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# Implementation of Discovery Learning to Improve CNC Machining Learning Achievement in Vocational High Schools

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**ABSTRACT:** The low competence of vocational high school graduates in Indonesia is a problem in meeting the needs of the world of work. Limited learning facilities and infrastructure cause low competence. This class action research aims to analyze the implementation of discovery learning on CNC machining learning achievement. This research was conducted on 18 students of class XII of Mechanical Engineering 2 of SMK Negeri 2 Sragen. Data was collected using multiple choice test instruments to measure knowledge learning achievement and observation sheets to measure CNC machine operation skills learning achievement and 21st-century skills learning achievement. The results showed that implementing discovery learning can improve knowledge learning achievement, CNC machine operation skills learning achievement, and 21st-century skills learning achievement. The increase in knowledge learning achievement can be seen from the pre-cycle results, which reached 6% to 44% in cycle 1 and 83% in cycle 2. The increase in learning achievement of CNC operating skills can be seen from the results of cycle 1, which reached 33% and 94% in cycle 2. The increase in learning achievement of 21st-century skills can be seen from the results of cycle 1, which reached 61% and 89% in cycle 2. These results show that the application of discovery learning has a positive impact on improving student learning achievement. This research is expected to have a follow-up from the teacher so that implementing CNC learning can facilitate students' talents and interests.

**KEYWORDS:** Education, Vocational High Schools (SMK), CNC, Discovery Learning, Learning Achievement, 21st Century Skills

## I. INTRODUCTION

Education is a benchmark for a nation to see the quality of its human resources. The low quality of human resources increases a country's unemployment rate (Purwanda, 2022). The increase in unemployment reflects that the quality of education has not been able to meet the demands of the needs of the world of work. Vocational education is a work-oriented education that prepares students to improve their skills in a particular field after graduating (Fauzi & Nuhcron, 2017; Yoto et al., 2024). BPS statistics data in 2023 on the open unemployment rate based on education level show that vocational high school graduates from 2015 to 2022 contributed the highest unemployment rate in Indonesia. The open unemployment rate for vocational school graduates in 2022 reached 9.42%. The open unemployment rate for vocational high school graduates in 2022 reached 9.42%.

These data show that the objectives of vocational high schools are still not as expected. These educational goals will not be achieved if supporting factors such as curriculum, buildings and facilities, teachers, students, and class dynamics do not adapt to current developments (Cindy et al., 2022). An irrelevant curriculum will make it difficult for graduates to compete in the job market. The Independent Curriculum emerged as an innovation in Indonesian education reform (Fauzan et al., 2023; Irwan et al., 2024). The main objective of the independent curriculum is to encourage quality and recovery from the learning crisis (Irawati et al., 2022). The independent curriculum provides flexibility to educational institutions, including Vocational High Schools, to design relevant and innovative learning according to the potential of students (Satriyanto, 2023; Suri & Nuryanto, 2023).

The Independent Curriculum emphasizes developing practical skills based on the demands of industry and the world of work. An important aspect lies in integrating 4C skills (Communication, Collaboration, Critical Thinking, and Creativity) in the learning process (Ichsan et al., 2023; Sibuea et al., 2023). The 4C skills that are the focus of the independent curriculum in 21st-century learning can be realized by implementing various innovative learning models (Partini, 2023). The independent curriculum offers several learning models, such as project-based learning, problem-based learning, inquiry-based learning, discovery-based learning, and teaching factory. The independent curriculum allows students to apply knowledge and skills in actual contexts (Ferwati et al., 2023). The results of the implementation of the independent curriculum, based on research conducted by Nasution et al. (2024),

show that vocational high school teachers experience several obstacles in implementing the independent curriculum. Minimal references, lack of teacher competence, limited digital access, and inadequate facilities cause these obstacles.

Similar research conducted by Jannatun and Syah (2023) showed that the obstacles to implementing the independent curriculum in vocational schools lie in adjusting to the characteristics of students. The results of this study are reinforced by the results of research by Nafiah et al. (2024), which showed that the factors that make it challenging to implement the independent curriculum in vocational schools are the diversity of student characteristics, the level of understanding of the independent curriculum, and limited facilities to improve competencies according to the industrial work environment. Limited facilities and infrastructure for practice are some of the factors that hinder the improvement of the competency of vocational school students (Helda & Syahrani, 2022). The high cost of CNC machines results in the limited availability of CNC machines in learning, which impacts the low competency possessed (Sasan & Baritua, 2022).

