

Improving Milling Machining Practice Competence through Competency-Based Evaluation at SMK PGRI 3 Malang

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Article Info

Keywords:

Classroom action research;
competency-based evaluation;
milling practice;
practical competence.

ABSTRACT

Milling practice learning in vocational schools requires students to possess work competencies aligned with skill-based standards. However, problems remain, such as low student accuracy and limited understanding of work procedures, with the average practical score in the previous semester reaching only 72. This study aimed to improve students' milling practice competence through competency-based evaluation at SMK PGRI 3 Malang using Classroom Action Research (CAR) conducted in two cycles involving 63 students of class X Machining Engineering. Data were collected through observation, documentation, and assessment of practical work, then analyzed using descriptive quantitative techniques. The results showed that competency-based evaluation improved students' practical skills, particularly in work preparation, machine operation, work accuracy, and occupational safety. Students' practical competence improved, as shown by the average score increasing from 76 to 81 in the first cycle and 88 in the second cycle, with learning mastery increasing from 75% to 80% and 89%. Students also became more active, careful, and responsible during practice. Therefore, competency-based evaluation is effective in improving students' milling practice competence in vocational schools.

Informasi Artikel

Kata Kunci:

Evaluasi berbasis kompetensi;
kompetensi praktik;
penelitian tindakan kelas;
praktik frais;
teknik pemesinan.

ABSTRAK

Pembelajaran praktik frais di SMK menuntut siswa memiliki kompetensi kerja sesuai standar berbasis keterampilan. Namun, masih ditemukan kendala seperti rendahnya ketelitian dan pemahaman prosedur kerja siswa, dengan rata-rata nilai praktik semester sebelumnya hanya 72. Penelitian ini bertujuan meningkatkan kompetensi praktik frais siswa melalui evaluasi berbasis kompetensi di SMK PGRI 3 Malang menggunakan metode Penelitian Tindakan Kelas (PTK) dalam dua siklus dengan subjek 63 siswa kelas X Teknik Pemesinan. Data dikumpulkan melalui pengamatan, dokumentasi, dan penilaian praktik, kemudian dianalisis secara deskriptif kuantitatif. Hasil penelitian menunjukkan bahwa evaluasi berbasis kompetensi mampu meningkatkan keterampilan praktik siswa, terutama pada aspek persiapan kerja, pengoperasian mesin, ketepatan hasil, dan keselamatan kerja. Kompetensi praktik siswa meningkat, ditunjukkan dari rata-rata nilai yang naik dari 76 menjadi 81 pada siklus I dan 88 pada siklus II, dengan ketuntasan belajar meningkat dari 75% menjadi 80% dan 89%. Siswa juga menjadi lebih aktif, teliti, dan bertanggung jawab selama praktik. Dengan demikian, evaluasi berbasis kompetensi efektif digunakan untuk meningkatkan kompetensi praktik frais siswa di SMK.

Article History

Received : 15/08/2026

Revised : 10/09/2026

Accepted : 21/10/2026

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1. Introduction

Vocational education plays a crucial role in preparing skilled human resources who meet the demands of the labor market and industry. In Vocational High Schools (SMKs), students are expected not only to acquire theoretical knowledge but also to master practical skills that comply with occupational competency standards. Practical learning in vocational education should provide authentic work experiences that enable students to develop the technical skills and work procedures required in industrial settings [1]. Work readiness among vocational students, particularly those majoring in machining engineering, has been shown to be significantly influenced by industrial work practice experiences. Specifically, non-technical aspects of industrial internships contribute positively and significantly to students' work readiness, accounting for 48.9% of the variance [2]. Furthermore, project-based and case-based learning approaches have been reported to improve students' learning outcomes in machining courses [3]. However, students continue to experience difficulties in understanding the functions, operating principles, and procedures of milling machines, indicating the need for more structured instructional and assessment strategies to enhance competency achievement [4]. Furthermore, assessment approaches in TVET have been shown to provide precise feedback on whether students have successfully attained learning outcomes, thereby improving teaching quality and supporting stakeholders in making informed educational decisions [5].

