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The development of authentic scientific inquiry assessment to measure the laboratory skills

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Abstract. Assessment in learning is an important aspect to analyze the learning progress. Nowadays, the assessment runs a shifted paradigm from measuring in higher-order thinking aspects to performance assessment. This study aims to develop an assessment instrument based Authentic Scienti_c Inquiry Assessment (ASIA) in measuring the laboratory skills. The laboratory skills consist of _ve skills categories, they are safety skills in the laboratory, experiment management, measuring skills, collecting data, and interpreting skills. From those skills, we derive 20 aspects. We used 4D methods in developing the instruments, define, design, develop, and disseminate. The results of construct validation and content show that the instrument is valid and reliable. We perform the effectivity test and gain the tcount = 25281; ttable = 1,708 with significance level less than 0,05. We also perform a questionnaire for the lecturers and laboratory assistant that shows 85% positive response, 11% of negative response, and 4% of abstance. We can conclude that our instrument is effective to measure the laboratory skills.

1. Introduction

Nowadays assessment has become very crucial, educators and policy makers have made reforms to the education system in response to the challenges of the world today. Doran et al. state that weak scientific performance, low levels of scientific literacy and the lack of international test results in science require educators and policy makers to turn to alternative assessments [1]. This assessment is no longer conventional, such as written tests or rote memorization, but an assessment that demands the creativity, demonstration or performance of students.

Dochy was quoted by Jonsson in an article state that assessments in higher education shift from traditional tests that focus on knowledge to "assessments for learning". The cultural shift in the current assessment is no longer limited to knowledge and low-level cognitive skills but the objective is to assess high-level thinking processes and competencies in the form of performance assessment [2].

Johnson states that in the performance assessment, students apply knowledge and skills by involving themselves in a process or creating a product. Performance assessment is an assessment that requires students to carry out a task in actual situations that applies the knowledge and skills needed in science [2].

Gustina says that performance assessment as an alternative assessment is very suitable to measure student outcomes in science learning. Performance assessment gives students opportunities to demonstrate their science process skills, think logically, apply preliminary knowledge to a new situation, and identify new solutions to a problem, so students' learning outcomes will not only be based on test scores in end of learning but also based on the learning process in accordance with the ability of each student's skills [3].

Assessment of skills in physics is closely related to laboratory activities. However, Susila in an article said that the performance evaluation in the laboratory was still inadequate [4]. The use of performance assessment tools in laboratory learning is indeed still limited and uses direct assessment at the time of evaluation or tests at the end of learning so that learning outcomes obtained by students are only measured by the final test scores without seeing the learning process carried out by students. In line with Moni in Gobaw which states that the actual activity in a laboratory is rarely assessed [5]. The process of evaluating laboratory performance is currently inadequate due to the lack of a component of laboratory skills to be assessed, guidelines for extraction in tools that are unclear making it difficult to use, and components assessed as difficult to observe and therefore tend to be ignored.

Lintern in his book states that there are some skills needed in the laboratory; (1) basic laboratory techniques such as health and safety, measuring and calculating data, (2) analyzing data in a research, drawing conclusions to visualizing the data obtained, and (3) writing a result in scientific writing and communicating the results effectively obtained [6]. From these laboratory skills, it is very necessary to develop laboratory performance tools that will facilitate educators to assess performance in the laboratory.

Some researchers have done some development of assessment instruments in the practicum. Susilaningsih developed a chemical practicum assessment instrument. This study aims to develop a chemical practicum assessment instrument that has been tested for reliability by using the coefficient of generalisability with the results obtained is 0.72, which means that the reliability needs to be improved and revised to get a 0.95 which means valid [7].

Johnson et al. performance is a series of responses aimed at a particular environment with specific goals [2]. Thus, performance assessment is an assessment that covers the whole process of a series of responses carried out in a particular environment and certain goals to obtain reliable values that accurately reflect the expertise of the person being tested. This performance assessment demonstrates his knowledge and abilities by involving a product or making a product.

Diartha revealed that in teacher assessment activities require non-written tests to get a picture of students' abilities [8]. Skills in laboratory practice are needed, among others, namely the development of skills using laboratory tools and materials, problem solving and social skills such as working together , caring attitude, communicating, to appraise these activities appropriately the teacher must observe the performance of the students.

Lintern in his book "Laboratory Skills for Science and Medicine" writes there are five basic concepts of skills in the laboratory, (1) safety and health skills in the laboratory, (2) measurement skills, (3) skills in planning and managing practicum, (4) data recording skills, and (5) communication skills through scientific writing [6].