The results of pre-research interviews conducted at SMK Negeri 1 Sawit, SMK Negeri 2 Surakarta, SMK Negeri 2 Sragen, SMK Binawiyata Karangmalang, and SMK Muhammadiyah 1 Surakarta regarding the obstacles to implementing the independent curriculum in CNC learning are the limited availability of CNC machines. The limited availability of CNC machines results in ineffective learning conditions in the classroom. The limited availability of CNC machines, compared to the number of students, poses serious challenges and problems in organizing practical learning. This limitation makes it difficult for teachers to provide understanding and direct experience to students in operating CNC machines. This problem results in students' low achievement in non-conventional machining elements. The limited facilities and infrastructure for these practices can be overcome if we look at the opportunities for the development of Science, Technology, and Communication (IPTEK) in the era of globalization.

Technological advances can make daily work more accessible but require mastery of new skills and knowledge (Menteri Pendidikan dan Kebudayaan Republik Indonesia, 2020). Simulator software results from technological developments that can be used as a CNC learning medium. A CNC simulator is a computer program that simulates the operation of a CNC machine to practice and learn CNC machining techniques without the need for a physical machine (Suyetno & Yoto, 2021). Integrating simulators into learning can provide a real solution to the limitations of CNC machines in schools. There are several CNC simulator software available on the market, some of which are Mastercam, Solidworks, Fusion 360, CNC Simulator Pro, Swansoft, and Android smartphone-based CNC simulators such as CNC Simulator Free and CNC Milling Simulator. Simulators have been proven effective in improving CNC learning achievement during the COVID-19 pandemic when face-toface learning is limited (Ma'rufiati et al., 2024).

Based on the above background, it is necessary to apply an appropriate learning model and utilize facilities and infrastructure as well as learning media resulting from technological developments so that students can have competencies by the needs of the world of work. The discovery learning model was chosen as the object of research. This learning model was selected because it is a recommended learning model in the independent curriculum that is relevant to the actual conditions in SMK. The limitations of CNC machines in research are overcome by utilizing Swansoft simulator learning media in the hope that it can be a solution in producing competent SMK graduates according to the need to enter and develop independently in the face of any changes caused by the development of the world of work. Based on the previous description, research is needed to determine how implementing discovery learning in CNC practical learning for students majoring in Mechanical Engineering can improve learning achievement in knowledge, CNC operating skills, and 21st-century skills.

## II. METHOD

This research is classroom action research that aims to improve learning. The research model used is the Kurt Lewin model, which includes four steps: planning, action, observation, and reflection. The subjects of this study were XII class students of Machining Engineering 2 SMK Negeri 2 Sragen, totalling 18 students who were taking CNC learning. The object of research is the discovery learning model applied to students in CNC learning. Data collection in this study was carried out using tests, observation, documentation, and interview techniques. Tests were conducted to collect data on knowledge learning achievement. The observation was conducted to collect data on the learning achievement of CNC operating skills and 21stcentury skills. Documentation was conducted as an archive of research actions in learning activities. Written interviews were conducted to obtain data on difficulties and conveniences in learning. The data analysis techniques used are qualitative and quantitative data analysis techniques. The success criteria of the action can be achieved if the percentage of student learning achievement is 80%, with a minimum score of 75 for each learning achievement.

Pre-research activities include field observations, preparation of learning modules, and preparation of research instruments. The research instruments used were multiple choice questions to measure knowledge learning achievement, observation sheets to measure learning achievement of CNC operating skills, and observation sheets of learning achievement of 21st-century skills. The instruments were then tested for validity and reliability to ensure their reliability and consistency in measuring student learning achievement. The results of validity and reliability tests on 20 multiple-choice questions showed 17 valid and reliable questions. The results of the content validity test conducted on two education experts showed that the research instrument was ready to use.

This research was conducted collaboratively and participatively. Collaborative and participatory classroom action research is a type of research that is conducted collaboratively and involves the participation of various parties.

## III. RESULT AND DISCUSSION

This class action research aims to improve learning achievement of knowledge, CNC operating skills, and 21st-century skills in CNC learning in class XII Machining Engineering 2 SMK Negeri 2 Sragen. This research was conducted with pre-cycle, cycle 1, and cycle 2. The following is a presentation of data and a discussion of the results of the research that has been done.