In the Machining Engineering program, milling practice is one of the essential competencies that students must master because it involves machine operation skills, work precision, and product quality. Preliminary observations conducted at SMK PGRI 3 Malang revealed several challenges during milling practice, including students' lack of accuracy, limited understanding of operational procedures, and difficulties in operating milling machines. Similar challenges have been identified in vocational machining education, particularly during the preparation, implementation, and evaluation stages of practical learning [6]. In addition, students' competency achievement is influenced by various factors, including learning readiness, mastery of operational procedures, effective use of machinery and equipment, and adherence to competency standards during practical activities [7]. Based on the previous semester's assessment records, 25% of students failed to achieve the school's minimum mastery criterion (75), while the class average reached only 72. Differences in students' abilities also resulted in varying levels of practical competency achievement. Such conditions may affect students' ability to master machining competencies because practical competence has been found to be significantly associated with work readiness [8]. Likewise, as reported in [9], effective industrial work practice contributes positively to vocational students' work readiness, highlighting the importance of strengthening practical competencies during the learning process.

One potential solution to these challenges is the implementation of competency-based assessment. Competency-based assessment evaluates students according to predefined competency standards and performance indicators, allowing their abilities to be measured objectively, systematically, and consistently with industry requirements [10]. In vocational education, the competency-based approach has been shown to promote students' employability by ensuring that teaching and

assessment practices are aligned with real-world professional standards [11]. In practical learning, assessment should encompass both the work process and the final product to provide a comprehensive evaluation of students' competency achievement [12]. Moreover, competency-based assessment enables students to better understand the competency standards they are expected to achieve while providing more accurate information regarding their level of skill mastery [13]. Continuous feedback generated through competency-based assessment also enables teachers to identify students' learning difficulties at an early stage and implement more appropriate instructional improvements.

Although numerous studies have investigated competency assessment and evaluation in vocational education, most have focused on instrument validation, competency certification, or the implementation of Teaching Factory programs. Studies specifically examining the implementation of competency-based assessment to improve milling practice competency at the vocational high school level remain limited [14]. In addition, competency-based learning models in vocational education have increasingly emphasized skill acquisition and performance-based outcomes as a means to better prepare students for industry demands [15]. Therefore, this classroom action research aims to improve students' milling practice competency through the implementation of competency-based assessment in the Machining Engineering Program at SMK PGRI 3 Malang. The findings of this study are expected to contribute to the development of practical learning assessment systems in vocational education, particularly in enhancing students' competency in milling practice.

2. Method

This study employed the Classroom Action Research (CAR) method to improve students' competency in milling practice through the implementation of competency-based assessment at SMK PGRI 3 Malang. Classroom Action Research has been widely adopted in vocational education settings as it enables teachers to systematically identify learning challenges and implement targeted improvements within real classroom contexts [16]. Classroom Action Research is a systematic research approach conducted through iterative cycles consisting of planning, action, observation, and reflection to improve the quality of the teaching and learning process [12].

The participants of this study were 63 tenth-grade students enrolled in the Machining Engineering Program, consisting of 32 students from Class X TP A and 31 students from Class X TP C. The study was conducted over two action research cycles, each comprising four stages: planning, action, observation, and reflection.

The research addressed the low level of students' competency achievement in milling practice, particularly in machine operation, workpiece accuracy, and understanding of machining procedures. Preliminary observations also revealed that the existing assessment process primarily emphasized the final product, providing limited opportunities for students to understand the competency standards required in practical machining activities. To overcome these issues, competency-based assessment was implemented to evaluate both the work process and the final product according to predetermined competency indicators [8].

During the planning stage, learning materials, milling

practice job sheets, observation sheets, and competency-based assessment instruments were developed. The action stage involved implementing competency-based assessment during milling practice sessions. Subsequently, the observation stage focused on monitoring students' learning activities and competency development throughout the practical sessions. Finally, the reflection stage was conducted to evaluate the outcomes of each cycle and to identify improvements required for the subsequent cycle.

The Classroom Action Research procedure adopted in this study is illustrated in Figure 1.

