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Development of Performance Assessment Instrument to Measure Student's Laboratory Skills in Thermochemistry Practicum Exothermic and Endothermic Reactions

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Abstract: This development research was conducted to produce a performance assessment instrument that is feasible to use to measure students' laboratory skills in thermochemical practicum activities for exotherm and endotherm reactions based on field investigations and literature reviews that have been completed. The feasibility of performance assessment instruments is reviewed on validity, reliability, and practicality. The type of research used is research and development (Research and Development) with the 4-D method. The validity data was obtained using a validation questionnaire from the validator's assessment. Reliability data was obtained from student laboratory skills scores from two assessors. Affectivity data is obtained from the educator response questionnaire filled out by educators after using the performance assessment instrument. The validity results showed that the aspects of the content component of the performance assessment instrument were declared valid, the presentation feasibility aspect was declared valid, the physical criteria aspect was declared valid, the illustration aspect was declared valid, and the language aspect was declared valid. Reliability results based on the inter-rater reliability analysis obtained a kappa coefficient 0.739 with excellent agreement. Practicality results based on educator responses that received a percentage of 100% with very good criteria. Based on the results of the performance assessment instrument's validity, reliability, and practicality, it is declared feasible to use it to measure the science process skills of students in the laboratory.

Keywords: Exothermic and Endothermic Reactions; Performance Assessment Instrument; Student's Laboratory Skills.

Introduction

Learning is mentioned in English with the term "instruction" and in Greek with the term "instructus" or "inruere", which means conveying a thought [1]. Learning creates environmental conditions that make learning activities and relationships between educators, learners, and learning sources. A curriculum is needed to support learning activities, which is used as a direction for implementing the learning. A curriculum is a set of plans and arrangements regarding the objectives, content, learning materials, and methods used as guidelines for organizing learning activities to achieve certain educational goals [2]. The curriculum currently being used is Kurikulum Merdeka. Kurikulum Merdeka is a new curriculum implemented for education in Indonesia starting in the 2022/2023 academic year. Kurikulum merdeka emphasizes the formation of students' characteristics, so the assessment that occurs is not only to assess academics but also to emphasize the characteristics of each student [3].

Implementation of learning activities requires a learning resource; this is based on Chapter 1 Clause 20 Constitution of the Republic Indonesia Number 20 of 2003 About the National Education System that reads, "Learning is the interaction process of educators, learners, and learning sources in a learning environment" [2]. Based on this, learning resources have an important role in learning activities. Learning resources are all sources that are used to make the steps in the learning process easier [4]. Learning resources can come from anywhere, such as the environment. One environment utilized as a learning resource is the school environment, including classrooms, school grounds, school gardens, libraries, and laboratories. Learning resources are the main elements that must be fulfilled. The element that must be fulfilled is a procedural technique, which contains practical references for using equipment and materials to convey the message. The school laboratory is a learning resource for students in learning practices utilized to benefit teaching and learning activities and applied directly to master academic expertise in learning [5]. Chemistry is related to practical activities in the laboratory. Chemistry studies composition, changes, properties, structure, and the energy accompanying them. Besides that, chemistry also studies phenomena that occur in nature. These natural phenomena can be explained using concepts, theories, and laws in chemistry [6]. There are 75% of students at SMAN 3 Surabaya stated that chemistry is a difficult subject to understand, and 86,12% of students stated that chemistry could be easily understood if the subject was explained not only through theory but also through practicum.

Thermochemistry is the study of verifying natural energy change processes. This proof can be done through experimental activities in the laboratory. The first thermochemistry practicum to build students' thinking

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concepts is exothermic and endothermic reactions. During the practicum, students use previously acquired knowledge about exothermic and endothermic reactions and laboratory skills to use laboratory equipment and observe chemical changes. Laboratory skills are students' ability to use tools, do experiments, and collect experimental data. Basic skills that can be observed during practicum include: (1) taking materials, (2) using tools, (3) observing, (4) communicating, and (5) work safety [7].

