



The Analysis of Scientific Practices Skills of Students in Basic Physics Practicum: Authentic Assessment

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Abstract

Assessment of practicum activities must encompass all aspects of scientific practices. Observations in this research indicate that the assessment utilized by the Physics Education Study Program at Universitas Muhammadiyah Makassar for practicum activities is an Authentic Assessment consisting of three assessment components: response, practicum activities, and report. This assessment is the result of development by one of the lecturers who taught courses integrated with practicum activities in 2015, and its implementation began in 2016. Using authentic assessment instruments in the form of worksheet, this study aims to assess the scientific practice skills of students enrolled in Basic Physics practicum. This research employed quantitative descriptive research. Thirteen first-semester students in the academic year 2022/2023 participated as the research subject. The results demonstrate that the assessment conducted using authentic assessment in practicum activities did not encompass all indicators of scientific practice skills. The authentic assessment did not include three of the eight indicators of scientific practice skills, namely the ability to ask questions, develop and use a model, and discover, evaluate, and communicate data findings. Therefore, it is necessary to utilize specialized assessment to measure the effectiveness of scientific practices, such as scientific practices assessment instruments.

Keywords: Authentic Assessment; Practicum; Scientific Practices

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INTRODUCTION

The curriculum, learning process, and assessment system are crucial and interdependent aspects of education. Educational institutions must have an assessment system that is tailored to the student's requirements for assessing their abilities. In the college courses that

integrate practicum activities, the required assessment system includes not only an evaluation of the learning process in the classroom but also an evaluation of the learning process during the practicum (Darling-Hammond et al., 2020; El Masri et al., 2023; Filippi et al., 2019).



Physics Education at Universitas Muhammadiyah Makassar is a study program with 40% of compulsory courses incorporated with practicum activities. The primary goals of courses integrated with practicum activities are for students to understand physics practicum and its implementation and problem-solving skills. These goals emphasize training and enhancing the scientific practices of students directly. This is consistent with scientific literacy, one of the pillars of science education (Kähler et al., 2020; Ke et al., 2021), including Physics education. Scientific practices are skills that prospective educators must possess (Chan et al., 2021), particularly prospective science educators (Jimenez-Liso et al., 2021). According to the National Research Council in North America, there are eight scientific practices indicators that students must master, including the ability to ask questions, develop and use a model, design, and conduct experiments, analyze and interpret data, use mathematics and computational thinking, make descriptions, make arguments based on data, and find, evaluate, and communicate data findings (Council, 2012; Stephenson et al., 2020).

Students must demonstrate proficiency in scientific practices through practicum activities (Cooper et al., 2022). A suitable assessment system is required to measure students' scientific practice skills in practicum activities, for an objective assessment system will generate the best results for self-improvement (Sani, 2021). Moreover, the assessment results obtained by students based on their abilities can indirectly motivate them (Jeprianto et al., 2021).

The Physics Education Study Program at Universitas Muhammadiyah Makassar uses an authentic assessment instrument to measure students' abilities in practicum activities. Authentic

assessment is a comprehensive evaluation of learning input, process, and outcomes, including affective, cognitive, and psychomotor outcomes (Ajjawi et al., 2020). Authentic assessment can play a role in improving the learning experience of higher education students by increasing their involvement in learning, increasing their satisfaction, and positively influencing their efforts to achieve educational goals (Sokhanvar et al., 2021; Sotiriadou et al., 2019).

Many studies have discussed authentic assessment in learning. Juli and Patricia's research examined how a preschool teacher designs an authentic assessment using structured and unstructured observations. The results of their research showed that authentic assessment with structured observations is more effective and efficient (Pool & Hampshire, 2020). According to additional research (James & Casidy, 2018; Syaifuddin, 2020), authentic assessment can foster positive student attitudes and behaviors. Based on the abovementioned research findings on authentic assessment, it can be concluded that authentic assessment has a significant impact on learning.

Observations in August 2022 were conducted through interviews. The observations have revealed that the assessment currently used in the Physics Education Study Program at Universitas Muhammadiyah Makassar for courses integrated with practicum activities is authentic, consisting of three assessment components: response, practicum activities, and report. The results of interviews with five lecturers who teach courses integrated with practicum activities indicate that the authentic assessment used was developed by one of the lecturers who taught courses integrated with practicum activities in 2015 and implemented in 2016 in the courses of Measurement and Measurement Tools, Basic Physics 1

and 2, Modern Physics, and High School Physics Practicum.

