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THE EFFECT OF USING A CNC SIMULATOR IN LEARNING THE MECHANICAL ENGINEERING SKILLS PROGRAM

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KEYWORDS	ABSTRACT
CNC simulator; CNC machine; student competency	The 21st century is better known as the digital era, an era of rapid development of information technology with data-based document management, digital transformation, and network-based communications. The research aims to evaluate the use of computer numerical control (CNC) simulators, analyze the effect of using CNC simulators, and find factors inhibiting the use of CNC simulators in learning Mechanical Engineering at Muhammadiyah 1 Playen Gunungkidul Vocational High School (SMK). The research uses quantitative methods by conducting experiments. The experimental design used is quasi-experimental or quasi-experimental design research. The variables used in this research are the independent and dependent variables. The research was carried out at Muhammadiyah I Playen Vocational School. The research subjects were students of class XII Machining Engineering, which consisted of three classes. The data obtained was analyzed using the SPSS 20.0 for Windows application for normality testing and hypothesis testing. The research results show that using CNC simulators in learning the Mechanical Engineering Skills Program at SMK Muhammadiyah 1 Playen Gunungkidul went smoothly. The results of the t-test analysis for the experimental class and control class obtained sig. (2-tailed) experimental class is 0.000< 0.05, and sig. (2-tailed) control class is 0.001. 0.001<0 .05. There is an inhibiting factor in using CNC simulators in learning the Mechanical Engineering Skills Program at SMK Muhammadiyah 1 Playen Gunungkidul; namely, the number of CNC simulators provided is still limited, with the lowest type of CNC simulator.
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INTRODUCTION

The development of the 21st century Industrial Revolution 4.0 is the focus of attention. The 21st century is better known as the digital era, an era of rapid development of information technology with data-based document management, digital transformation, and network-based communications. Equipment and machines are moving from manual technology to automation and robotic systems. Machines powered by electricity are increasingly being used by society and industry. Mass production and demand for quality products are the industry's main targets. In the 21st century, education is becoming increasingly important to ensure that students have learning and innovation skills, technology and information media skills, and can work and survive using life skills (Wijaya et al., 2016).

Preparing competent and skilled graduates is the school's duty and obligation. Republic of Indonesia Government Regulation Number 29 of 1990 concerning Secondary Education, article 3, paragraph 2 states that Vocational High Schools (SMK) prioritize preparing students to enter the workforce and develop professional attitudes. Soft skills, one of which is communication, rank first among all existing soft skills (Patacsil & Tablatin, 2017). Communication skills are essential for vocational school graduate students. So vocational school graduates are expected to be in the global region (Setiawan et al., 2020). In a book on the global area (Armstrong & Westland, 2018). In the book Asian Economic Integration in an Era of Global Uncertainty, the opening and issues of Asia and the global system states:

"The fourth industrial revolution in e-commerce, the internet, robotics, and automation represents both a challenge and an opportunity for Asia and the world. Innovative policies regionally could contribute to positive and pre-emptive policies globally (Kelsey et al., 2020)."

The fourth industrial revolution in e-commerce, the internet, robotics, and automation is both a challenge and an opportunity for Asian countries and the world. Innovative policies implemented regionally can provide positive contributions and pre-emptive policies globally.

The ASEAN Economic Community (MEA), also known as the ASEAN Free Trade Area (AFTA), is a form of agreement between ASEAN member countries to form a free trade area in order to increase the economic competitiveness of the ASEAN regional region (Untari et al., 2019). Developing the character of a workforce capable of critical thinking must start from the beginning, namely from learning at school. The learning process must use industry-standard equipment/machines to provide competency and work insight according to the industry's requirements (Wijaya et al., 2016). States:

"Learning in technology education institutions/vocational schools is a form of interaction that leads to the formation and development of cognitive, affective, and skills competencies, optimal development of individual competencies with the dynamics of life's needs in society, and development of individual competencies as a prerequisite for developing life skills needed in the context of life at the family and community (industry) level."

Computer Numerical Control (CNC) machines were created to meet the challenges of production speed and product precision in modern manufacturing. Products produced by CNC machines can be guaranteed with an accuracy of 1/100 mm. CNC machines can produce products with the same quality in a short time. Thus, using CNC machines is very profitable and increases production effectiveness compared to manual machines. The advantages of CNC machines compared to conventional machines (Suharto et al., 2017) are: (1) complete flexibility, (2) accuracy and durability, (3) shorter production time, 4) capable of working on complex contours, (5) adjustment easy machine, (6) without experienced and skilled operators, and (7) operators have free time.

Flexibility is implemented in the component programs required to produce new components. Product accuracy is guaranteed even at maximum spindle speed and complete feed. Machine setup is easy, so it takes less time than other machining. The need for experienced and skilled operators can be avoided. Operators can maximize free time to supervise other machining operations or operate multiple machines simultaneously. Types of CNC machines (Rahmatullah et al., 2021) include CNC lathes, milling machines, laser cutters, electric discharge machines (EDM), and others.

The need for CNC machines is very high, so the development of CNC machine models is increasing. DUDI uses CNC machines to manufacture relatively complex components in large quantities (20 to 10,000 components each year). For machining components that have very complicated surfaces or shapes that are very difficult and even almost impossible to machine on conventional machine tools (Krisnanda, 2022), CNC machines are produced in various models according to usage requirements, with large, sturdy shapes, structural dimensions, and immense power, so production costs are high. The price of one CNC machine unit reaches hundreds of millions to billions.