### A. RESULT

The application of discovery learning assisted by Swansoft CNC Simulator (SSCNC) learning media in CNC learning can facilitate student learning needs. Students feel more enthusiastic and do not feel bored during the learning process, which affects the improvement of student learning achievement. The following is a presentation of data results regarding knowledge learning achievement, CNC operating skills learning achievement, and 21st Century skills learning achievement.

#### 1. Knowledge Learning Achievement

Data on learning achievement of CNC operation skills is obtained based on the results of the implementation of observations during the cycle. Learning achievement observations were implemented using a CNC operating skills observation instrument consisting of 5 competencies. The skill observation instrument was used as an observation guide for 18 students of class XII Machining Engineering 2 SMK Negeri 2 Sragen during the implementation of the action. The distribution data of learning achievement of CNC operation skills obtained by students in cycle 1 and cycle 2 are presented as follows:

**Table 1 Data Distribution of Knowledge Learning Achievement at Pre-Cycle, Cycle 1, and Cycle 2**

| Description | Pre-Cycle | Cycle 1 | Cycle 2 |
|---|---|---|---|
| Complete | 1 | 8 | 15 |
| Not Complete | 17 | 10 | 3 |
| Percentage Complete | 6% | 44% | 83% |
| Percentage Not Completed | 94% | 56% | 17% |
| Maximum Grades | 88 | 94 | 100 |
| Minimum Grades | 35 | 47 | 65 |
| Average | 51,0 | 69,3 | 80,4 |

#### 2. Learning Achievement of CNC Operation Skills

Data on learning achievement of CNC operation skills is obtained based on the results of the implementation of observations during the cycle. Learning achievement observations were implemented using a CNC operating skills observation instrument consisting of 5 competencies. The skill observation instrument was used as an observation guide for 18 students of class XII Machining Engineering 2 SMK Negeri 2 Sragen during the implementation of the action. The distribution data of learning achievement of CNC operation skills obtained by students in cycle 1 and cycle 2 are presented as follows:

**Table 2 Data Distribution of Learning Achievement of Skills Cycle 1 and Cycle 2**

| Description | Cycle 1 | Cycle 2 |
|---|---|---|
| Complete | 6 | 17 |
| Not Complete | 12 | 1 |
| Percentage Complete | 33% | 94% |
| Percentage Not Completed | 67% | 6% |
| Maximum Grades | 88 | 98 |
| Minimum Grades | 58 | 70 |
| Average | 68,7 | 81,4 |

#### 3. 21st-Century Skills Learning Achievement

Data on learning achievement of 21st-century skills are obtained based on the results of the implementation of observations during the cycle. The observation of learning achievement was carried out using a 21st-century skills observation instrument consisting of 3 competencies. The skill observation instrument was used as an observation guideline for 18 students in class 12 of machining technique 2 of SMK Negeri 2 Sragen during the implementation of the action. Data on the distribution of learning achievement of 21st-century skills obtained by students in cycle 1 and cycle 2 are presented as follows:

**Table 3 Data Distribution of Knowledge Learning Achievement at Pre-Cycle, Cycle 1, and Cycle 2**

| Description | Cycle 1 | Cycle 2 |
|---|---|---|
| Complete | 6 | 17 |
| Not Complete | 12 | 1 |
| Percentage Complete | 33% | 94% |
| Percentage Not Completed | 67% | 6% |
| Maximum Grades | 88 | 98 |
| Minimum Grades | 58 | 70 |
| Average | 68,7 | 81,4 |