This study collected data on the deployment of authentic assessment during the odd semester of the academic year 2021/2022. Responses, practicum activities, and reports received scores based on the results of implementing the authentic assessment instrument. However, it has not been specified for eight scientific practices indicators. Therefore, it cannot be determined how students' scientific practice skills have developed. Consequently, this study thoroughly examines the ability of student scientific practices in practicum activities, subdivided into eight indicators as measured by authentic assessment.

Several prior studies have developed assessment instruments for physics practicum activities, such as 1) Performance Assessment Instruments in Practicum Activities on the Topic of Dynamic Fluids (Mandolang et al., 2022). The resulting instrument assessed the activities of students during practicum. 2) Character-Based Presentation Assessment in Basic Physics Practicum at Universitas Muhammadiyah Makassar (Nurlina et al., 2018), which assessed only students' presentation skills in reporting practicum results. 3) Physics Practicum Performance Assessment Instrument based on the 2013 Curriculum (Sartika et al., 2020). This research produced instruments adapted to the 2013 curriculum without considering the existing circumstances and situations. Some of these studies have resulted in instruments that do not cover all aspects of the practicum process, including before, during, and after practicum, namely reporting results. With the scientific practices assessment, all practicum activities can be evaluated.

The following are the research questions based on the background of the research:

RQ: How are the scientific practices of students in Basic Physics practicum activities assessed using Authentic Assessment instruments?

METHOD

This quantitative descriptive study describes (Petrongolo & Toothaker, 2021; Siedlecki, 2020) the students' scientific practice skills in Basic Physics practicum activities using Authentic Assessment instruments. This study was conducted at the Universitas Muhammadiyah Makassar on the Physics Education Study Program in the Faculty of Teacher Training and Education, which designed the Basic Physics course.

Thirteen Physics Education students in the odd semester of 2022/2023 at Universitas Muhammadiyah Makassar who enrolled in the Basic Physics course participated in this research subject. The research subject was determined using purposive sampling, where the selected subjects had to meet the prerequisite of being in the Basic Physics course. Thirteen students programmed this course during the academic year 2022/2023 by following five experimental topics: Motion, Density, Simple Harmonic Motion, Hooke's Law, and Friction. Each experimental subject had one supervisor. Thus, five supervisors interacted with thirteen students.

The research procedure consisted of accumulating all students' Basic Physics practicum scores from the beginning of the course to the time of reporting. After collecting all practicum scores, they were analyzed to determine each indicator's value of scientific practices. The instrument utilized was a performance form with eight scientific practice indicators. Before using the instrument, the V-Aiken formula (Aiken, 1985) is applied to determine the instrument's content validity. The validation results totaled 0.673,

indicating that the instrument was appropriate for use (valid).

The data of this study were descriptively analyzed using the average score formula. The analysis results disclosed the average student score for each aspect of practicum activities related to students' scientific practice skills.

Each experimental topic's response activity consisted of five points of questions administered by the supervisor to evaluate the students' response-ability. The utilized scoring system refers to the existing authentic scoring rubric, in which each question has a distinct ideal score. The scoring results are converted to a score from 1 to 100 using the following formula.

$$\text{Score} = (\text{number of students' scores}/\text{maximum score}) \times 100$$

The examples of authentic scoring rubrics in this research include:

1. Response

Indicator: Students can explain why only certain colors are visible in the spectrum

Question: Why are only certain colors visible in the spectrum?

