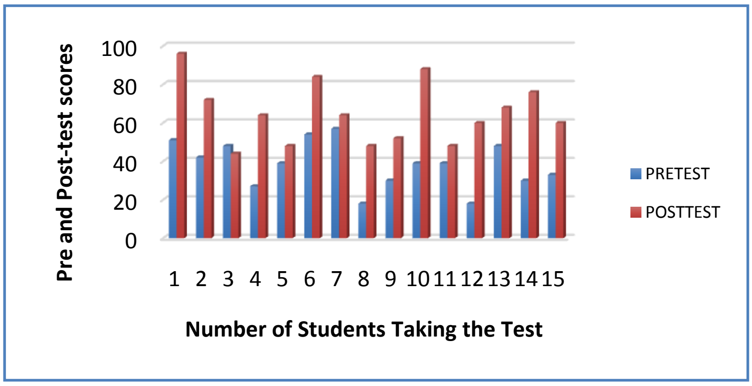

Figure 1 shows the results of the student pretest and posttest in the limited trial

With posttest scores ranging from 44 to 96. Based on the results of frequency analysis of student posttests, it was found that 33% of students obtained a minimum score of 71. Although there was an increase in posttest results on average, the competence of student learning outcomes did not meet the criteria, which requires at least 75% of students to achieve a minimum score of 71 or equivalent to a grade B.

By using SPSS Statistics 26 analysis, the following results were obtained:

a) Cognitive test results were first tested for data normality and obtained a Sig. value of 0.632 (Pretest) and 0.379 (Posttest) as shown in Table 2. The value is greater than 0.05, so it is concluded that the data is normally distributed (data normality requirements are met). These results are also shown in Figure 2 and Figure 3 where it can be seen that the curve lines tend to be symmetrical, meaning that the distribution of data in the pretest and posttest of the limited test is normally distributed.

Table 2. Results of the Limited Trial Normality Test

Tests of Normality

	Kolmogorov-Smirnova			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
PRETEST	.126	15	.200*	.956	15	.632
POSTTEST	.122	15	.200*	.940	15	.379

a. Lilliefors Significance Correction

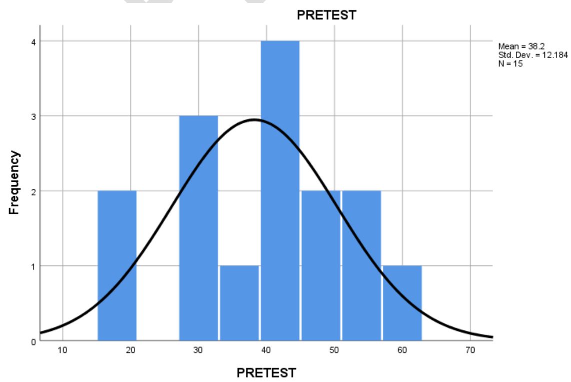

Figure 2 Histogram Graph of Student Pretest in Limited Trial

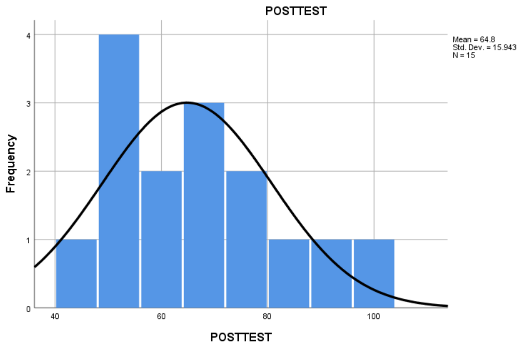

Figure 3 Histogram Graph of Student Postetst on Limited Trial

b) The average value (mean) of the posttest is greater than the mean of the pretest, namely 64.80> 38.20 as shown in Table 3. This data shows that there is an increase in the average value of student learning outcomes, namely at the time of the pretest the average value of 38.20 increased at the time of the posttest with an average value of 64.80 or equivalent to a C grade. Although there was an increase in the average value of learning outcomes, it did not meet the expected learning outcome competency criteria, namely the average value of learning outcomes of at least 71 or equivalent to a grade B.

