Effectiveness of the rubric of competency-based assessment on the achievement of performance in the workbench practicum for students in engineering education

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ABSTRACT: The adoption of an assessment method for instructors is ultimately decisive in measuring the success of teaching-learning processes of college students. An assessment process is said to be successful if it gives a clear understanding about the instructor's method in assessing his/her students. A rubric of competency-based assessment has been implemented for seven years to assess competence achievement of engineering education students on their performance in projects and assignments in the workbench practicum. Subsequently, to ensure the success of the assessment, the researchers used an evaluation model, the so-called CIPP (context, input, process and product), to discover the effectiveness of the rubric in engineering education. The data for this research were collected by surveying all college students having taken the workbench practicum and interviewing the course instructor. Furthermore, the explanation of evaluation components is explained in this article.

INTRODUCTION

Competence-based assessment is an innovative method of assessment related to behaviours [1-3]. Competence-based assessment was previously employed as a means of assessing managerial and supervisory competencies [4][5], but, in the flow of time, it is now used in non-managerial activities to assess potential workers in industry or governmental institutions [6-9]. Špaček and Šíp said that the assessment method is a direct and relevant method for measuring the performance assessed [10].

One of the competence-based assessment methods particularly well-suited to the chosen practical situation in engineering education is projects and assignments. The method can be adopted to test the ability to complete either individual or collective assignments [11-13]. It is based on what people do on work outputs and what is important for work [14].

The assessment can also enable individuals to have a more balanced and fairer assessment, for it focuses not on personalities or cultural factors, but on behaviours [6][15]. According to Meiring and Buckett, fairness in an assessment is related to careful consideration of the values implemented in decisions and actions, based on assessment by giving students feedback, so that they can see their shortcomings by stressing the behaviours and the improvement of students' performance [16].

Fastré et al [17] mentioned that the advantage of competence-based assessment directly affects important aspects of work, providing information about students' strengths and weaknesses in completing their assignments in the workbench practicum developed in engineering education in cooperation with industry [17][6].

Competence-based assessment engineering education developed with industry is aimed at devising assessment methods and systems with which to measure the level of competence in areas industry expects. This assessment is not only implemented, but also it needs evaluating to identify better tools and procedures. Therefore, the researchers carried out a comprehensive evaluation of the implementation of this assessment method in the workbench practicum at the State University of Malang, Malang, East Java, Indonesia, by applying the so-called CIPP (context, input, process and product) evaluation model.

The researchers expected that the study would result in useful information concerning the effectiveness level of the implementation of the rubric of competence-based assessment to measure the competence achievement of students' learning processes under the standard established by engineering education. What is more, the research result will enable instructors to improve the standard of the competence-based assessment to prepare their students for their future careers.

METHODS

This research used the evaluation method taking the quantitative approach. The research also used the CIPP model [18], designed to provide more effective and more accurate data [19] on the effectiveness of the implementation of the rubric of competence-based assessment in the workbench practicum of engineering education students. All students taking the workbench practicum at the State University of Malang, Indonesia were chosen to be the population and sample of the research. The data were collected by distributing questionnaires to the research respondents and holding interviews with instructors.

As for the CIPP evaluation model, the data were processed through four constructs, including contexts (nine items), inputs (14 items), processes (20 items), and products of the final score of project and assignment products by students. The validity of the constructs is 0.84 for questionnaire contexts, 0.80 for questionnaire inputs and 0.85 for questionnaire processes, with the level of reliability 0.78, 0.82 and 0.78 for each consecutively. Meanwhile, the validity and reliability of the product were not measured, for it results from products co-developed by students and their instructors.

As to the data analysis, the researchers identified five categories to provide answers to each of the questionnaire items; namely, very ineffective or good, ineffective or good, slightly effective or good, effective or good and highly effective or good. Descriptive analysis was subsequently carried out to show a clear picture of the questionnaire data collected from the evaluation of the implementation of the competence-based assessment by using SPSS version 21 for Windows. The results of the descriptive analysis of the research data can be seen in Table 1.

Table 1: The summary of the result of the descriptive analysis of the research data.