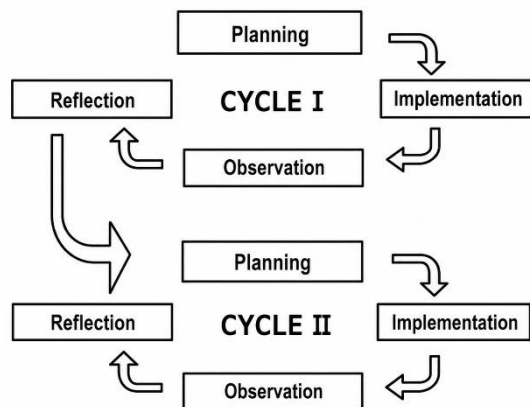


Figure 1 Classroom Action Research Flow

As illustrated in Figure 1, the Classroom Action Research (CAR) was conducted through four iterative stages in each cycle: planning, action, observation, and reflection. During the planning stage, lesson plans and competency-based assessment instruments were developed. The action stage involved implementing competency-based assessment during milling practice to enhance students' practical competencies. The observation stage focused on monitoring students' learning activities and competency development throughout the practical sessions, while the reflection stage was conducted to evaluate the outcomes of the implemented actions and to identify necessary improvements for the subsequent cycle.

The competency-based assessment instrument employed in this study consisted of several assessment components, including work preparation, operation of milling machines and equipment, workpiece accuracy, occupational safety, and students' work attitudes during practical activities. The assessment was conducted continuously throughout each research cycle to evaluate students' competency achievement and monitor their learning progress.

The assessment aspects and performance indicators were developed based on the competency standards for milling practice that students were expected to achieve. The detailed assessment criteria used in this study are presented in Table 1.

Table 1 Competency-Based Assessment Rubric for Milling Practice

No	Assessment Aspect	Assessment Indicator	Weight (%)
1	Work Preparation	Preparation of tools and materials and interpretation	20

		of engineering drawings	
2	Machine and Equipment Operation	Accuracy in setting up the milling machine and proper use of measuring instruments	25
3	Machining Process	Compliance with standard operating procedures during milling practice	25
4	Workpiece Quality	Dimensional accuracy, surface flatness, and overall workpiece quality	20
5	Occupational Safety and Work Attitude	Compliance with occupational safety procedures, discipline, and responsibility	10

Data were collected through observation and documentation techniques. Observation was conducted to obtain information regarding students' learning activities and performance during milling practice, whereas documentation was used to collect students' practical work results, assessment sheets, and records of classroom learning activities.

Students were considered to have achieved individual mastery if they obtained a minimum score of 75, which corresponds to the school's Minimum Mastery Criterion (MMC). Classical mastery was considered achieved when at least 85% of the students met or exceeded the MMC. The percentage of classical mastery was calculated using the following equation:

$$P = \frac{n}{N} \times 100\% \quad (1)$$

where:

- **P** = percentage of classical mastery (%)
- **n** = number of students achieving mastery
- **N** = total number of students

The research data were analyzed using descriptive quantitative analysis by comparing the results obtained during the pre-cycle, Cycle I, and Cycle II. The analysis focused on students' average scores, the percentage of classical mastery, and improvements in each competency component. The improvement in students' competency was further evaluated using the normalized gain (N-Gain) formula:

$$N\text{-Gain} = \frac{\text{Cycle II Score} - \text{Pre Cycle Score}}{\text{Maximum Score} - \text{Pre Cycle Score}} \quad (2)$$

The interpretation of the N-Gain values is presented in Table 2.

Table 2 N-Gain Classification

N-Gain Value	Category
N-Gain > 0.70	High
0.30 ≤ N-Gain ≤ 0.70	Moderate
N-Gain < 0.30	Low

The implementation of competency-based assessment was expected to gradually improve students' competency in milling practice by providing a more structured assessment process aligned with the characteristics of vocational education. The study was considered successful if the percentage of classical mastery reached at least 85%, in accordance with the predetermined success criteria.

3. Results and Discussion

This classroom action research was conducted in two cycles through the implementation of competency-based evaluation in milling practice learning in class X Machining Engineering at SMK PGRI 3 Malang. The research focused on improving students' competence in the aspects of work preparation, milling machine operation, work accuracy, occupational safety, and work attitude during practice. The evaluation was carried out gradually to determine the development of students' competence in each research cycle.