They are choosing a machine capacity that is too large and needs to be utilized adequately, resulting in increased operational costs per product unit, thus affecting the company's competitive ability (Efendi et al., 2019). The price of expensive CNC machines can still be reached by the business world of industry (DUDI). As long as they profit, capital investment to purchase CNC machines is not a problem for companies. In contrast to conditions in vocational schools, the price of CNC machines is expensive, which will be difficult to afford and burden the budget for years. The average school can only afford one or two CNC machines. This condition occurred for years until an indefinite time limit. Many vocational schools ultimately only hope to get CNC machines from government assistance.

The Indonesian government has established a vocational school revitalization policy by issuing **Presidential Instruction** (Inpres) Number 09 of 2016 concerning Improving the Quality of Human Resources. The revitalization program implemented by SMK includes developing and aligning the curriculum with DUDI, learning innovation that encourages 21st-century skills, fulfilling and increasing the professionalism of teachers and education staff, standardizing main facilities and infrastructure, updating industrial cooperation programs, managing and structuring institutions, as well as improving access competency certification. Based on this Presidential Instruction, it is possible to increase the number of machines in vocational schools with new and modern machines. However, the machine increase still needs to be increased if calculated based on comparing machines with the number of students. CNC machines are tools that describe production conditions and types of machines in industry. The demands for developing machine technology in industry have yet to be matched by the development of machines in schools. So, the competency fulfillment for vocational school graduates has yet to be achieved. Strategy and creativity are needed so that learning implementation runs well and student competency is achieved. One strategy to improve CNC machine learning quality is using a CNC simulator. Benefits and advantages of CNC simulators (Wei, 2013)**.** Is a CNC simulator with a simple structure, small size, and low machine manufacturing costs.

The development of CNC simulators has been carried out in various universities and the industrial world. CNC simulators are imitations of machines created, developed, and produced in large quantities. The company produces various types, types, and models of CNC simulators for the public. The similarity of the shape and control system is close to that of a real CNC machine (Kusnanto, nd). The machining process and accuracy are one of the main benefits of this tool. The CNC simulator is computerized and can be used for engraving, such as in CNC milling and cutting machine work on various non-metallic materials (Malik et al., 2019). Small/ portable CNC simulator, specifically designed to meet the needs of the world of education (Ernest & Setyanto, 2018) in his book Design and Analysis of Small-Scale Cost-Effective CNC Milling Machine (2013):

"In the CNC engraving machine, the structure is made as simple as possible, and there are not many sensors, and its dimensions are relatively smaller, so the cost required to make the machine is relatively cheaper (Wei, 2013)."

The structural CNC simulator machine is made simply with reduced sensors and relatively minor dimensions, so operational costs are relatively cheaper. CNC simulator prices are very affordable, with prices starting at 3.59 million. The higher the price of the CNC simulator, the higher the workpiece processing ability and the larger the workpiece that can be worked. The CNC Router Simulator 1610 mini machine is capable of producing workpieces from acrylic, wood, and aluminum. For the aluminum production process, consumption and speed must be low so the CNC simulator can operate well and last long. When compared to a CNC machine, the price of a CNC simulator is much cheaper. The small size of the CNC simulator with the ability to produce small workpieces will save space, so there is no need to expand the practical workshop area, reduce operational costs, and be efficient in fulfilling the number of learning tools. This is reinforced by the opinion (Patel et al., 2019) which states:

"The main objective behind the design of this machine is to develop a low-cost automatic mini CNC machine for engraving, cutting, reaming, marking, drilling, and milling on wood, acrylic, and PCB materials. This system reduces the cost of machines and machining and increases the flexibility of the manufacturing system (Madekar et al., 2016)."

For example, if a school has one CNC machine and then procures a certain number of CNC simulators (according to the student-practice ratio), then learning will run smoothly so that performance standards that reflect the operation of CNC machines in industry are met. A CNC simulator can train students to create programs and execute/apply them directly to machines. This requires direction so that students understand machining in the industry regarding the type and quality of workpieces being worked on.

Muhammadiyah 1 Playen Vocational School is one of three vocational schools in Gunungkidul with a Mechanical Engineering Skills Program with a CNC machine. One of the Competencies in the Machining Engineering Skills Package is being able to carry out machining work with a CNC machine. Competencies in machining work with CNC machines include students being able to create programs and use CNC machines. Achieving competency in this learning is broader than theory but requires practice operating a CNC machine. Therefore, the Machining Engineering Skills Package at Vocational Schools must have adequate facilities such as CNC machines and simulators as learning media. (Hilmawan, 2016) in his research, he stated that the CNC simulator (Swansoft) can create students' desire to learn to focus more on learning and motivate them to optimize their interest in learning. Swansoft's CNC simulator media represents a real CNC machine, which can simulate button functions on the control panel, CNC program input data that will be entered into the CNC machine system, and CNC program execution.

The results of observations at SMK Muhammadiyah 1 Playen in February 2020 showed that CNC subjects were starting to be given to class XI students. Delivery of learning material is carried out using the lecture-question and answer method, using computer software program simulators, and practice with CNC machines. The use of CNC machines in second grade is just an introduction. Introduction to the machine starts from the physical machine, the names of the machine components, to the simple machine operating system. Advanced use is carried out in third grade because, in second grade, industrial practice (PI) is carried out for three to six months. The use of CNC machines in class three starts with basic and advanced machining processes.

