Development of Generic Science Skills Assessment Instruments for Chemistry Practicum on Thermochemistry and Reaction Rate

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Abstract: Generic science skills are essential skills that must be mastered by students. Generic science skills can be assessed when students carry out practical activities through performance assessments. This study aims to develop an instrument based on general science in chemistry practicums on thermochemistry and reaction rates. This study was R&D with the ADDIE model, namely analysis, design, development, implementation, and evaluation. The instruments used are validation sheets, reliability test sheets, and questionnaires. The results of data analysis showed that the instrument developed was valid, with an average score of 0.89 in a very good category. The results of the reliability test have a reliable category with an average intraclass correlation coefficient (ICC) for the thermochemistry practicum of 0.766 and a reaction rate of 0.80, while the average values for the two labs are 0.903 and 0.921. The results of the practicality test showed that the percentage of positive responses was 91.29%, so it can be stated that the product has a practical category. Based on the result, the generic science skills instruments can be used in the assessment of thermochemistry and reaction rates in the practicum because they meet the valid, reliable, and practical requirements.

Keywords: assessment instrument, reaction rate, generic science skills, thermochemistry.

INTRODUCTION

Generic science skills are skills that can be used to learn various concepts and solve problems in science. There is a skill that can train thinking and problem solving in the field of science, namely generic science skills (Sumarni, Sriyono and Ngazizah, 2016). Efforts to build knowledge require certain basic skills that students must possess. These basic skills are generic science skills that are very useful for students to solve problems (Widiati, Indrawati, and Subiki, 2013). This skill is very important in the process of learning chemistry.

Generic science skills are the foundation for the formation of scientific knowledge for students and are useful for their lives in an increasingly competitive and innovative future. Generic science skills can be developed through the chemistry learning process only to understand various concepts and problem solving (Urios et al., 2015; Rosidah, Astuti and Wulandari, 2017). The chemical thinking process is a complex skill set used by scientists in carrying out scientific work (Hargrove, 2013). Generic science skills can make it easier for students to understand concepts and practice critical thinking skills and psychomotor skills. Generic science skills can be measured and assessed through practical activities. Generic science skills can be stimulated through practical activities (Yuliyanti, Hasan, and Syukri, 2016).

Practical activities, are psychomotor activities to verify theory in the laboratory. Practicum is a learning activity that supports understanding of theories and concepts obtained from theoretical subjects (Sari, Permanasari and Supriyanti, 2017). Practical activities are application activities of theories that have been studied to solve various problems through experiments in the laboratory (Wiratma and Subagia, 2015). Laboratory activities have important roles and benefits in the science curriculum, through practicum activities, students can carry out the chemical observation process, train thinking skills, be scientific, and solve problems (Mar'atus and Prayitno, 2022). In addition, practicum is a learning activity that combines cognitive, affective, and psychomotor skills (Risna, Hamid and Winarti, 2017). Practical activities can be assessed through performance appraisals.

Performance appraisal is a form of authentic assessment in which students are asked to

demonstrate and apply their knowledge into various contexts.

According to the desired criteria (Masrukan, 2014). This assessment is used to see the abilities and skills of students without having to wait until the learning process ends. Performance appraisal is applied in practical activities because it is in accordance with the learning experience of students in practical activities, where practicum activities can explore and bring up the skills, knowledge, and performance of students. So that the application of performance appraisal is appropriate to measure the skills of students in carrying out practical activities.

Based on the results of interviews with chemistry teachers at one of the private schools in Kudus, it is known that teachers do not conduct assessments during practicum activities. The assessment of each practicum is only done based on the results of the practicum report. This causes educators not to know the practical skills of students in the psychomotor aspect. The absence of a performance appraisal in the chemistry practicum causes the overall assessment of skill competencies to be unmeasured. When the assessment is not carried out specifically and systematically, the level of competence of students in practical learning will not be measured (Urios et al., 2015). Performance assessment, especially the assessment of basic science or generic skills, becomes very important to be developed in every chemistry practicum. Moreover, there are not many assessment instruments that can be used to measure generic science skills (Mar'atus and Prayitno, 2022).