3.1 Initial Condition of Milling Practice Learning

Based on the initial observation, the milling practice learning process still showed several obstacles affecting students' competence achievement. Some students still experienced difficulties in setting up the milling machine, using measuring tools, and systematically understanding work procedures. In addition, the evaluation process used was still more focused on the final results of the workpiece without considering the students' work process during practice. This condition caused some students to have insufficient understanding of the competency standards to be achieved.

The initial evaluation results showed that students' milling practice competence still needed improvement. This was indicated by the students' average score of 76 with a classical mastery of 75%, meaning that 16 out of 63 students had not yet reached the school's KKM. In addition, some students were still not careful in measuring workpieces, had not been able to operate the milling machine optimally, and had not applied work procedures according to the established standards.

The initial condition of students' competence in each assessment aspect also showed results that were not yet optimal. The aspects of machine and tool usage and the work process were the aspects with the lowest achievement, indicating that students still required more intensive guidance in correctly and systematically understanding the milling machine's operational procedures.

3.2 Implementation of Action in Cycle I

In the planning stage of Cycle I, the teacher prepared learning tools including the milling practice jobsheet, observation sheets, and a competency-based evaluation instrument covering five assessment aspects. The teacher also prepared a more structured learning scenario so that students could understand the work procedures before the practice began.

In the implementation stage, competency-based evaluation was applied by assessing not only the final result of the workpiece but also the students' work process during practice. Students began to be given an understanding of the competency indicators used in the assessment, and the teacher provided

guidance on work procedures so that students could understand the work standards to be achieved. During the practice, students appeared to be more active and paid more attention to each work step performed.

The observation results in Cycle I showed that most students began to pay better attention to work procedures. However, some students still experienced difficulties in setting up the milling machine and using measuring tools. Limited practice time and the alternating use of machines also affected the effectiveness of the learning process. The students' average score in Cycle I reached 81 with a classical mastery of 80%, an improvement from the initial condition but not yet meeting the minimum success indicator of 85%.

Based on the reflection results of Cycle I, it was found that some students still had difficulties in calculations and the use of the dividing head, and some students still lacked confidence in operating the milling machine independently. Therefore, several improvements were agreed upon for Cycle II, namely providing more intensive mentoring, presenting more structured work examples, and emphasizing competency indicators that had not yet been achieved.

3.3 Implementation of Action in Cycle II

In the planning stage of Cycle II, the teacher redesigned the learning scenario by adding more detailed demonstrations of work steps, particularly regarding the use of the dividing head and the setup of the milling machine. The practice jobsheet was also clarified with more detailed work-step instructions so that students could follow the work procedures more independently.

In the implementation stage, the teacher provided more intensive mentoring to students who still experienced difficulties in machine operation and workpiece measurement. Guidance on work procedures and occupational safety was also strengthened so that students became more disciplined during practice. Emphasis on the competency indicators to be achieved made students more motivated to work according to the established standards.

The observation results in Cycle II showed quite significant changes. Students were better able to operate the milling machine independently, machine setup errors began to decrease, and the quality of the workpiece results improved in terms of dimensional accuracy and surface flatness. The implementation of occupational safety procedures also improved, as shown by students' increased awareness in using personal protective equipment. The students' average score reached 88 with a classical mastery of 89%, exceeding the established success indicator.

The reflection in Cycle II showed that the improvements made successfully addressed most of the obstacles found in Cycle I. Students were able to operate the milling machine more independently, their understanding of work procedures and occupational safety improved significantly, and all competency aspects showed improvement. Nevertheless, 7 students had not yet achieved learning mastery, which was likely due to differences in initial ability and varying levels of understanding.

3.4 Results of Students' Competency Assessment

The implementation of competency-based assessment resulted in a gradual improvement in students' milling practice competency throughout the research cycles. The overall

improvement in students' performance is presented in Table 3.