The comparison between the number of students carrying out learning and the number of CNC machines available must be balanced. Data from research at vocational schools shows that the ratio of machines to the number of students is not adequate, namely machines 1: 15 – 17 students. Apart from that, students can study the learning material at home because there is a lack of learning resources or supporting learning materials (Kurnia, 2014). SMK Muhammadiyah 1 Playen has two units of CNC machines. The number of class XI students is 90 children. The number of class XII students is 90 children, so the total number of students is 180 children. If calculated in one week (five working days), in one day, one CNC machine is used by 36 children. This is very disproportionate and makes students very poor in understanding CNC lessons. The number of CNC machines that do not meet standards makes the learning situation unpleasant, busy, and less than optimal in the learning process. This condition causes students' competency achievement targets not to be achieved.

(Waris, 2020) states that increasing student competency in vocational schools is influenced by six aspects, namely: (1) cooperation between the business world and the industrial world, (2) curriculum development and alignment, (3) learning innovation, (4) professional development of teachers and education staff, (5) standardization of facilities and infrastructure, as well as (6) institutional management and structuring. One of the factors that influence students' achievement of competency from the description above is clarity in the delivery of lesson material, adequacy of teaching aids/support, and learning situations. Students' ability to master practical CNC machine material will not be achieved if they are hampered by limited equipment because students will have difficulty observing, studying, and carrying out exercises. Learning seems less active for students because students can only create CNC programs if they know how to run the results of the CNC program on a real CNC machine. Students can only imagine how the program works and the results after it is executed with a CNC machine. The clarity of delivery of lesson material, the adequacy of teaching aids/learning supports need to be improved, and research carried out using CNC simulators.

The research aims to evaluating the use of CNC simulators in learning the Mechanical Engineering Skills Program at SMK Muhammadiyah 1 Playen Gunungkidul. Analyze influence of using a CNC simulator in learning the Mechanical Engineering Skills Program at SMK Muhammadiyah 1 Playen Gunungkidul. The benefits of this study are to developing knowledge and service to society, especially in the world of vocational education and solving learning problems that exist in the world of vocational education.

METHOD

The research uses quantitative methods by conducting experiments. The experimental design used is quasi-experimental or quasi-experimental design research. The variables used in this research are the independent and dependent variables. The research was conducted at SMK Muhammadiyah 1 Playen, with the address at Jalan Wonosari-Yogya KM3 Playen Gunungkidul. The research was carried out in February-March 2021. The population in the research were all students in class XII of the Mechanical Engineering Skills Program at SMK Muhammadiyah 1 Playen.

There are three classes of students in the Mechanical Engineering Skills Program at the school, with a total of 90 students. The research samples used at SMK Muhammadiyah 1 Playen were all class XII TPM C, totaling 30 students, as the experimental class, and some students from Class XII TPM A, B, totaling 38 students, as the control class. The instrument created is closed because it has alternative answers, which respondents must choose by ticking the answer column. Data collection techniques use questionnaires and tests. The questionnaire used as an instrument must go through the validity and reliability testing stage before the data analysis stage. In quantitative research, data analysis techniques use statistical methods. The normality test in this research was carried out using the one sample Kolmogorov Smirnov test with the SPSS 20.0 for Windows program.

RESULTS AND DISCUSSION

Research data consists of school data, research data, validity-reliability tests, statistical data analysis, and hypothesis testing.

School Data

The research was conducted at SMK Muhammadiyah 1 Playen. Muhammadiyah 1 Playen Vocational School, located on Wonosari–Yogya KM road. 03 Siyono Wetan, Logandeng, Playen. Muhammadiyah 1 Playen Vocational School was established on July 29, 1982 (based on the decree of the Head of the Regional Office of the Department of Education and Culture of DIY Province Number 193/I.13.1/I.82, December 22, 1982). The spectrum of expertise programs at SMK Muhammadiyah 1 Playen is as follows: (1) Automotive Engineering (Crolla et al., 2015), (2) Mechanical Engineering (Machining Engineering), (3) Electronics Engineering (Audio Video Engineering) and (4) Computer and informatics engineering (Computer and Network Engineering).

SMK Muhammadiyah 1 Playen is accredited "A" and obtained an ISO 9001–2008 certificate from the VEDCA-IQS certification body. School development and student learning are carried out through collaboration with PT. AHM Honda Class program, collaboration with PT. ADM Smart Together Daihatsu (PBD) program, in collaboration with PT. Mabito Karya Axioo Class, and collaboration with PT. HIT Program (ACP) Polytron. The total number of students at SMK Muhammadiyah I Playen is 1075 students. The vision of SMK Muhammadiyah I Playen is to produce graduates who excel in achievements based on faith and piety. The mission of SMK Muhammadiyah I Playen is to foster a spirit of academic and non-academic excellence, increase faith, piety, and noble character, and improve the quality of active, creative, and competent student learning.