The importance of designing an assessment instrument that can assess generic science skills is based on the fact that the assessment so far has only covered cognitive domains. The actual assessment of chemistry learning requires an assessment instrument that not only includes understanding and memorization, but also assesses whether or not students are able to apply the concepts they learn when facing a problem in everyday life. So far, the learning process has only emphasized cognitive abilities, while other aspects such as psychomotor, affective, including generic science skills are sometimes forgotten (Sumarni et al., 2016; Nastiti et al., 2018). There is no assessment to reveal the generic skills and chemical literacy skills of students from the aspect of the science process (Tsui and Treagust, 2010). Many generic science skills-based assessment instruments have been developed, but there is no assessment instrument construction that can be used to assess generic science skills in practical activities (Haksani, 2013; Rosnita, 2016). This study aims to develop an instrument for assessing generic science skills in the implementation of thermochemistry and reaction rate practicum.

METHOD

Research Design

This research is research and development (R&D), which produces a product in the form of an instrument for assessing students' generic science skills. The development model used in this study is the ADDIE development model adopted from Branch (2009). The Analysis, Design, Develop, Implement, and Evaluate (ADDIE) development model consists of five stages, including the analysis, the design, the development, the implementation, and the evaluation (Branch, 2009). Each stage consists of several activities. The analysis stage involves analyzing needs, analyzing student abilities, and analyzing learning materials; the design stage involves determining aspects of generic science skills, selecting formats, and making initial designs; the development stage involves making improvements and product validation; the implementation stage involves conducting small-scale class trials; and the evaluation stage involves conducting an assessment of the quality of the instruments developed from the initial stage to the final stage.

Sample / Participants / Group

This research was conducted at SMA Negeri 1 Jekulo Kudus in the 2021/2022 academic year. The subjects were nine students of class XI MIPA 2 with high, medium, and low levels of understanding based on generic science skills test questions. The subjects were selected by the purposive sampling technique.

Instrument and Procedures

The instruments in this study consisted of 10 items of interview sheets, 8 items of preliminary research questionnaires, 5 items of student assessment, 21 items of validity sheets by expert validators, 15 items of reliability test sheets by observers, and 22 items of practicality test sheets. The product developed was validated by three expert validators, consisting of two chemistry education lecturers and one chemistry teacher. Whether or not a product is developed is reliable, it can be seen from the use of the product during the practicum by the observer. A total of 3 chemistry education students as observers in the small-scale

trial process. And as many as 3 respondents were involved in order to find out whether the product developed was practical or not. Thermochemistry is a branch of chemistry that qualitatively and quantitatively describes the energy changes that occur during chemical reactions. Energy is the ability to do work. Thermodynamics is the science that determines the probability and direction of transformations in chemical reactions and studies the equilibrium and final conditions. The reaction rate is the change in the concentration of reactants and products per unit time. Chemical reactions take place at very different speeds depending on the nature of the reacting substances, the type of chemical transformation, temperature, and other factors. Reactions usually slow down over time as the amount of reactant decreases. In some cases the presence of a catalyst can speed up the reaction rate. Thermochemistry and reaction rates are closely related. The two materials are not only studied in theory but there are several practical activities that can be done so that students understand better.

Data Analysis

The assessment instrument is said to be feasible if it is valid, reliable and practical. Quality analysis is done through validity test, reliability test and practicality test. The validity test was analyzed using Aiken's V (content validity coefficient) (Aiken, 1985). Then was converted based on the criteria in Table 1.

Table 1. Aiken Validity Criteria

No.	Index	Category
1.	≤0,40	Not good
2.	0,41 ≤ V ≤ 0,80	Pretty good
3.	V > 0,80	Excellent

(Retnawati, 2014; 2016)

The reliability test was analyzed using intraclass correlation coefficients assisted by the SPSS 23 program. An instrument is said to be reliable if it has an intraclass correlation coefficient value for each indicator > 0.50 and a value for each indicator 0.70 (Bambang and Widhiarso, 2015). The results of the reliability test are converted based on the criteria in Table 2.