Assessment of students' laboratory skills is needed to see the level of laboratory skills that students have and predict the achievement of learning objectives that have been prepared. Based on Chapter 1 Clause 2 of Regulation Number 21 of 2022 of the Minister of Education and Culture of the Republic of Indonesia concerning educational assessment standards in early childhood education, basic education, and secondary education, assessment is the process of collecting and processing information to determine the learning needs and developmental achievements or learning outcomes of student [8]. Chapter 16 Clause 3 Constitution of Republic Indonesia Number 20 of 2003 about the National Education System reads, "The assessment of student learning outcomes must be carried out in accordance with the objectives of the assessment in an equitable, objective, and educational manner [2]. 88,89% of students stated that educators who teach in XI-5 classes have never assessed practical activities directly, nor did performance assessments. Therefore, research was created titled "Development of Performance Assessment Instrument to Measure Student's Laboratory Skills in Thermochemistry Practicum Exothermic and Endothermic Reactions".

Performance assessment instrument is an assessment technique for assessing students' activities directly with process-based assessment and direct observation by educators of both the process and results with an assessment guide in the form of a rubric containing criteria and scores [9]. Rubrics are guidelines created to assess and evaluate the quality of student performance achievements so that educators can provide the assistance needed to improve performance. Educators can also use rubrics to focus on the competencies that must be mastered. Performance achievements are expressed as criteria or dimensions to be assessed, which are made in stages from poor to best [10]. Performance assessment assesses the achievement of competencies that require students to perform certain tasks, such as practicum activities. With practicum activities, students can follow the process, observe an object, analyze, prove, and draw their own conclusions about an object, situation, or something[11]. The advantages of the performance assessment instrument developed compared to the pre-existing instruments are that it has a complete form, starting from the cover, clarity of instructions for use, completeness of assessment to assess cognitive, affective, and psychomotor students and clarity of assessment rubrics. Five indicators of laboratory skills are measured using performance assessment instruments: skills in preparing and using tools and materials, performing work steps, data collection, work safety, and laboratory hygiene [12].

Research Methods

The research used is R&D (Research and Development) with the 4D method. The research and development method is used to produce certain products. Research and development aims not to test theories but to create products for use in schools[13]. This research aims to produce a performance assessment instrument that is feasible to use to measure students' laboratory skills in thermochemical practicum activities for exotherm and endotherm reactions. The stages of 4-D research include defining, designing, developing, and disseminating. The implementation of the 4-D development research stage is limited to the development stage because this research is used to determine the feasibility of the performance assessment instrument. The first stage in the 4-D development method is defined. Front-end analysis, student analysis, and concept analysis are carried out at the define stage. Front-end analysis aims to surface basic problems, determine learning conditions, and review the assessment instruments. Student analysis aims to determine the characteristics of students, which include students' abilities during practicum activities, starting with choosing the right tools and materials, how to use laboratory equipment, processing practicum data, and making conclusions. Concept analysis aims to identify concepts in thermochemical material that have been accepted by students, especially in the sub-material of exothermic reactions and endothermic reactions. The second stage in the 4-D development method is design. At the design stage, the format and initial design of the instrument are selected. The last stage of this research is development. At the development stage, a review was carried out by one chemistry lecturer, and three experts did validation. After the instrument was declared valid, it was tested on a limited basis by two educators who assessed the same 30 students simultaneously at SMA Negeri 3 Surabaya.

The instrument developed has at least valid and reliable criteria [14]. A test or measuring instrument can be said to have high validity if the tool performs its measuring function or provides results that are in accordance with the purpose of the measurement[15]. The validity test is the reliability and validity of the measuring instrument used. Instrumen said valid means indicating the measurement tool used to obtain the data is valid or can be used to measure what should be measured[16]. Validity in this research was obtained from a validation sheet filled in by three experts. The three experts provided validity scores based on the Likert scale in Table 1:

Table 1. Likert Scale

Category	Scale
Very valid	4
Valid	3
Quiet Valid	2
Less Valid	1
Invalid	0

The validation data was analyzed using the mode technique. An instrument can be declared valid with a mode score of ≥4 [16].

Practicality is one way to measure a product's usefulness [17]. Practicality data in this study comes from the educator's response questionnaire, filled in after the educator uses the performance assessment to assess students' laboratory skills in exothermic and endothermic reactions practicum. Then, the data is analyzed using percentages, and the conclusion is made as a descriptive sentence. The percentages obtained are calculated based on the Guttman scale.