Table 3. Improvement in Students' Milling Practice Competency

Indicator	Pre-cycle	Cycle I	Cycle II
Mean score	76	81	88
Classical mastery	75%	80%	89%

As shown in Table 3, students' mean scores increased consistently across the research cycles. During the pre-cycle stage, the average score was 76, with a classical mastery rate of 75%. Following the implementation of competency-based assessment in Cycle I, the mean score increased to 81, while the classical mastery rate reached 80%. Further improvement was observed in Cycle II, where the mean score increased to 88, accompanied by a classical mastery rate of 89%. These findings indicate that competency-based assessment contributed to continuous improvement in students' learning outcomes during milling practice.

In addition to the improvement in average scores and classical mastery rates, the number of students achieving the minimum mastery criterion also increased throughout the study. The detailed results are presented in Table 4.

Table 4 Number of Students Achieving Mastery

Stage	Number of Students	Achieved Mastery	Did Not Achieve Mastery	Classical Mastery
Pre-cycle	63	47	16	75%
Cycle I	63	50	13	80%
Cycle II	63	56	7	89%

As presented in Table 4, the number of students who achieved the minimum mastery criterion increased in every research cycle. Initially, 47 students achieved mastery during the pre-cycle stage. This number increased to 50 students in Cycle I and further increased to 56 students in Cycle II. Concurrently, the number of students who had not achieved mastery decreased from 16 in the pre-cycle to 7 by the end of Cycle II. These findings demonstrate that competency-based assessment effectively supported a greater proportion of students in achieving the expected competency standards.

The improvement in students' competency was further evaluated using the normalized gain (N-Gain), calculated as follows:

$$N-Gain = \frac{88 - 76}{100 - 76} = \frac{12}{24} = 0,50 \quad (3)$$

The obtained N-Gain value of 0.50 falls within the moderate improvement category, indicating that the implementation of competency-based assessment had a meaningful positive effect on students' milling practice competency.

Improvements were also observed across all competency assessment aspects. The average scores for each assessment component in every research cycle are presented in Table 5.

Table 5 Average Scores for Each Competency Assessment Aspect

Assessment Aspect	Pre-	Cycle	Cycle
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	cycle	I	II
Work Preparation	74	79	87
Machine and Equipment Operation	72	78	86
Machining Process	75	80	88
Workpiece Quality	77	82	89
Occupational Safety and Work Attitude	80	85	90

As shown in Table 5, all competency assessment aspects demonstrated continuous improvement throughout the research cycles. The greatest improvement was observed in Machine and Equipment Operation, where the average score increased from 72 in the pre-cycle to 86 in Cycle II. This finding suggests that competency-based assessment effectively enhanced students' understanding of machine setup, operation, and machining procedures through continuous performance evaluation and feedback. Meanwhile, the Occupational Safety and Work Attitude component consistently achieved the highest scores across all cycles, indicating that students maintained a strong awareness of occupational health and safety (OHS) practices during milling activities.

These findings are consistent with previous research [17], which reported that work preparation often represents the weakest component in machining practical competency compared with work process and product quality. The study found that achievement in work preparation reached only 59%, whereas work process, work quality, work attitude, and time management achieved 82%, 72%, 76%, and 21%, respectively. This comparison suggests that strengthening competency-based assessment, particularly during the preparation stage, can contribute to more balanced competency development across all aspects of practical machining.

3.5 Discussion

The findings of this study demonstrate that the implementation of competency-based assessment consistently improved students' competency in milling practice throughout the Classroom Action Research cycles. The observed improvements were reflected not only in higher mean scores and classical mastery rates but also in students' work attitudes, procedural compliance, and overall performance during practical activities. These findings suggest that competency-based assessment promotes continuous competency development by providing students with clear performance standards and structured feedback throughout the learning process.

The progressive improvement observed across the research cycles supports the principles of authentic assessment, which emphasize evaluating students' actual performance in completing real-world tasks rather than relying solely on final learning outcomes [8]. By assessing both the learning process and the quality of the final workpiece, competency-based assessment provides a more comprehensive and objective evaluation of students' practical competencies than conventional assessment methods, which typically focus only on the finished product. Consequently, students become more aware of the performance standards they are expected to achieve and are better able to identify areas requiring improvement.