Table 3 Results of Paired Sample Statistics Limited Trial Test

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	PRETEST	38.20	15	12.184	3.146
	POSTTEST	64.80	15	15.943	4.116

Table 4 shows a Sig. (2-tailed) value of 0.000, which is smaller than 0.005. This indicates that there is a significant difference in learning outcomes between before and after the implementation of the POPBL learning model based on manufacturing product design in the limited trial. The analysis suggests that the POPBL model has a positive impact on student learning outcomes, as evidenced by the significant difference in pretest and posttest scores.

Table 4 Results of Paired Sample Test of Limited Trial

Paired Samples Test

	Paired Differences: Mean	Paired Differences: Std. Deviation	Paired Differences: Std. Error Mean	95% Confidence Interval of the Difference: Lower	95% Confidence Interval of the Difference: Upper	t	df	Sig. (2-tailed)
Pair 1 PRETEST POSTTEST	--26.600	16.039	4.141	-35.482	-17.718	-6.423	14	.000

From the results of the SPSS output analysis above, it shows that although there is a difference in student test results after using the POPBL model based on manufacturing product design in the limited trial, but the results of student test achievement still need to be improved in order to meet the effectiveness criteria.

Expanded Trial

1. Student responses on the extended trial

The results of the analysis of student responses to learning using the POPBL model based on the design of manufactured products in the extended trial are in Table 5.

Table 5 Results of Student Response to Learning in the Expanded Trial

No.	Aspects Assessed	response: NA	LA	A	VA	%
A	Attitude in the Learning Process	0	0	11	24	92
B	Knowledge in the Learning Process	0	0	11	24	92
C	Skills in the Learning Process	0	0	12	23	91
D	Activity in the Learning Process	0	0	10	25	93
	Total Average	0	0	11	24	92

Description:

NA	: Not Agreed	A	: Agreed
LA	: Less Agreed	VA	: Very Agreed

Based on the data in Table 5 above, in the extended trial, the results of the assessment of each aspect showed an average value of 92% of students gave a very agreeable response to learning activities using the POPBL model based on manufacturing product design. The response of students strongly agreed includes every aspect assessed, namely the assessment of attitudes, knowledge, skills and student activities using the POPBL model based on the design of manufactured products. The increase in each aspect is shown, among others, the application of the POPBL model based on the design of manufactured products adds to the enthusiasm of students, improves student social skills, trains student cooperation, and is able to identify and solve problems.

Based on the description of student responses to learning, it was found that the POPBL model based on manufacturing product design met the criteria for effectiveness (≥80%) according to student responses in the extended trial.

2. Cognitive test results of students on the extended trial

The results of student cognitive tests on the extended trial obtained using pretest and postest are depicted in the bar chart in Figure 4.

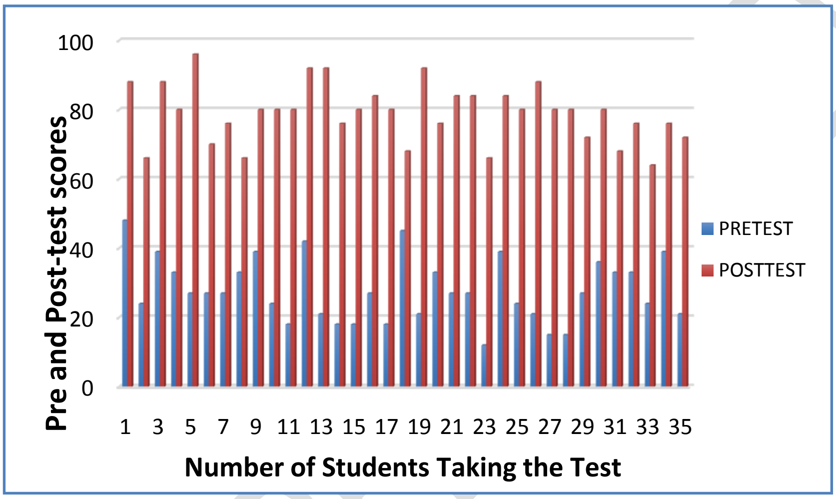

Figure 4 Expanded Trial Student Cognitive Test Results

Based on Figure 4, the results of the student posttest in the extended trial have a range of scores from 56 to 96. According to the results of the frequency analysis of student posttests, 80% of students obtained a minimum score of 71. These results indicate that the competence of student learning outcomes has met the criteria, which requires at least 75% of students to achieve a minimum score of 71.