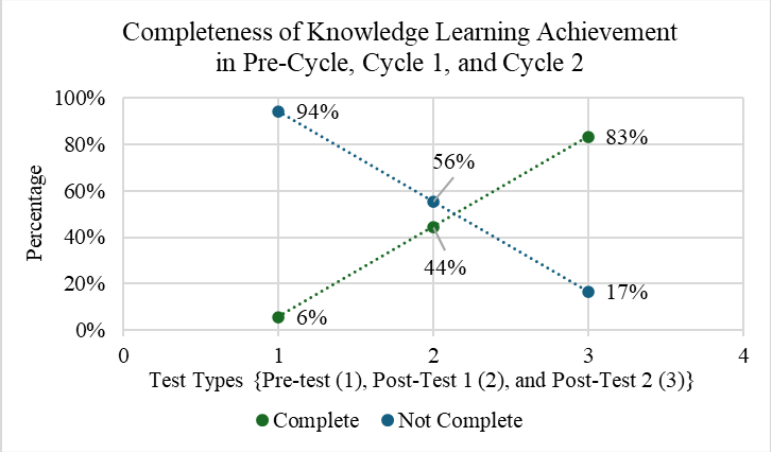
## B. DISCUSSION

This research process was conducted in 2 cycles. The data analysis results showed a significant increase from pre-cycle to cycle 1 and to cycle 2 for the three learning achievement data: knowledge learning achievement, CNC operation skills learning achievement, and 21st-century skills learning achievement. The data results in the implementation of cycle 1 showed that the three learning achievements had increased but had not yet met the research completion indicators. Based on the data results and reflection of cycle 1, a follow-up was carried out in cycle 2. The data results in the implementation of cycle 2 showed that the three learning achievements had increased and met the success criteria of the actions that the teacher and researcher had prepared. The following is a further discussion of the learning achievement of knowledge, learning achievement of CNC operating skills, and learning achievement of 21st-century skills of students in CNC learning.

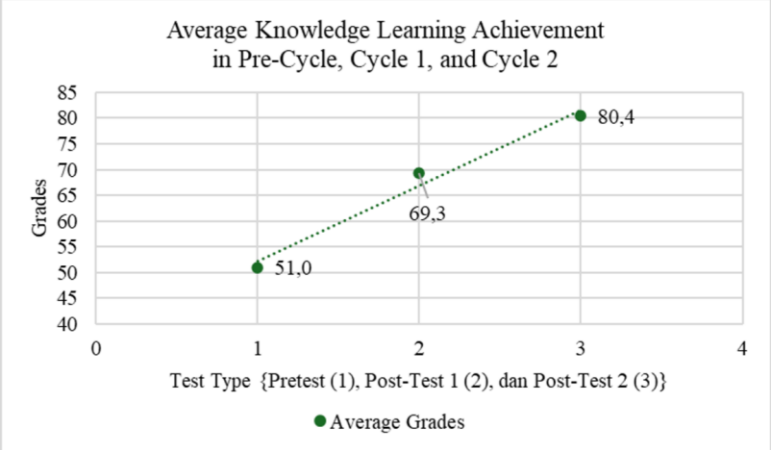
### 1. Improving Learning Achievement of Knowledge

Based on the distribution of knowledge learning achievement data, a scatter diagram can be presented in the following image:

Picture 1 Percentage of Knowledge Learning Achievement Completion in Pre-Cycle, Cycle 1, and Cycle 2




Picture 2 Average Knowledge Learning Achievement in Pre-Cycle, Cycle 1, and Cycle 2




The implementation of cycle 1 showed an increase in student learning achievement. The post-test 1 results showed an average score of 69.3, with a minimum score of 47 and a maximum score of 94. The results of post-test 1 after implementing learning actions in cycle 1 showed an increase in the percentage of class completeness. The percentage of completeness, previously 6% or one student, increased to 44% or ten students. This shows that the action in cycle 1 has not yet met the percentage of learning achievement

completeness set by the school. However, its implementation has positively affected students' learning achievement. Based on these results, researchers conducted follow-up in the form of learning improvements in cycle 2.

The results of the implementation of cycle 2 in CNC learning showed an increase in student learning achievement. The results of post-test 2 showed an average score of 80.4, with a minimum score of 65 and a maximum score of 100. The results of post-test 2 showed an increase in the percentage of class completion, previously in cycle 1 of 44% or ten students, increased to 83% or fifteen students. The results of these data show that the percentage of cognitive domain learning completion of students after the implementation of cycle 2 has met the research completion criteria.