Table 2. Criteria Range of r Values

No.	r value range	Reliability Level
	0,00 ≤ a < 0,40	Low
	0,41 ≤ a ≤ 0,59	Currently
	0,60 ≤ a ≤ 0,74	High
	0,75 ≤ a ≤ 1	Excellent

(Domenic V, 1994)

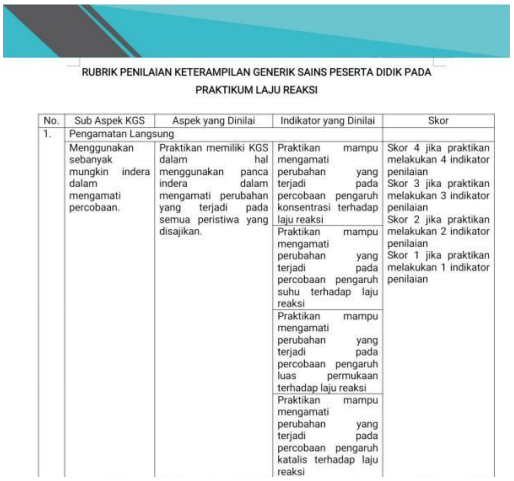
The practicality test was analyzed using the percentage of positive and negative responses. An instrument can be said to be practical if the observer has a response to the assessment instrument if 50% of the observers give a positive response to 70% of the aspects asked (Ali, Ruslan, and Jumadi, 2014).

RESULTS AND DISCUSSION

The result of this research is an instrument for assessing students' generic science skills in thermochemistry and reaction rate practicum. The development of assessment instruments is motivated by the absence of a comprehensive assessment instrument and students are less challenged and motivated to have practical skills with the existing assessment system. Therefore, a performance assessment instrument was developed to measure generic science skills in practical learning.

The steps taken after analyzing the problems that exist in the school are compiling a grid of assessment instruments. A total of 5 aspects of science's generic skills were observed, including direct observation, awareness of scale, symbolic language, logical inference, and the law of cause and effect. This is because these 5 aspects can be found in the thermochemistry and reaction rate practicum and are adjusted to the format of the practicum instructions in the school.

This assessment instrument is accompanied by an assessment rubric. Assessment instruments that use assessment rubrics, both holistic and analytical, can provide fair and accurate assessments and foster understanding in the learning process (Urios *et al.*, 2015). The developed rubric contains certain and specific statements and is equipped with a score for each statement.



RUBRIK PENILAIAN KETERAMPILAN GENERIK SAINS PESERTA DIDIK PADA PRAKTIKUM LAJU REAKSI

No.	Sub Aspek KGS	Aspek yang Dinilai	Indikator yang Dinilai	Skor
1.	Pengamatan Langsung			
	Menggunakan sebanyak mungkin indera dalam mengamati percobaan.	Praktikan memiliki KGS dalam hal menggunakan panca indera dalam mengamati perubahan yang terjadi pada semua peristiwa yang disajikan.	Praktikan mampu mengamati perubahan yang terjadi pada percobaan pengaruh konsentrasi terhadap laju reaksi Praktikan mampu mengamati perubahan yang terjadi pada percobaan pengaruh suhu terhadap laju reaksi Praktikan mampu mengamati perubahan yang terjadi pada percobaan pengaruh luas permukaan terhadap laju reaksi Praktikan mampu mengamati perubahan yang terjadi pada percobaan pengaruh katalis terhadap laju reaksi	Skor 4 jika praktikan melakukan 4 indikator penilaian Skor 3 jika praktikan melakukan 3 indikator penilaian Skor 2 jika praktikan melakukan 2 indikator penilaian Skor 1 jika praktikan melakukan 1 indikator penilaian

Figure 1. KGS Assessment Instrument Rubric

Data analysis technique is how to process data after the research process is carried out. The data analysis process begins by examining all available data from various sources after conducting research (Sugiyono, 2012). Data analysis techniques in this study are as follows:

1) Validity Test

A validation test is used to determine whether the product developed is feasible or not. The importance of the validity test in the development of the assessment instrument is to determine the extent to which the instrument can assess what should be assessed (Azwar, 2012). The feasibility of the assessment instrument can be seen from the validation sheet that has been filled out by an expert validator consisting of two lecturers and one teacher in charge of chemistry subjects. The validation sheet contains 7 aspects of the assessment, namely content, construction, objectivity, linguistic, systematic, graphic, and practical. Each aspect is scored based on criteria using a Likert scale, which is arranged in the form of four responses that indicate levels, as shown in Table 3.