Scoring:

Table 1 Scoring

Answer	Score
Because most of the colors in the spectrum that are invisible to the eye are in the infrared or ultra violet.	
Incomplete answer	1

2. Practicum

Table 2 Rubric: Operating measurement tools

No.	Criteria	Yes	No
1	Determining NST of the measurement tools correctly		
2	Accuracy in using measurement tools in collecting accurate data		
3	Reading the scale shown in the measurement		

No.	Criteria	Yes	No
4	Using measurement tools safely		
Score			

Table 3 Scoring criteria

Scoring Criteria	Assessment score
Fulfill the four criteria of using measurement tools	4
Fulfill three criteria of using measurement tools	3
Fulfill two criteria of using measurement tools	2
Fulfill one of the criteria of using measurement tools	1
Do not fulfill the four criteria of using measurement tools	0

3. Report

Table 4 Rubric: Technique of data analysis

No.	Criteria	Yes	No
1	The data analysis technique begins with explaining the measured and calculated quantities.		
2	The mathematical equation to be used is written appropriately.		
3	The symbols in each mathematical equation are accompanied by a complete description of their respective units.		
4	Formulas for the measurement uncertainty analysis are derived precisely and structured.		
5	Technics of data analysis are derived in a structured manner.		
Score			

Table 5 Scoring criteria

Scoring criteria	Assessment score
Fulfill the five criteria of the data analysis technique	5
Fulfill four criteria of data analysis technique	4
Fulfill three criteria of data analysis technique	3
Fulfill two criteria of the data analysis technique	2
Fulfill one of the criteria of the data analysis technique	1
Do not fulfill the four criteria of the data analysis technique	0

RESULTS AND DISCUSSION

The results of the assessment analysis of practicum activities using authentic assessment with three components, namely response, practicum, and report, demonstrate that the practicum score is the practicum result from the Basic Physics course, which consists of five experimental topics: Motion (I), Density (II), Simple Harmonic Motion (III), Hooke's Law (IV), and Friction (V). Thirteen students enrolled in the Physics Education Study Program for the academic year 2022/2023 participated in this practicum activity. Table 6 displays the results of an analysis of student practicum scores on each experimental topic, including response, practicum, and report scores.

Table 6 The average students' scores on each experimental topic using authentic assessment

Authentic Assessment Aspect	Average Score/Experimental Topic				
	I	II	III	IV	V
Response	64.1	63.4	63.5	63.0	67.1
Practicum	84.2	83.0	84.8	86.5	83.9
Report	84.2	84.5	84.3	78.5	83.4

Table 6 provides an overview of the average score attained by students on each experimental topic for the three authentic assessment aspects of response, practicum, and report. It can be seen that the response

aspect has the lowest score of the three for all experimental topics. The findings of interviews with five supervisors for each experimental topic (one lecturer per experiment) indicate that response activities are conducted verbally by posing questions to each student face-to-face regarding the topic to be practiced. Before practicum activities commence, students must complete response activities as a prerequisite for participation in practicum activities. The minimum score that students must achieve on the response activities is 60. When a student receives a score below 60, he or she is permitted to participate in practicum and is given the opportunity to restudy and retake the response activities. This opportunity is only granted to students three times. When the opportunity has been presented three times, and the student's performance has not met the required standard, he or she is ineligible for practicum.

The practicum and report aspects have an average score of over 80. This indicates that the average student can earn a score of 80 or higher for both aspects. The practicum activities are conducted in groups, but each supervisor completes the assessment individually using a performance form. The report is completed individually with the supervisor's guidance on each experimental topic until the practicum report is deemed acceptable.

Based on the results of the assessment carried out by the supervisor using authentic assessment, it is necessary to examine students' scientific practices from these results since authentic assessment should cover all aspects assessed (Silverman et al., 2021; Villarroel et al., 2020). Therefore, the researchers reviewed the supervisor's assessment sheet for each experiment and student practicum report so that data on the scientific practices skills consisting of eight indicators with achievement indicators for each were obtained:

1. Asking questions: Students can convey questions to supervisors and

- classmates related to the topic of the experiment.
2. Developing and using a model: Students can choose a practicum model according to the experimental topic.
 3. Designing and carrying out experiments: Students can provide facilities, determine variables, and collect data related to experimental topics.
 4. Analyzing and interpreting data: Students can classify experimental data based on the objective of the experiment.
 5. Using math and computational thinking: Students can apply formulas in analyzing data from experiments.
 6. Making a description of the experimental results: Students can describe in detail the experimental results that have been analyzed.
 7. Making arguments based on data: Students can argue based on the data obtained with solid theoretical foundations.
 8. Finding, evaluating, and communicating data findings: Students can summarize the experimental results obtained, describe the failure and success of the experiment, and account for the experimental results obtained in front of many people.