Table 2. Guttman Scale

Category	Scale
Yes	1
No	0

The percentage of data obtained is calculated using the following formula:

$$\text{Percentage answer} = \frac{\sum \text{"yes" answer from respondent}}{\text{number of responden}} \times 100\ \%$$

Table 3. Criteria for Interpreting Educator Response Questionnaire Score Result

Percentage	Category
0-20 %	Not Practical
21-40 %	Less Practical
41-60 %	Quiet Practical
61-80 %	Practical
81-100 %	Very Practical

Based on Table 3, the instrument developed is said to be practical when the percentage of educators answering yes is ≥61% [18].

Reliability is an index that shows how much a measuring device can be trusted or relied upon. The reliability test can be used to determine the consistency of the measuring instrument and whether the measuring instrument remains consistent if the measurement is repeated. A measuring instrument is reliable if it produces the same results even though it is measured many times [19]. Reliability data is obtained from agreement between raters or assessors after using the performance assessment instrument in limited trials. The reliability test used in this research is inter-rater reliability. Interrater reliability is determined by discussing the results of observations with other observers, or it can be said to be an agreement between two observers[20]. Inter-rater reliability was assessed by the degree of agreement based on the Kappa coefficient (K).

Table 4. Interpretation of Kappa Coefficient

Kappa Coefficient	Agreement
< 0.40	Poor agreement
0.40-0.69	Fair to good agreemet
≥ 0.70	Excellent agreement

The degree of agreement is considered good if the K value is close to 1 (≥ 0.70) [21].

Results and Discussion

The first stage in the 4-D development method is defined. Front-end, student, and concept analyses are carried out at the define stage. The problem that emerged based on the results of pre-research conducted on October 2–13, 2023, in class XI–5 SMA Negeri 3 Surabaya was the students' inaccuracy in using laboratory equipment, which can affect the results of the practicum, as well as educators not taking assessments of the laboratory skills of each student. Then, in the student analysis, it was found that some students did not memorize the names of laboratory equipment; for example, they could not differentiate between measuring cups and chemical beakers and misused laboratory equipment so that the practicum data obtained was inaccurate, which caused errors when processing the data. Practical results obtained. Some students are still confused and cannot differentiate between exothermic and endothermic reactions. Students stated memorising the differences between exothermic and endothermic reactions was easier if they did practical work than just reading theory. The second stage in the 4-D method is design. In the design section, a design for the performance assessment instrument is prepared, consisting of a cover section, instructions for using the instrument, instrument identity, a summary of the material, practice activities, and an assessment sheet accompanied by an assessment rubric. The last stage in the 4-D method is developed. In this section, instrument validation and limited instrument testing were carried out.

The validity of the performance assessment instrument was obtained from a validation sheet filled out by three validators: two chemistry lecturers and one high school chemistry educator. The validation results obtained from the three validators are presented in Table 5.

Table 5. Validation results of Performance Assessment Instrument

Number	Rated Aspect	Validators			Mode	Validity Category
		1	2	3		
CONTENT ELIGIBILITY CRITERIA						
1.	Performance Assessment Instrument Components The aim is to determine the suitability of instrument using criteria related to the components of the performance assessment instrument:					
	a. The learning outcomes and learning objectives contained in the performance assessment instrument are written operationally	4	5	4	4	Valid
	b. The questions in the performance assessment instrument are easy to understand	4	5	5	5	Very Valid
	c. The sentences in the assessment rubric are easy to understand and do not give rise to multiple interpretation	3	4	4	4	Valid