Table 3. Likert Scale

Score	Category
4	Very Good
3	Good
2	Bad
1	Very Bad

Validation score data obtained from expert validators in the form of quantitative data. The data was analyzed using an index proposed by Aiken called Aiken's V (content validity coefficient). Aiken's V is an index of the rater's agreement on the suitability of the item with the aspect to be measured using the item. Index V has a scale ranging from 0-1.00 (Azwar, 2012). The results of the validity tests carried out by experts on the products developed are described at Figure2.

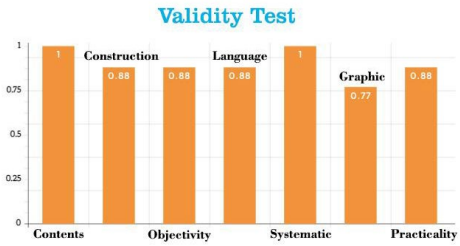


Figure 2. Expert Validation Results

Based on the results of the assessment for each aspect, the quality is very good and quite good. If it is calculated as a whole which includes 7 aspects of the validator's assessment, the validity average is 0.89 with a very good category. The average results of the validity of the assessment instrument developed indicate that this product is feasible to be used to assess the generic science skills of students during thermochemistry practicum and reaction rates. The requirements for a good assessment instrument are that one of them has a valid category (Nugraha, 2017; Umami, Rusdi and Kamid, 2021; Sari and Nada, 2022).

2) Reliability test

A reliability test is a test that shows the extent to which measurements produce results that are not much different when repeated measurements are made with the same subject (Basuki and Hariyanto, 2014). The data obtained at the small-scale trial stage were analyzed to determine the reliability of the assessment instrument. The higher the reliability of the assessment instrument, the better, so it is recommended that it be checked by 3 observers so that consistency is more guaranteed (Basuki and Hariyanto, 2014).

The reliability test of the assessment instrument is calculated based on the Intraclass Correlation Coefficients with the help of the SPSS 23 program. The use of intraclass correlation coefficients is preferred over kappa coefficients, because the scores generated on the generic science skills assessment instrument are more ordinal (Bambang and Widhiarso, 2015). The value of the test results can be said to be reliable if it meets the requirements where for each indicator > 0.50 and the value for each indicator 0.70 (Bambang and Widhiarso, 2015). The results of the reliability test for each item can be seen in Figure 3.

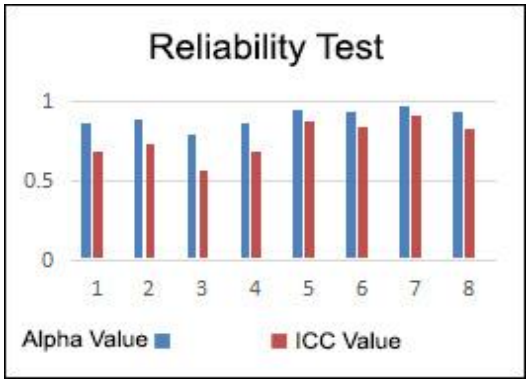


Figure 3. Reliability Test Results for The Thermochemistry Practicum

Figure 3 shows the results of the reliability test of the SGS assessment instrument for thermochemistry practicum. Aspects of direct observation are seen in numbers 1 and 2 which produce ICC values of 0.689 and 0.733, respectively, and values of 0.869 and 0.892. The awareness aspect of the scale seen at number 3 shows the ICC value and value of 0.566 and 0.796, respectively. The symbolic language aspect is seen from numbers 4 and 5 which produce ICC values of 0.683 and 0.875, respectively, and values of 0.866 and 0.955, respectively. Aspects of logical inference can be seen from numbers 6 and 7 which produce ICC values of 0.838 and 0.917, respectively, and values of 0.939 and 0.971, respectively. The legal aspect of cause and effect seen from number 8 shows the ICC value and value of 0.830 and 0.936, respectively. The average ICC value and value in all aspects of the assessment are 0.766 and 0.903 with a very high category.