Furthermore, to determine whether there is a significant difference in the pretest and posttest results using SPSS 26, the following steps can be taken:

a) The test results were first assessed for data normality, and a significance (Sig.) probability value of 0.262 (Pretest) and 0.206 (Posttest) was obtained, as shown in Table 6. Since these values are greater than 0.05, it is concluded that the data is normally distributed, and the data normality requirements are met. This can also be observed in Figure 5 and Figure 6, where the curve lines on the histogram graph tend to be symmetrical and centered in the middle of the data, indicating that the data distribution in the pretest and posttest of the extended trial is normal.

Table 6. Results of Normality Test of Expanded Trial

Tests of Normality

	Kolmogorov-Smirnova			Shapiro-Wilk		
	Statistic	**df**	**Sig.**	**Statistic**	**df**	**Sig.**
PRETEST	.166	35	.016	.962	35	.262
POSTTEST	.187	35	.003	.929	35	.026

a. Lilliefors Significance Correction

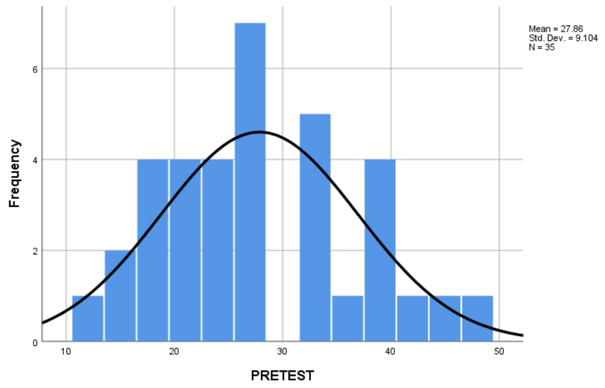

Figure 5 Histogram Graph of Expanded Trial Pretest

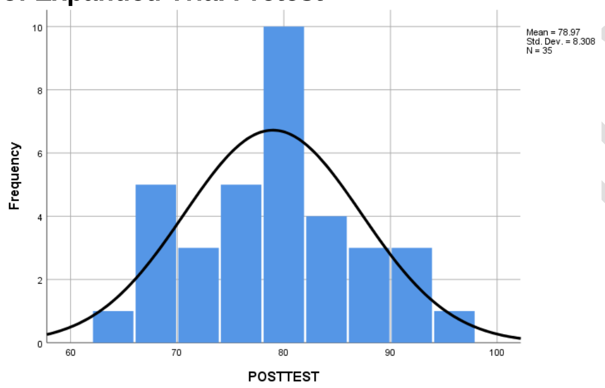

Figure 6 Histogram Graph of Expanded Trial Posttest

The average value (mean) of the posttest is greater than the mean of the pretest, which is 78.97> 27.86 as shown in Table 7. This data shows that there is an increase in the average value of student learning outcomes, namely at the pretest the average value of 27.86 increased at the posttest with an average value of 78.97 or equivalent to A- (A minus). From the pretest results, it fulfils the expected learning outcome competency criteria, namely the average learning outcome score of at least 71 or equivalent to grade B.

Table 7 Results of Paired Sample Statistics of the Expanded Trial

Paired Samples Statistics					
		Mean	N	**Std. Deviation**	**Std. Error Mean**
Pair 1	PRETEST	27.86	35	9.104	1.539
	POSTTEST	77.60	35	10.942	1.849

The obtained Sig. (2-tailed) value of 0.000, which is smaller than 0.005, indicates that there is a significant increase in learning outcomes between before and after the implementation of the POPBL learning model based on manufacturing product design in the extended trial. This significant difference in learning outcomes highlights the positive impact of the POPBL model on student learning.