Variables and constructs	Mean	Standard deviation	Percentage of implementation effectiveness	Category level
1. Context	38.78	2.60	88.1%	Very effective
▪ Job sheet modules	12.81	1.47	85.4%	Very effective
▪ Assessment modules	13.41	1.11	89.4%	Very effective
▪ Setting of tolerance standard of implementation	12.54	1.50	83.7%	Very effective
2. Input	27.54	6.29	67.2%	Fairly effective
▪ Objectives of practicum	4.01	0.85	80.2%	Very effective
▪ Tool condition	14.93	4.35	59.8%	Ineffective
▪ Work place condition	8.59	2.59	71.6%	Ineffective
3. Process	103.67	11.02	85.7%	Effective
▪ Practicum module socialisation	8.78	1.06	87.8%	Very effective
▪ Job steps	8.63	1.07	86.3%	Very effective
▪ Job attitude	8.60	1.02	86.1%	Very effective
▪ Ease of consultation	7.80	1.10	78.0%	Effective
▪ Job evaluation	69.84	8.85	85.2%	Effective
4. Product	75.90	4.25	92.1%	Effective
▪ Score for drilling process	79.84	8.94	80.6%	Good
▪ Score for making nut	91.78	6.27	92.7%	Fairly good
▪ Score for stamping job materials	55.65	9.97	75.2%	Fairly good
▪ Score for sawing process	79.70	7.54	84.8%	Good
▪ Score for making bolt	72.51	11.67	80.6%	Good

RESULTS

Effectiveness of Contexts of the Competence-Based Assessment Implementation

The analysis resulted in the fact that effectiveness of contexts for implementing the rubric of competence-based assessment is very effective (88.1%). This is shown by components supporting the rubric instructors implemented in measuring the achievement of standardised competence established by engineering education and industry. The components are: 1) job sheet modules; 2) assessment modules; and 3) settings of tolerance standards of implementation.

The job sheet module constitutes a very effective component (85.4%) to give students detailed explanations about the project and assignment. It is distributed to all students in the first term of study, so that they fully understand the project and assignment planned by the instructor. The main objectives are: 1) to have an objective assessment; 2) to collect accurate information concerning the competence achievement; 3) to enable students to assess and measure their own work; and 4) to make easier the clarification process of the assessment results.

This model of the job sheet contains the picture of the assigned works, which students need to do while undertaking sets of practicum activities in the workbench course, including drilling, making nuts, stamping on job materials, sawing and making bolts.

Meanwhile, the assessment rubric of the workbench practicum module is highly effective (89.9%) with students' aspirations. The module assesses the conducting of workbench courses by referring to competencies consisting of components, such as job attitude and some aspects examined in some activities; namely, drilling, making nuts, stamping job materials, sawing and making bolts. Similarly, Lok et al stated that assessment processes should be based on criteria and norms [20].

As to the competence-based assessment, the assessment process should be based on the criterion basis. This means the rubric of competence-based assessment is aimed at measuring demonstrable or observable competencies from several indicators, that is to say, an authentic assessment.

The component of setting a tolerance standard for the workbench practicum for the rubric of competence-based assessment is very effective (83.7%). This tolerance standard was set by engineering education to the level desired by industry. There are many things that must be taken into consideration in this process, which include work-related matters, tool condition and available time. In the same way, McAllister et al have said that assessment forms a plan to show authenticity for complex jobs in a workplace which can in turn demonstrate students' competence in an objective way [21].

Additionally, Anson et al stated that when students have been informed about scoring criteria transparently in the first place, they can be involved in the work process much better [22]. Understanding the rubric of competence-based assessment will make students more aware of the required standard, so as to know how to produce outstanding professional work. Through the implementation of the rubric, scoring processes of the instructors and students will become more objective and consistent. Besides, the assessment process will be more efficient, for developing this rubric leads to the remarkable ease and takes less time for instructors to score students' works and assignments. This is in alignment with the main objectives of the implementation of the rubric, that is, to have an objective assessment, to collect accurate information concerning the competence achievement, to enable students to assess and measure their own work, and to make easier the clarification process of the assessment result.

Effectiveness of Inputs of the Competence-Based Assessment Implementation

The input of the implementation of the rubric is fairly effective (67.2%), due to the lack of support from the poor condition of tools and workplaces for students' activities. It is determined by 1) the objective of the practicum; 2) the condition of the tools; and 3) workplace conditions.