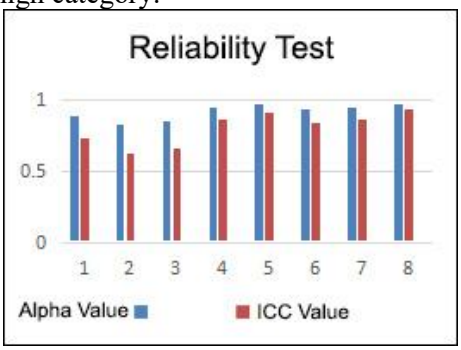


Figure 4. Reliability Test Results for The Reaction Rate Practicum

Figure 4 shows the results of the reliability test of the KGS assessment instrument for the reaction rate practicum. Aspects of direct observation are seen in numbers 1 and 2 which produce ICC values of 0.733 and 0.625, respectively, and values of 0.892 and 0.833, respectively. The aspect of awareness about the scale seen at number 3 shows the ICC value and value of 0.660 and 0.853, respectively. The symbolic language aspect is seen from numbers 4 and 5 which produce ICC values of 0.867 and 0.918, respectively, and values of 0.951 and 0.971, respectively. Aspects of logical inference can be seen from numbers 6 and 7 which produce ICC values of 0.844 and 0.862, respectively, and values of 0.942 and 0.949, respectively. The legal aspect of cause and effect seen from number 8 shows the ICC value and value of 0.942 and 0.980, respectively. The average ICC value and value in all aspects of the assessment are 0.806 and 0.921 with a very high category.

All assessment indicators consisting of 8 indicators can be said to be reliable because they have met the minimum requirements for the ICC value for each indicator >0.50 and the value for each indicator ≥0.70 (Bambang and Widhiarso, 2015). So that the developed generic science skills assessment instrument can be used to measure the students' generic science skills because they have met the reliability test requirements. Instrument can assess students' abilities if it is reliable (Sumarni *et al.*, 2016; Khaerunnisa and Pamungkas, 2018; Dessiane and Kristin, 2021).

3) Practicality Test

An assessment instrument developed must have good practicality, the instrument is said to be good if it is possible to use the large instrument (Purwanto, 2009). The practicality test is used to determine the user's perception or response to the instrument. Practicality is measured by the level of ease of use of the developed assessment tool. Practicality test scores are generated through teacher and observer response questionnaires. Data related to responses to the developed instrument were analyzed using quantitative descriptive techniques. The teacher and observer response questionnaire used a Likert scale based on the criteria of strongly agree (score 4), agree (score 3), disagree (score 2), and disagree (score 1). The data obtained was then analyzed by counting the number of respondents who gave positive responses in accordance with the statements presented and then calculating the percentage, with the following equation:

$$\% = \frac{gained\ score}{maximum\ score} \text{ x } 100\%$$

The criteria used as a benchmark to determine that the observer has a positive response to the instrument product developed are that 50% of the respondents give a positive response to a minimum

of 70% of the stated aspects (Ali, Ruslan and Jumadi, 2014). The result of the practicality test of the SGS assessment instrument can be seen in Figure 5.

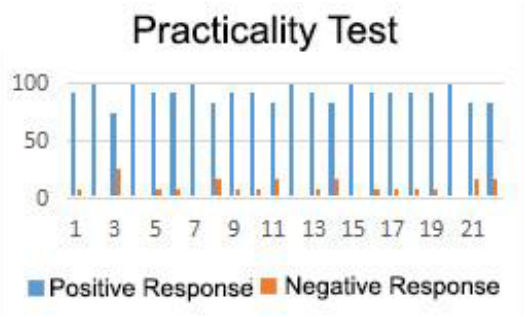


Figure 5. Practicality Test Results

Based on Figure 5, it can be seen that the value response data given by the supervisor and observer as a respondent is 91.29%. So it can be said that the assessment instrument developed is practical to measure the generic science skills of students.

CONCLUSION

Based on research results, it can be concluded that the instrument for assessing generic science skills in thermochemistry and reaction rate practicum has decent quality, reliable and practical use. The results of the validation test obtained a value of 0.89 with a very good category. The results of the reliability test based on the assessment between raters on the small-scale test showed the average value of the ICC measurements in the thermochemistry practicum was 0.766 and the reaction rate practicum was 0.806. Meanwhile, the average value in the thermochemistry lab is 0.903 and the reaction rate is 0.921. The results of the reliability test in each practicum can be said to be reliable, with a very high category. The results of the practicality test showed a positive response with a percentage of 91.29%, so it can be stated that the science generic skill assessment instrument in thermochemistry and reaction rate practicum was declared practical with a very good category.

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