Research data

The research was carried out on February 17 – March 17, 2021. The research was carried out in three stages: preparation stage, research implementation, and report preparation stage. The preparation stage is making a learning implementation plan (RPP), a questionnaire, and preparing questions and a schedule. The implementation stage is providing treatment to the experimental class, using a CNC simulator and still using a CNC machine. In the control class, learning runs as usual, using CNC machines. Details of research activities are:

Table 1 Research Activity Schedule

No	Stages	Date month	Activity
1.	Preparation	August 2020	a. Observation
		September 2020	b. Application for research permit
		October 2020	c. Consultation with CNC subject teachers
		November 2020	d. Making lesson plans
		December 2020	e. Preparation and validation of questionnaires
		January 2021	f. Preparation of post-test questions
		February 2021	g. Duplication of questionnaires and questions
2.	Implementation	February 17, 2021 - March 17, 2021	a. Implementation of experimental class learning b. Implementation of control class learning.
		February 17, 2021 - March 17, 2021	c. Providing a questionnaire on the use of experimental class CNC simulators
		March 2021	d. Providing a questionnaire on the use of CNC machines
		March 2021	e. Give posttests to the experimental class
		March 2021	f. Give posttests to the control class
	Reporting	April 2021	a. Perform data analysis and testing
		May 2021	b. Consultation
		June-July 2021	c. Preparation and guidance of reports

Learning Media

Utilizing a CNC simulator begins with procuring/purchasing a CNC simulator tool. The type of CNC simulator used is the CNC Arduino Uno, with a price of IDR 3,500,000.00. The first stage is assembling the CNC simulator. The CNC simulator is carried out using a program that has been provided (example program) from the manufacturer and an example program created by the researcher. So that learning runs smoothly and is not crowded, group schedules are created. One experimental class of 30 students was divided into six groups, each of which consisted of five students. The schedule for using the CNC simulator, taking questionnaires, and posttests is as follows:

Table 2 CNC Simulator Utilization Schedule,
Taking Questionnaires, and Experimental Class Posttest

No	Group	Week 1	Week 2	Week 3	Week 4
1.	Group 1	Simulators CNC	Machine CNC	Machine CNC	Filling out questionnaires and competency post-tests
2.	Group 2		Machine CNC	Machine CNC	Filling out questionnaires and competency post-tests
3.	Group 3	Machine CNC	Simulators CNC	Machine CNC	Filling out questionnaires and competency post-tests
4.	Group 4	Machine CNC		Machine CNC	Filling out questionnaires and competency post-tests
5.	Group 5	Machine CNC	Machine CNC	simulators CNC	Filling out questionnaires and competency post-tests
6.	Group 6	Machine CNC	Machine CNC		Filling out questionnaires and competency post-tests

Each group learns by using the CNC simulator alternately. Group one received a schedule for using the CNC simulator for meeting 1 (week 1) from the 1st to the 4th hour. Group two received a schedule for using the CNC simulator in week one from the 5th to the 8th hour. Group three received a schedule for using the CNC simulator in week two from the 1st to the 4th hour. Group four received a schedule for using the CNC simulator in Week 2 from the 5th to the 8th hour. Group five received a schedule for using the CNC simulator in week three from the 1st to the 4th hour. Group six received a schedule for using the CNC simulator in week three from the 5th to the 8th hour. In the control class, learning is carried out using a CNC machine. In the fourth week (end of the meeting), a questionnaire on using CNC machines was completed. Competency/post-test scores were taken, and in the fourth week, a questionnaire using the CNC simulator and a competency post-test.

Questionnaire and Post-test

The results of filling out the questionnaire on the use of CNC simulators and the questionnaire on the use of CNC machines were obtained from distributing questionnaires to students in writing or by filling in online/Google forms. The results of the experimental class students' use of the CNC simulator questionnaire are as follows:

Table 3 Results of the Experimental Class CNC
Simulator Utilization Questionnaire Results

No	Student's name	Total score	No	Student's name	Total score
1.	Student_1	100	16.	Student_16	89
2.	Student_2	95	17.	Student_17	91
3.	Student_3	100	18.	Student_18	115
4.	Student_4	100	19.	Student_19	120
5.	Student_5	113	20.	Student_20	120
6.	Student_6	109	21.	Student_21	108
7.	Student_7	109	22.	Student_22	106
8.	Student_8	114	23.	Student_23	112
9.	Student_9	115	24.	Student_24	102
10.	Student_10	128	25.	Student_25	113
11.	Student_11	111	26.	Student_26	101
12.	Student_12	113	27.	Student_27	101
13.	Student_13	99	28.	Student_28	104
14.	Student_14	102	29.	Student_29	102
15.	Student_15	111	30.	Student_30	99

From the entire questionnaire given, all students filled in/responded. The results of the control class students' use of CNC machine questionnaires are as follows:

Table 4 Results of the Control Class CNC Machine Utilization Questionnaire

No	Student's name	Total score	No	Student's name	Total score
1.	Student 1	120	16.	Student 16	119
2.	Student 2	123	17.	Student 17	119
3.	Student 3	117	18.	Student 18	119
4.	Student 4	117	19.	Student 19	120
5.	Student 5	122	20.	Student 20	117
6.	Student 6	119	21.	Student 21	119
7.	Student 7	123	22.	Student 22	115
8.	Student 8	122	23.	Student 23	112
9.	Student 9	119	24.	Student 24	103
10.	Student 10	119	25.	Student 25	100
11.	Student 11	106	26.	Student 26	115
12.	Student 12	106	27.	Student 27	118
13.	Student 13	119	28.	Student 28	123
14.	Student 14	119	29.	Student 29	113
15.	Student 15	119	30.	30 students	115

Of the total questionnaires given, 30 students filled in/provided responses.