Number	Rated Aspect	Validators 1	2	3	Mode	Validity Category
ELIGIBILITY OF PRESENTATION						
1.	Presentation of Performance Assessment Instrument The aim is to determine the suitability of instrument using criteria related to the presentation of the performance assessment instrument, including:					
	a. Presentation of performance assessment instrument is logical and systematic	4	5	5	5	Very Valid
	b. Presentation of performance assessment instrument can be easly read by educators	4	5	5	5	Very valid
	c. Presentation of performance assessment instrument is interesting	4	5	5	5	Very Valid
2.	Physical Performance Assessment Instrument The aim is to determine the suitability of the instrument using criteria related to the physical performance assessment instrument, including:					
	a. The font size of performance assessment instrument is easy to read	4	5	5	5	Very Valid
	b. The font of performance assessment instrument is easy to read	4	4	5	4	Valid
	c. The picture of performance assessment instrument helps readers understand the contents of the instrument	4	5	4	4	Valid
	d. Systematic writing	4	5	4	4	Valid
	e. The cover presents the contents of the performance assessment instrument	4	5	5	5	Very Valid
3.	Illustration Performance Assessment Instrument The aim is to determine the suitability of the instrument using criteria related to the illustration of the performance assessment instrument, including:					
	a. Illustrations or pictures on the performance assessment instrument are relevant to the main material	4	5	4	4	Valid
	b. Illustrations or pictures on the performance assessment instrument can clarify concepts	4	5	4	4	Valid
LINGUISTIC CRITERIA						
1.	Language of Performance Assessment Instrument The aim is to determine the suitability of the instrument using criteria related to the language of the performance assessment instrument, including:					
	a. Writing performance assessment instruments using good and correct Indonesian language	4	4	5	4	Valid
	b. Writing performance assessment instruments using language that is easy for educators to understand	4	5	5	5	Very Valid

Based on Table 5, all components are declared valid under the following rules: In the content eligibility criteria, two components get a mode score of 4, and one component gets a mode score of 5. In the eligibility of the presentation, five components get a mode score of 4, and five components get a mode score of 5. In the linguistic criteria, one component gets a mode score of 4 and a mode score of 5.

After the performance assessment instrument developed was declared valid, a limited trial was carried out. Limited trials were conducted on 30 students in class XI-5 SMA Negeri 3 Surabaya, with one practicum meeting for exothermic and endothermic reactions. The process of activities carried out by students is assessed by two raters using performance assessment instruments. The students' laboratory skills scores obtained from two raters were then analyzed using inter-rater reliability and evaluated based on the Kappa coefficient (K). The results of the reliability data analysis can be seen in Table 7.

Table 7. Reliability Analysis Results

		Value	Asymptotic Standard Error[a]	Approximate T[b]	Approximate Significance
Measure of Agreement	Kappa	0.739	0.106	5.720	0.000
N of Valid Cases	30				

Based on Table 7, the Kappa coefficient obtained from the reliability test is 0.739, so the degree of agreement obtained is excellent. If the K value is close to 1 (≥0.70), then the degree of agreement is considered good [21].

Two chemistry educators who used the performance assessment instrument during limited trials then filled out the educator response questionnaire, which was used as practical

data. The results of the educators' responses can be seen in Table 6.

Tabel 6. Results of Educators Responses to the Performance Assessment Instrument

Purpose	Number	Rated Aspect	Responses		Validity Category
			Yes	No	
Knowing the benefits of performance assessment instrument	1.	Can the performance assessment instrument developed help you assess students' laboratory skills?	100%		Very valid
	2.	Can the performance assessment instrument developed help you measure students' laboratory skills?	100%		Very valid
	3.	Does the performance assessment instrument developed provide benefits for you?	100%		Very valid
Knowing the ease of use of performance assessment instruments	4.	Is using a performance assessment instrument an assessment of students' practicum activities more objectives?	100%		Very valid
	5.	Are the instructions and rubrics in the performance assessment instrument easy to understand and coherent?	100%		Very valid
	6.	Can a performance assessment instrument help you determine the extent of students' laboratory skills?	100%		Very valid
Knowing educators' interest in performance assessment instruments	7.	Can using this performance assessment instrument motivate you to use it in practicum assessments in other titles?	100%		Very valid

Based on the data in Table 6, a percentage of 100% positive responses were obtained for all questions in the questionnaire, so the performance assessment instrument developed was declared very practical.

Conclusion

Based on the analysis of research data, it can be concluded that the performance assessment instrument for measuring students' laboratory skills in thermochemistry practicum activities for exothermic and endothermic reactions that was developed is declared feasible in terms of several criteria, specifically the validity of the instrument developed is declared valid based on several aspects, namely the content component aspect, presentation feasibility aspect, physical criteria aspect, illustration aspect, and linguistic aspect; the reliability of the instrument developed was declared reliable based on the results of the inter-rater reliability analysis, which obtained a kappa coefficient of 0.739 with an excellent degree of agreement; the practicality of the instrument developed was declared practical based on the results of the educator response questionnaire, which received a percentage of 100% in the very practical category.

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