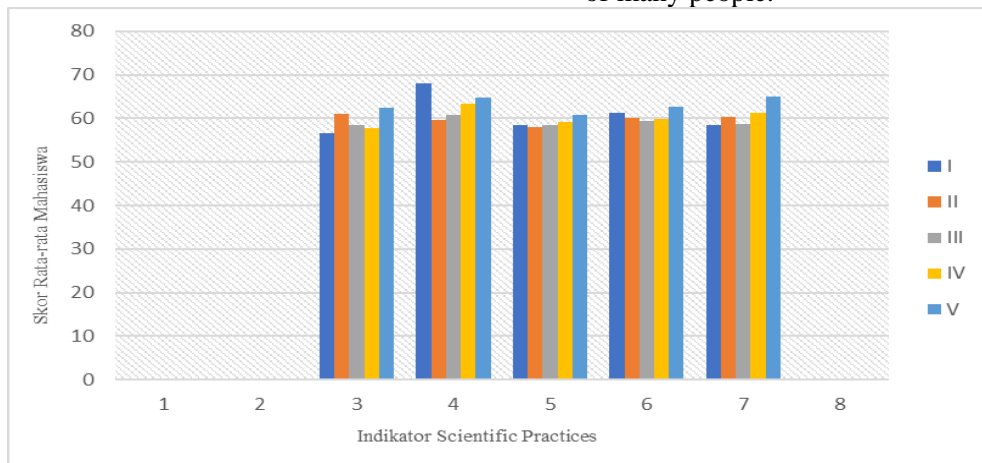


Figure 1 Diagram of the average students' scores for each scientific practices indicator in each experimental topic

The student's average score for each indicator is presented in the bar chart in Figure 1. The analysis of the average score of the scientific practices skills of Physics Education Study Program students in Basic Physics practicum activities for each indicator revealed that authentic assessment does not cover the indicators of the ability to ask questions, develop and use a model, and discover, evaluate, and communicate data findings. Figure 1 shows that the average score for all experiments for indicators 1, 2, and 8 is zero.

The authentic assessment covers indicators 3, 4, 5, 6, and 7, but the

average score attained falls between 56 and 68. The highest average score of 68 was only found in experiment 1 for indicator 4. This occurs because the standard assessment instrument directly evaluates response activities, practicum, and reports. The supervisor's assessment instrument does not encompass all scientific practice skills indicators, whereas every indicator of scientific practice skills is crucial for students to possess, particularly in practicum activities (Gao et al., 2021; Halawa et al., 2020; Özer & Saribaş, 2022).

The reasons why these three indicators were not covered were

determined based on supervisor and student interviews. Indicator 1 cannot be measured because no introductory activity allowed students to discuss the topic that would be practiced. The practicum began with response activities. Meanwhile, indicator 1, the ability to ask questions, should be attained through preliminary discussion activities (Saputri et al., 2019; Winarti et al., 2019) related to the experiment's topic to be conducted before beginning the response activity.

Indicator 2 cannot be measured because the supervisor had devised the experimental model from the outset without student participation. In contrast, indicator 2, namely the ability to develop and use a model in practicum activities, can be obtained by assigning each student problems related to experimental topics. Students should be directed to develop a practicum model to address these problems (Chen & Terada, 2021; García-Carmona, 2020).

Indicator 8 was not measured because students were not allowed to present their experimental results during practicum activities. In contrast, indicator 8, which was discovering, evaluating, and communicating data findings, can be obtained by providing each group with the opportunity to present their practicum report detailing the experimental results (Habig et al., 2020; Habig & Gupta, 2021; Hsin & Wu, 2022; Weiss & Chi, 2018).

CONCLUSIONS

This research concludes that the assessment carried out using authentic assessment in practicum activities does not cover all aspects of the scientific practice skills based on the results of the data analysis. Among the eight indicators of scientific practice skills, three indicators are not included in the authentic assessment: the ability to ask questions, the ability to develop and use a model, and the ability to discover,

evaluate, and communicate data findings. Therefore, a special assessment is needed to measure scientific practice skills. For example, the ability to ask questions indicator can be assessed during the presentation of practicum results with a separate scoring rubric. It is suggested that further research can develop an assessment tool for scientific practice skills.

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