## 2. IMPROVED LEARNING ACHIEVEMENT OF CNC OPERATION SKILLS

Based on the distribution of data on learning achievement of CNC operating skills, a scatter diagram can be presented in the following figure:

Figure 3 Percentage of Learning Achievement of CNC Operating Skills in Cycle 1 and Cycle 2

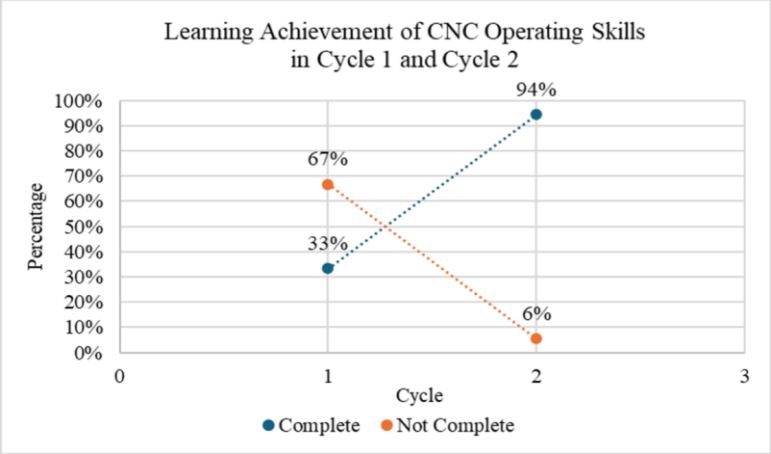
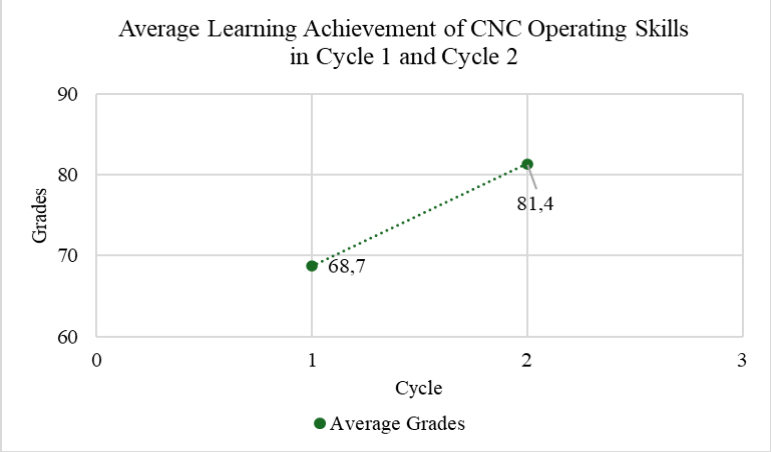



Figure 4 Average Learning Achievement of CNC Operating Skills in Cycle 1 and Cycle 2




Based on Figure 3 and Figure 4, the implementation of cycle 1 in CNC learning shows an increase in student learning achievement. The observation results show that the average value obtained is 68.7, with a minimum value of 58 and a maximum of 88. The results of observations during the implementation of learning actions in cycle 1 show that students who previously said they could not practice operating a CNC milling machine began to experience an increase in competence. This is evidenced by the completion of learning achievement in cycle 1 skills, which is 1 out of 33% or six students. This shows that the actions in cycle 1 have not met the percentage of learning achievement completion set by the school. However, its implementation has positively affected the learning and achievement of CNC operating skills.

Based on these results, researchers conducted a follow-up by preparing a reflection on learning in cycle 1, which was used as a guide to improve learning planning in cycle 2. The results of the implementation of cycle 2 in CNC learning showed an increase in student learning achievement. The observation results of cycle 2 showed that the average score obtained was 81.4, with a minimum score of 70 and a maximum score of 98. The observation results of cycle 2 showed an increase in the percentage of class completeness, which previously, in cycle 1, amounted to 33% or six students and increased to 94% or seventeen students. The results of this data indicate that the percentage of learning completeness of CNC operating skills obtained by students after the implementation of cycle 2 has met the research completeness criteria.

## 3. IMPROVED 21ST-CENTURY SKILLS LEARNING ACHIEVEMENT

Based on the distribution of data on learning achievement of 21st-century skills, a scatter diagram can be presented in the following figure:

Figure 5 Percentage of Learning Achievement of 21st Century Skills in Cycle 1 and Cycle 2