Competency scores consist of knowledge questions and skills questions. Knowledge questions are in multiple-choice, matching, and fill-in-the-blank forms. Meanwhile, skills questions take the form of assignments/program creation. The competency scores for experimental class XIIMC students are as follows:

Table 5 Experimental Class Student Competency Values

No	Student's name	The Value of Knowledge	Skill Value	Competency Value
1.	Student_1	90	82	85
2.	Student_2	40	60	52
3.	Student_3	79	60	68
4.	Student_4	66	82	76
5.	Student_5	91	82	86
6.	Student_6	91	60	72
7.	Student_7	91	60	72
8.	Student_8	91	60	72
9.	Student_9	97	82	88
10.	Student_10	94	82	87
11.	Student_11	94	82	87
12.	Student_12	40	71	59
13.	Student_13	80	82	81
14.	Student_14	94	60	74
15.	Student_15	42	82	66
16.	Student_16	42	82	66
17.	Student_17	100	60	76
18.	Student_18	100	82	89
19.	Student_19	100	60	76
20.	Student_20	100	60	76
21.	Student_21	100	60	76
22.	Student_22	92	60	73
23.	Student_23	92	82	86
24.	Student_24	94	82	87
25.	Student_25	47	71	61
26.	Student_26	97	91	93
27.	Student_27	94	82	87
28.	Student_28	94	60	74
29.	Student_29	94	82	87
30.	Student_30	31	82	62

Of all the questions given, all students worked on and collected them.

The competency scores for control class students are as follows:

Table 6 Control Class Student Competency Scores

No	Student's name	The Value of Knowledge	Skill Value	Competency Value
1.	Student 1	95	80	86
2.	Student 2	67	52	59
3.	Student 3	73	58	64
4.	Student 4	65	50	66
5.	Student 5	81	66	72
6.	Student 6	67	52	70
7.	Student 7	65	50	66
8.	Student 8	67	52	69
9.	Student 9	67	52	70
10.	Student 10	94	82	86
11.	Student 11	65	50	66
12.	Student 12	88	73	79
13.	Student 13	88	73	80
14.	Student 14	97	82	89
15.	Student 15	84	69	75
16.	Student 16	65	50	66
17.	Student 17	65	50	66
18.	Student 18	86	71	80
19.	Student 19	65	50	66
20.	Student 20	85	70	76
21.	Student 21	88	73	79
22.	Student 22	85	70	76
23.	Student 23	79	64	71
24.	Student 24	85	70	76
25.	Student 25	85	70	76
26.	Student 26	85	70	76
27.	Student 27	65	50	66
28.	Student 28	85	70	76
29.	Student 29	65	50	66
30.	30 students	85	70	76

Of the total questions given, 30 students worked on and collected them.

Validity-reliability test

Expert Validity Test

The expert validity test used two experts, namely the Mechanical Engineering expert teacher at SMK Muhammadiyah 1 Playen, namely Mr. Anharoly Lestiantoro, M. Pd., and one expert from the CNC subject teacher at SMK Muhammadiyah 1 Playen, namely Mr. Rohmat Nurkholik, S.Pd. Results from expert validation tests on questionnaires and questions, namely providing notes and improvements. The notes given are (1) additional work safety/K3 material or work procedures, (2) corrected question material on the CNC machine questionnaire, (3) corrected letter errors in writing, and (4) corrected sentences in the assessment aspect. Then, after improvements and revalidation were carried out, the questionnaire and questions were declared suitable for research instruments (attached).

Empirical Validity Test

Empirical validity tests were carried out on questionnaires using CNC simulators and CNC machines. The instruments regarding knowledge and skills regarding student competency were not subjected to empirical testing, because the questions were taken from the competency test sheet in the handbook and from a collection of questions that had been tested or declared valid. Validation of the questionnaire uses bivariate correlations of Pearson product-moment. With a sample size of 30 students, $\alpha = 0.05$, the r table is 0.361. The questionnaire is declared valid if rcount>rttable; conversely, it is declared invalid if rcount>rttable. The validation calculation results are as follows:

Table 7 Validity Test Results for Using Experimental Class CNC Simulators

No	Question Items	r-table	r-count	Information
1.	Item1	0.361	0.523	Valid
2.	Item2	0.361	0.104	Invalid
3.	Item3	0.361	0.192	Invalid
4.	Item4	0.361	0.655	Valid
5.	Item5	0.361	0.769	Valid
6.	Item6	0.361	0.876	Valid
7.	Item7	0.361	0.598	Valid
8.	Item8	0.361	0.517	Valid
9.	Item9	0.361	0.203	Invalid
10.	Item10	0.361	0.103	Invalid
11.	Item11	0.361	0.200	Invalid
12.	Item12	0.361	0.089	Invalid
13.	Item13	0.361	0.233	Invalid
14.	Item14	0.361	0.384	Valid
15.	Item15	0.361	0.414	Valid
16.	Item16	0.361	0.368	Valid
17.	Item17	0.361	0.617	Valid
18.	Item18	0.361	0.679	Valid
19.	Item19	0.361	0.634	Valid
20.	Item20	0.361	0.557	Valid
21.	Item21	0.361	0.599	Valid
22.	Item22	0.361	0.136	Invalid
23.	Item23	0.361	0.488	Valid
24.	Item24	0.361	0.288	Invalid
25.	Item25	0.361	0.079	Invalid
26.	Item26	0.361	0.165	Invalid
27.	Item27	0.361	0.181	Invalid
28.	Item28	0.361	0.427	Valid
29.	Item29	0.361	-,115	Invalid
30.	Item30	0.361	0.079	Invalid
31.	Item31	0.361	0.050	Invalid
32.	Item32	0.361	0.187	Invalid
33.	Item33	0.361	0.426	Invalid
34.	Item34	0.361	0.290	Invalid
35.	Item35	0.361	0.474	Valid

From the results of the calculation above, it can be seen that there are 19 valid question items in numbers 1, 4, 5, 6, 7, 8, 14, 15, 16, 17, 18, 19, 20, 21, 23, 27, 28, 33 and 35. Invalid question items are numbers 2, 3, 9, 10, 11, 12, 13, 22, 24, 25, 26, 29, 30, 31, 32 and 34. Valid questionnaire items are suitable for use in research. In contrast, invalid questionnaire items are declared invalid and discarded for complete calculation results (attached).