Table 8 Results of Paired Sample Test of Expanded Trial

Paired Samples Test								
	Paired Differences							
				95% Confidence Interval of the Difference				
	Mean	**Std. Deviation**	**Std. Error Mean**	**Lower**	**Upper**	**t**	**df**	**Sig. (2-tailed)**
Pair 1 PRETEST POSTTEST	--49.743	13.470	2.277	-54.370	-45.116	-21.848	34	.000

From the results of the SPSS output analysis above, it shows that the use of the POPBL model based on manufacturing product design in the extended trial has met the criteria of effectiveness.

DISCUSSION

According to Nieveen (1999), a learning model is said to be effective if the results of the application of the learning model using learning tools applied in the classroom provide results in accordance with the criteria set in this study. The POPBL learning model based on manufacturing product design developed has met the effective criteria through 2 (two) indicators, namely the assessment of student responses to the POPBL model based on manufacturing product design and the results of student cognitive tests through pre-test and post-test.

The findings of each indicator, namely that students gave a very agreeable response to learning activities using the POPBL model based on manufacturing product design. This can be seen from the average response value of 80% in the limited trial and increased to 92% in the extended trial. The results of this student response indicate that the POPBL model learning based on manufacturing product design has been running effectively as indicated by active student involvement in planning, organising, and reflecting through assignments given by lecturers. Students are not only passive in receiving knowledge from lecturers, but actively deepen the material through direct interaction with sources of information, such as farmers, farmers, mechanics, agricultural extension workers, and other sources relevant to the theme of student design. This is in line with Rongbutsri (2017) who stated that with problem-oriented learning students can collaborate with various parties in demonstrating their creativity. The results of this kind of learning not only improve students' understanding, but also improve students' attitudes and thinking skills. By increasing students' understanding, attitudes, and skills during the learning process, the achievement of learning competencies will increase, so that learning will be more effective (Chongdarakul, 2021).

The next indicator is the findings of the student learning outcomes competency test in the form of pretest and posttest assessments. In the limited trial, the average posttest result of 64.80 was greater than the pretest average of 38.20 and in the expanded trial, the posttest average of 78.97 was greater than the pretest average of 27.86. The average posttest score on the expanded trial of 78.97 which is equivalent to an A- grade indicates that the students' cognitive test scores have met the graduation criteria, which is a minimum score of 71 (equivalent to a grade B) which refers to the assessment criteria in the Academic Regulations. Although in the limited trial there was an increase in the average posttest score, this result still did not meet the criteria because the posttest score was still in the range equivalent to a C grade. The lack of student understanding in the limited trial is in line with the findings of Chuan&Sirui (2021), which is due to the fact that some students still have difficulty identifying the overall concept of mechanical design. For this reason, revisions were made to the model developed by reviewing the syntax of project monitoring which was previously carried out for two face-to-face sessions plus four face-to-face sessions so that students could further deepen their project data processing. In addition, revisions were also made by reviewing the student understanding test grids so that students could more easily understand the test questions and be able to answer the questions properly and correctly.

Furthermore, from the results of the SPSS statistical test using the t-test, it was also obtained that the significance value (Sig. 2-tailed) was 0.000 which was smaller than the value of 0.005 both in the limited trial and the expanded trial. This result shows that there is a difference in learning outcomes before and after the implementation of the POPBL model based on manufacturing product design, both in the limited trial and the extended trial. In the extended trial, the results showed that 80% of the students got a minimum score of 71 with an average score of 78.97 or equivalent to A- (A minus).

Thus, referring to the findings on student response assessment indicators and student competency test results, it can be concluded that the POPBL learning model based on manufacturing product design has met the effective criteria.

CONCLUSION

Furthermore, from the results of the SPSS statistical test using the t-test, it was also obtained that the significance value (Sig. 2-tailed) was 0.000 which was smaller than the value of 0.005 both in the limited trial and the expanded trial. This result shows that there is a difference in learning outcomes before and after the implementation of the POPBL model based on manufacturing product design, both in the limited trial and the extended trial. In the extended trial, the results showed that 80% of the students got a minimum score of 71 with an average score of 78.97 or equivalent to A- (A minus).

Thus, referring to the findings on student response assessment indicators and student competency test results, it can be concluded that the POPBL learning model based on manufacturing product design has met the effective criteria.

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