The objective of the workbench practicum seems very effective (80.2%). The objective of the practicum includes: 1) stamping job materials; 2) sawing; 3) drilling; 4) making nuts; and 5) making bolts [23]. The success of the objectives is indicated by students' ability to:

1)   stamp job material precisely;
2)   sawing precisely;
3)   drilling precisely;
4)   making a nut precisely;
5)   making a bolt precisely.

In addition, the implementation greatly affects students' soft skills, that is, their working precisely with good discipline; thereby, producing products of high quality. However, the condition of tools for the practicum and workplace conditions are rather ineffective (59.8% and 71.6%). This poor condition is shown by:

1)   stamping job material is boring;
2)   broken parts in nuts and bolts;
3)   some bad sawing tools;
4)   limited tools available;
5)   old stamps with words that are illegible;
6)   drills in poor condition.

Additionally, because the practicum room was being renovated, it made learning practices more uncomfortable.

Fry et al [24] stated that in providing for tools and rooms, it is advisable that both be able to help identify authentic assessment by:

1)   giving students a chance to display their contextual and varied skills and understanding;
2)   making an assessment in an orderly and consistent manner in accordance with the instructional objective;
3)   developing tangible products and observable performances;

4) encouraging students to undertake self-assessment, identify their strengths and weaknesses to increase the strength of the former and overcome the latter;
5) showing students their competencies based on the established criteria.

Effectiveness of Processes of the Competence-Based Assessment Implementation

The learning process accelerated in the well-organised way shows the implementation process of the rubric is effective (85.7%). This component depends on:

1) practicum module socialisation;
2) job steps;
3) job attitudes;
4) the ease of consultation;
5) job evaluation.

The socialisation of the practicum module is done very well, with an effectiveness level of 87.8%. It is done at the first course meeting, with the instructors distributing the modules to students for free and subsequently explaining how to use the modules, which makes students more motivated to have as good jobs as possible.

Job steps and job attitudes about the workbench practicum are effective (78% and 85.2%). The former presents steps in making work items according to the set measure in accordance with the standard operational procedures (SOP), which students have to understand. The latter, meanwhile, is indicated by discipline, neatness and work safety.

Similarly, the ease of consultation and the job evaluation are effective (78% and 85.2%). Students consult the instructors, if they are unable to understand the work process they have to undertake. The consultation is usually about job steps, dimensions and techniques for the use of tools. Concurrently, the instructors make their evaluation by using an assessment sheet and guidance in the practicum module. The assessment sheet is filled in and answered by students with the instructor for each work. Through this process of assessment, students are more likely to accept the result of their performance and the final assessment they made together.

King [25] and Zamani-Gallaher [26] mentioned that the standard for carrying out practicum programmes in engineering education must include establishing some criteria for determining the quality of the assessment process. Some of the criteria are:

1) assessment consistency with the decision planned to be informed;
2) the assessment of achievements and chances of study;
3) the relevance of technical quality concerning the collected data to the consequences of actions taken based on the data;
4) naturalness and objectivity of the assessment process;
5) the reasonable conclusion drawn in accordance with the assessment of the achievement and students' opportunity to study.

Effectiveness of the Products of the Competence-Based Assessment Implementation

The effectiveness of products of the competence-based assessment implementation is very good (92.1%). This is shown by scores of the result of students' drilling processes, making a nut, stamping job material, sawing processes and making a bolt. Nevertheless, students still need to exercise more patience in the marking process.

Research by Söderholm and Norrbin [27] recommended that the development of students' products in practicum classes be relevant to the results of the practicum, in which the progress of the implementation needs to be compared with the planned result. This is instrumental in knowing whether or not the impacts of the practicum are in accordance with the set objectives that were planned to be achieved.

CONCLUSIONS

An evaluation of the implementation of competence-based assessment in the practicum in engineering education is highly effective in achieving the established objective of learning. The success of the assessment also relies on the support of the related staff involved in the learning process and good communication between instructors and students. The evaluation and improvement in competence standards need to be continuously carried out in engineering education and industry in preparing students' competence for their future careers.

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