Table 8 Validity Test Results for Using Control Class CNC Machines

No	Question Items	r-table	r-count	Information
1.	Item_1	0.361	0.619	Valid
2.	Item_2	0.361	0.609	Valid
3.	Item_3	0.361	0.620	Valid
4.	Item_4	0.361	0.472	Valid
5.	Item_5	0.361	0.082	Invalid
6.	Item_6	0.361	-,134	Invalid
7.	Item_7	0.361	0.345	Invalid
8.	Item_8	0.361	0.303	Invalid
9.	Item_9	0.361	0.555	Valid
10.	Item_10	0.361	0.387	Valid

11.	Item_11	0.361	0.122	Invalid
12.	Item_12	0.361	0.397	Valid
13.	Item_13	0.361	-,112	Invalid
14.	Item_14	0.361	0.496	Valid
15.	Item_15	0.361	0.294	Invalid
16.	Item_16	0.361	0.852	Valid
17.	Item_17	0.361	0.463	Valid
18.	Item_18	0.361	-,106	Invalid
19.	Item_19	0.361	0.436	Valid
20.	Item_20	0.361	-,394	Invalid
21.	Item_21	0.361	0.464	Valid
22.	Item_22	0.361	0.750	Valid
23.	Item_23	0.361	0.368	Valid
24.	Item_24	0.361	0.875	Valid
25.	Item_25	0.361	0.382	Valid
26.	Item_26	0.361	0.361	Valid
27.	Item_27	0.361	0.223	Invalid
28.	Item_28	0.361	0.028	Invalid
29.	Item_29	0.361	-,137	Invalid
30.	Item_30	0.361	0.103	Invalid
31.	Item_31	0.361	-,208	Invalid
32.	Item_32	0.361	0.225	Invalid
33.	Item_33	0.361	0.107	Invalid
34.	Item_34	0.361	-,021	Invalid
35.	Item_35	0.361	0.181	Invalid

From the calculation above, it can be seen that there are 17 valid questions, namely numbers 1, 2, 3, 4, 9, 10, 12, 14, 16, 17, 19, 21, 22, 23, 24, 25 and 26. Invalid question items are number 5, 6, 7, 8, 11, 13, 15, 18, 20, 27, 28, 29, 30, 31, 32, 33, 34 and 35. Valid questions are suitable for use in research. In contrast, invalid question items are declared invalid and discarded for complete calculation results (attached).

Reliability Test

The reliability test is carried out after the validity test and the instrument is declared valid. Reliability testing is used to determine whether the instrument being tested is consistent in providing measurement results that are carried out repeatedly. Instrument reliability testing uses the Cronbach-Alpha method. The questionnaire is declared reliable if the Cronbach-Alpha value is > 0.05. The data from the reliability test results for instruments using experimental class CNC simulators are as follows:

Table 9 Reliability Test Results for Using Experimental Class CNC Simulators

Cronbach's Alpha	N of Items
,882	17

Based on table reliability criteria, 0.882 is included in the reliability coefficient interval of 0.80 -1.00 with a very reliable level of influence. The data from the reliability test results for using control class CNC machines are:

Table 10 Reliability Test Results for Using Control Class CNC Machines

Cronbach's Alpha	N of Items
,897	17

Based on the reliability **criteria table**, 0.897 is included in the reliability coefficient interval of 0.80 -1.00 with a very reliable level of influence. The collected data was analyzed using statistical testing. The data tested was taken from student competency data. Before data analysis, an analysis prerequisite test is first carried out, namely the normality test.

Data analysis

Normality test

The normality test is carried out to determine whether the variance (diversity) of data obtained from research results is usually distributed or not normally distributed. Data normality is an absolute requirement before parametric statistical analysis (t-test). Normality tests were carried out on student competency results in both samples from the experimental and control classes. The normality test on the data from this study uses a significance level (α = 0.05). The results of the normality test calculation are:

Table 11 Normality Test Results

Class		Kolmogorov-Smirnov		
		Statistics	df	Sig.
Competence	CNC simulator (experiment)	,149	30	,088
	CNC machine (control)	,151	30	,081
	experimental competence	.143	30	.122
	control competence	,165	30	,037

Based on the output, it is known that the significance value (Sig) for all data in the Kolmogorov-Smirnof test is > 0.05, so it can be concluded that the research data is usually distributed.

Table 12 Results of Analysis of Student Competency Scores

	N	Minimum	Maximum	Amount	Average	Standard Deviation
Experimental class test	30	52	93	2294	76.47	10,375
Control class test	30	56	89	2173	72.43	7,704
Valid N	30					

From the results of the descriptive analysis above, the data obtained are: the largest (maximum) value for the experimental class is 93, and the most significant value for the control class is 89. The experimental class's smallest (minimum) value is 52, and the minimum value for the control class is 56. The experimental class's average (mean) value is 76.47, and the average value of the control class is 72.43. The total score for the experimental class is 2294, and the total for the control class is 2173.