The present findings are consistent with previous studies reporting that competency-based assessment provides a more

objective measure of students' competency achievement while ensuring alignment with established occupational competency standards [12]. Authentic assessment in vocational contexts connects curriculum knowledge with real-world scenarios, enabling students to apply acquired competencies to genuine practical problems encountered in professional settings [18]. Likewise, as demonstrated in [9], well-implemented industrial work practice significantly contributes to vocational students' work readiness, explaining approximately 60.4% of the observed variation in work readiness. Similarly, as reported in [3], structured instructional approaches in machining education increased students' average achievement from 75 to 83, accompanied by improvements in practical skills and work attitudes. Furthermore, systematic competency assessment enables teachers to accurately identify students' competency levels and utilize the results to improve instructional practices in vocational education [13]. Structured competency-based learning in vocational schools has also been linked to improved students' work readiness and employability skills, which are critical for graduates entering the competitive labor market [19].

Another important finding of this study is that competency-based assessment contributed to a more systematic and measurable practical learning environment. In vocational education, assessment should function not only as a tool for measuring learning outcomes but also as a mechanism for developing occupational competencies, including technical skills, work precision, discipline, and compliance with industrial procedures [13]. Furthermore, competency-based learning accompanied by continuous formative assessment feedback has been shown to effectively support students' acquisition of both technical and interpersonal competencies essential for professional work environments [20]. Through continuous assessment and constructive feedback, students are encouraged to improve both their technical performance and professional work behavior during practical activities.

The findings also reinforce the importance of aligning assessment practices with industry expectations. As reported in [7], a considerable discrepancy was found between competency test results achieved at school and graduates' employability in industry. This discrepancy between school-based assessment results and actual industry readiness underscores the importance of implementing competency-based assessment that is oriented toward both technical outcomes and professional behavioral standards, as emphasized in competency-oriented teaching reform in vocational high schools [21]. Although all students were declared competent during school-based competency assessments, only 39% of graduates were successfully employed in industry, and merely 20% of the manufactured products satisfied industrial dimensional quality standards. This discrepancy highlights the necessity of implementing competency-based assessment that evaluates not only technical outcomes but also process quality, accuracy, and adherence to industrial performance standards. Such an approach is expected to better prepare vocational graduates for workplace requirements.

Overall, the results indicate that competency-based assessment has a positive impact on improving students' milling practice competency. A structured assessment process enables students to better understand the competency standards expected in vocational practice while providing teachers with more comprehensive information regarding students' strengths and weaknesses. Consequently, the learning process becomes more

effective, systematic, and aligned with the competency requirements of the manufacturing industry.

4. Conclusion

This study demonstrates that the implementation of competency-based assessment effectively improved students' competency in milling practice at SMK PGRI 3 Malang throughout the Classroom Action Research cycles. Students' mean scores increased progressively from 76 in the pre-cycle to 81 in Cycle I and 88 in Cycle II. Similarly, the classical mastery rate improved from 75% to 80% and ultimately reached 89%. The calculated N-Gain value of 0.50, which falls within the moderate category, indicates that competency-based assessment had a meaningful positive impact on students' practical competency. Beyond the improvement in learning outcomes, students also demonstrated better work accuracy, discipline, and responsibility during practical activities.

These findings suggest that competency-based assessment is an effective approach for evaluating practical learning in vocational education because it emphasizes both the learning process and the quality of the final product while aligning assessment practices with industrial competency standards. The implementation of this assessment approach provides students with clear performance expectations and continuous feedback, thereby supporting the development of technical competence and professional work behavior.

Future studies are encouraged to investigate the implementation of competency-based assessment in combination with other instructional approaches, such as Teaching Factory or project-based learning, and to involve larger samples and different vocational competencies. Such studies would provide broader evidence regarding the effectiveness of competency-based assessment in enhancing students' competencies and improving their readiness to meet industrial workforce demands.

Acknowledgements

The authors would like to express their sincere gratitude to SMK PGRI 3 Malang for providing the opportunity and support to conduct this study. The authors also extend their appreciation to the principal, teachers, and students of the Machining Engineering Program for their cooperation and active participation throughout the research process. Their valuable contributions were essential to the successful completion of this study.

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