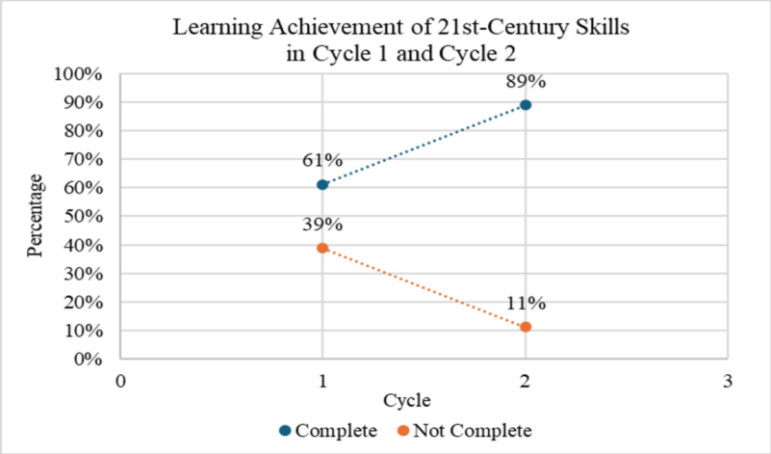
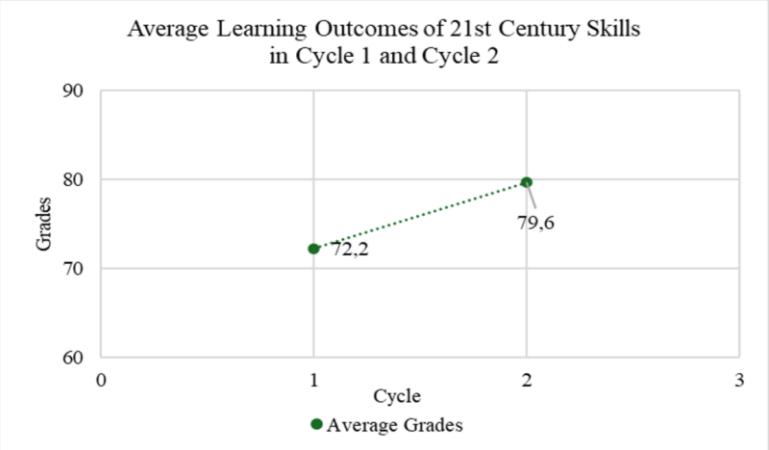



Figure 6 Average Learning Achievement of 21st-Century Skills in Cycle 1 and Cycle 2




Based on Figure 5 and Figure 6, the results of the implementation of cycle 1 in CNC learning show an increase in student learning achievement. The observation results show that the average score obtained is 72.2, with a minimum score of 50 and a maximum score of 83. The observations during the implementation of learning actions in cycle 1 showed that students who had not previously shown 21st-century skills in CNC learning began to experience increased competence, so they began to be able to show these 21st-century skills. This is evidenced by the percentage of students who complete 21st-century skills learning achievement, 61% or eleven students. This indicates that the action in cycle 1 has not met the percentage of learning achievement completeness that has been determined. However, its implementation has positively influenced students' learning achievement with 21st-century skills.

Based on these results, the researchers conducted a follow-up by preparing a reflection on learning in cycle 1, which was used as a guideline for improving learning planning in cycle 2. The results of the implementation of cycle 2 in CNC learning showed an increase in student learning achievement. The observation results of cycle 2 show that the average score obtained is 79.6, with a minimum score of 67 and a maximum score of 100. The results of cycle 2 observations show an increase in the percentage of class completeness, which previously in cycle 1 was 61% or eleven students, increased to 89% or sixteen students. The results of these data show that the percentage of learning completeness of 21st-century skills of students after the implementation of cycle 2 has met the criteria for research completeness.

## CONCLUSIONS

Based on the results of the research and discussion previously described, the following conclusions can be shown:

1. Learning by using discovery learning can improve learning achievement on knowledge in CNC learning in class XII Machining Engineering SMK Negeri 2 Sragen. The increase in knowledge learning achievement can be seen from the pre-cycle results, which reached 6%, increased to 44% in cycle 1, and increased to 83% in cycle 2.
2. Learning by using discovery learning can improve learning achievement of CNC operating skills in CNC learning in class XII Machining Engineering SMK Negeri 2 Sragen. The increase in learning achievement of CNC operating skills can be seen from the results of cycle 1, which reached 33%, then increased to 94% in cycle 2.

3. Learning by using discovery learning can improve the achievement of 21st-century skills in CNC learning in class XII Machining Engineering SMK Negeri 2 Sragen. The increase in 21st-century skills learning achievement can be seen from the results of cycle 1, which reached 61%, then increased to 89% in cycle 2.
4. Applying the discovery learning model in CNC learning can increase student enthusiasm and learning achievement. This is indicated by student responses and increased learning achievement in each cycle.

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