Hypothesis testing

The experimental class and control class research data that had been tested for normality obtained average distribution results and then continued with hypothesis testing. Hypothesis testing was conducted to analyze the positive influence/increase in student competency using CNC simulators in learning the Mechanical Engineering Skills Program at SMK Muhammadiyah 1 Playen Gunungkidul. The hypothesis test used in this research is a parametric statistical test, namely the Independent sample t-test.

Analysis to determine the influence of the CNC simulator on student competency achievement. The test is explained with the following steps:

1) Determine the hypothesis
   H 0: μ 1≤ μ 2 The CNC simulator does not affect student competency achievement. H 1: μ 1> μ 2 = There is an influence of the CNC simulator on student competency achievement.
2) Determine the level of significance.
   If the significance value is <α = 0.05, then H 1 is accepted, and H 0 is rejected. If the significance value ≥ α = 0.05, then H 1 is rejected, and H 0 is accepted.

3) Data Analysis Results

The results of the t-test data analysis are:

Table 13 Independent t-test test results

		Paired Differences							
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper	t	df	Sig. (2-tailed)
Pair 1	CNC_simulator-experiment_ competence	-12,300	10,446	1,907	-16.201	-8,399	-6,449	29	,000
Pair 2	CNC_machines-control_ competence	-8,967	12,716	2,322	-13,715	-4,219	-3,862	29	,001

Based on the data output, in pair one, we get sig. (2-tailed) is 0.000< 0.05, so it can be concluded that there is a positive influence on the competency results of experimental class students who learn using a CNC simulator and a CNC machine. In pair two, you get sig. (2-tailed) of 0.001< 0.05. From the data output, learning using the CNC simulator has a better effect, namely sig. (2-tailed) 0.000 compared to learning only using a CNC machine, namely sig. (2-tailed) 0.001.

Discussion

We are examining and evaluating the implementation of the use of CNC simulators in learning the Mechanical Engineering Skills Program at SMK Muhammadiyah 1 Playen Gunungkidul. Based on the implementation of the use of CNC simulators in learning the Mechanical Engineering Skills Program at SMK Muhammadiyah 1 Playen Gunungkidul, which has been carried out, the study and evaluation can be stated as follows:

a. Implementing the CNC simulator begins with purchasing a three-axis milling type CNC simulator tool at the lowest price, IDR 3,550,000.00.
b. The initial learning activity is introducing/displaying the CNC simulator and comparing the similarities and differences between the CNC simulator and the CNC machine. The results of taking a questionnaire with aspects of the simulator's appearance showed that 88% of the answers showed that the appearance of the CNC simulator was good, attractive, and modern. The questionnaire results with aspects of tool specifications on the operating button indicators showed that 73% of the answers were that the terms CNC simulator operating buttons were easy to understand.
c. They were making a schedule for using the CNC simulator in groups. One experimental class of 30 students was divided into six groups, each of which consisted of five students. Students are divided evenly, both in number and ability in the group. Each group learns by using the CNC simulator alternately. The group had the opportunity to use the CNC simulator in one meeting because the time spent on the research was one month.
d. Implementing learning with the CNC simulator ran smoothly, did not involve high risks, was easy, and had few errors. This was proven by taking a questionnaire with indicators of easy CNC simulator operation steps, which showed 72% of the answers. The questionnaire results with an indicator of the steps for installing the workpiece on the CNC simulator showed that the number of answers was 84%. The results of taking the questionnaire with the step indicator set to zero on the CNC simulator showed that the number of answers was 83%. The results of taking a questionnaire indicating that CNC simulator learning is not high risk showed that the number of answers was 88%. The results of taking a questionnaire with an interesting CNC simulator learning indicator showed that the number of answers was 78%. The results of taking a questionnaire with indicators

that students easily observe and understand the movements of the CNC simulator showed that the number of answers was 67%.

The results of this research are confirmed by researches which states that one strategy to improve the quality of CNC machine learning is to use a CNC simulator (Soori et al., 2023). The benefits and advantages of the simulator are that the CNC simulator has a simple structure, small size, and low machine manufacturing costs. Researches stated that the similarity of a CNC simulator's shape and control system is close to that of a real CNC machine (Martinov et al., 2020). Researches stated that the CNC simulator is computerized and can be used for engraving as in CNC milling and cutting machine work on various non-metallic materials (Chaubey & Jain, 2018). Researches stated that the CNC simulator is small/portable and specifically designed to meet the needs of the world of education (Eguia et al., 2017).

The Effect of Using CNC Simulators on Student Competency Achievement

Based on the analysis of research data, the use of CNC simulators has a positive effect on the achievement of student competency in the Mechanical Engineering Skills Program at SMK Muhammadiyah 1 Playen Gunungkidul. Judging from the mean value, the experimental class was higher than the control class, 76.47>72.43. Judging from the number of scores, it is known that the experimental class is more numerous than the control class, namely 2294>2173. Judging from the highest score, the experimental class was higher than the control class, namely 93>83.

Judging from the value comparison, based on the grouping/range of values, it can be displayed with the following diagram:

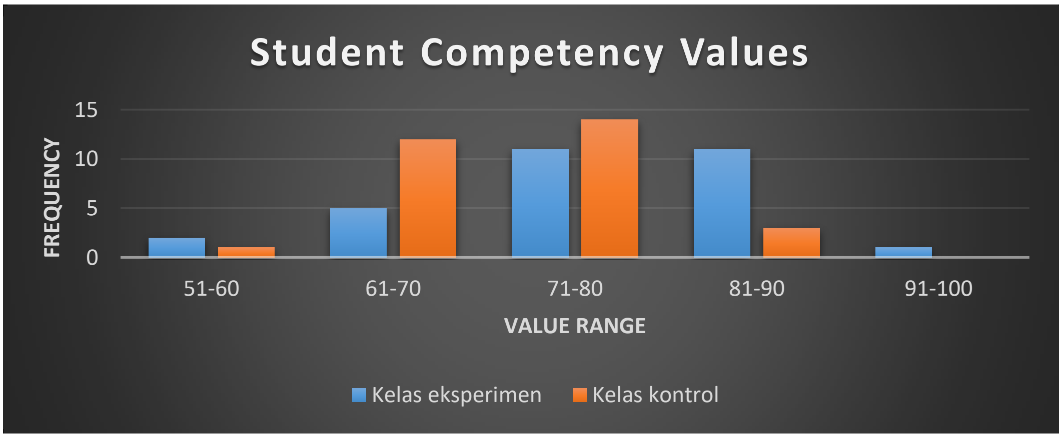

Figure 1 Comparison of Posttest Scores for Experimental Class and Control Class

Student competency scores were 81-90; the experimental class had more students than the control class, namely 11 students > 3 students. A score in the range of 81-90 is a score that meets the minimum completion criteria (KKM) standards. In the 71-80 range, the experimental class had fewer students than the control class, namely 11 students <14. Values in the range 71-80 are values that are between below and above the KKM. The KKM standard for the Mechanical Engineering skills program at SMK Muhammadiyah 1 Playen Gunungkidul is 75. The experimental class got a high score of 1 student in the range of 91-100.

Based on the data above, the results can be obtained: H 1: μ 1> μ 2 = There is an influence of the CNC simulator on student competency achievement. Thus, using the CNC simulator improves the quality of learning in the Mechanical Engineering Skills Program at SMK Muhammadiyah 1 Playen Gunungkidul.

This is in line with research by researches, which states that simulation programs give students more opportunities to participate in learning actively (Hilmawan, 2016). The use of simulation methods is more effective and efficient compared to other learning methods. Research **at SMKN 2 Surabaya found the effect of using Mach 3 turn simulation on student learning outcomes in the CNC** class XII machining engineering subject at SMKN 2 Surabaya. The use of CNC simulation in this research is software. The program is introduced, examples are given, and then students are given the task of inputting the program into the simulator. The research results showed that the average post-test learning outcomes for the experimental class were higher than those of the control class. There is a significant difference in the increase in student learning outcomes between the experimental classes that use Mach 3 turn simulation media.

Factors Inhibiting the Use of CNC Simulators

The factors inhibiting the use of CNC simulators in achieving competency for students in the Mechanical Engineering Skills Program at SMK Muhammadiyah 1 Playen Gunungkidul are:

a. The number of CNC simulators used still needs to be increased, namely only one unit. This is still very low compared to the number of students, so the ratio of students to CNC simulators still needs to be met. This dramatically affects learning completeness, as stated by (2014), who stated that research data in vocational schools shows that the ratio of machines to the number of students is not adequate, namely 1: 15 - 17 students, because there is a lack of learning resources or supporting learning materials, then students can study the subject matter at home. (Hilmawan, 2016) explained that the influence of the lack of CNC machines resulted in learning that seemed less active for students because students could only create CNC programs without being able to know how to run the results of the CNC program on a real CNC machine. Students can only imagine how the program works and the results after it is executed with a CNC machine.
b. The lowest price/type of CNC simulator procurement. Based on Table 1.3 regarding the CNC simulator price list, it can be seen that this price is in first place. (Soori et al., 2023) statement that CNC simulator machines are made with reduced sensors to make them cheap is based on the fact that in the use of CNC simulators in learning, the absence of sensors on the x, y, and z axes causes movement of the axes beyond the work area (crashing).
c. Some students' understanding of the CNC simulator in the experimental class was not achieved; this was indicated by the competency scores obtained by some students being lower than those in the control class, namely 52<56. This was indicated by two students filling in low questionnaire scores (scale one) regarding the ease of operating the CNC simulator.
d. There was a pandemic/disease outbreak while the research was taking place. Hence, the completeness of the material on the use of CNC simulators needed to be completed.

CONCLUSION

The research results can be concluded: Using the CNC simulator in CNC learning at SMK Muhammadiyah 1, Playen Gunungkidul can be implemented smoothly. The use of the simulator is carried out in groups using a rotating system. Each group had the opportunity to use the CNC simulator. Using simulators makes it easier for students to practice. Using CNC simulators in CNC lessons positively affects students' competency at SMK Muhammadiyah 1 Playen Gunungkidul in the Mechanical Engineering Skills Program. The KKM score obtained by the experimental class was better than the control class, namely 11 students>3 students, and the highest score obtained by the experimental class was more than the control class, 93>83. Factors that hinder the use of CNC simulators in achieving competency for students at SMK Muhammadiyah 1 Playen Gunungkidul are: the number of simulators is still insufficient, the type of CNC simulators is low, and there is a pandemic/disease outbreak while the research is taking place.

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