In developing this assessment tool, the author is more inclined to use seven categories that have been modified by Tweedy and Hoese and five basic concepts of laboratory skills compiled by Lintern, (1) safety skills in the laboratory, (2) management skills practicum, (3) measuring skills, (4) data recording skills, and (5) communication skills [6, 9].

2. Methods

The study was conducted at the Department of Physics, Faculty of Mathematics and Natural Sciences, Semarang State University. Research respondents to obtain data on the needs and characteristics of the physical laboratory assessment tools are lecturers and laboratory assistants in the Elementary Physics II course. While respondents to obtain trial data in this study for all tools are lecturers, laboratory assistants and students of Elementary Physics II courses.

The source of data in this development comes from the data collection stage, the design validation stage, the trial use phase. At the data collection stage, data is obtained from filling out the questionnaire by lecturers, laboratory assistants and students regarding the availability of ASIA-based laboratory learning devices, the use of authentic assessment tools, types and techniques applied by lecturers to assess student learning outcomes, availability of assessment tools to measure performance, design and the use of performance tools to assess student performance in the laboratory, difficulties in making and using performance tools, and the need for the development of performance tools.

At the expert validation stage, data obtained by the questionnaire on the feasibility of construction, substance, and language by FMIPA UNNES lecturers with a minimum education level of graduate programme who are experts in the field of assessment tools.

At the trial usage stage, data were obtained from questionnaires and interviews about the appropriateness of the equipment and the quality of the presentation according to the lecturers of the Faculty of Education in the study of the performance assessment results of the development.

3. Results and Discussion

Development assessment tool uses the 4D model, namely through four phases of development that the definition phase, designing, development and dissemination, at the stage of deployment is not done thoroughly.

3.1. Definition Phase

The definition stage is useful for determining and describing the needs or grids in the learning process as well as gathering various information related to the assessment tools to be developed. In this stage, it is divided into 2 stages, namely determining the objectives of the inquiry sensitivity process and determining the laboratory skills assessment tool grid.

In developing this assessment tool, the authors determine the skill grid using seven categories that have been modified by Tweedy and Hoese and five basic concepts of laboratory skills compiled by Lintern [6, 9]. From these two sources, eight skills categories in the laboratory are found in Table 1 .

3.2. Designing Phase

After getting the objectives and grids from the assessment tools at the definition stage, the next stage is the design stage. This stage is used to design laboratory skills assessment tools. This design phase is divided into two stages, namely the design of the tools and assessment rubrics and the initial design of the assessment tools. The design is divided into five skills; safety and laboratory skills, practicum management skills, measuring skills, data recording skills and communicating skills.

Next, every aspect of the skill is given the criteria to be assessed and the scoring criteria and the score that will be given according to the criteria fulfilled. There are five laboratory skills to be assessed, safety skills in the laboratory has 2 criteria, laboratory management skills have 6 criteria, measurement skills have 2 criteria, data recording skills have 2 criteria and finally communication skills have 8 criteria.

Students who are able to meet all the criteria for every aspect will get a perfect score. The maximum score of all criteria is 4. The score is then summed and averaged to see the final score, to see the final score of the score it will be averaged in a way, the sum of all aspects divided by the maximum score multiplied by 100.

$$N = \frac{\sum score\ of\ all\ skills}{maximum\ score}\ x\ 100$$

3.2.1. Initial Product Repair. After going through the validation test, this assessment tool needs to be revised. The revision given was in the assessment of safety skills in the laboratory, indicators using laboratory coats and PPE (personal protective equipment) were replaced by carrying out laboratory safety procedures. In the practicum management skills category, arriving on time and preparing the tools and needed materials were eliminated. In the category of skills in communicating results, the first indicator is replaced by writing the title, purpose and introduction correctly. The second and third indicators were omitted, while the fourth indicator was changed to systematically write tools and materials and procedures. The fifth to eighth indicators are removed and replaced by writing evidence in the form of data and graphics and drawing conclusions based on the evidence obtained and systematic writing. The ASIA-based laboratory skills assessment rubric used a Likert scale of 1 - 4 with the highest score of 4 and the lowest score of 1.

3.2.2. Limited Trial. After obtaining the initial product, a limited trial was conducted to determine the validity of the skills assessment items on the laboratory assessment skills tool in the Physics Basic 2 class. This trial is conducted on 25 students of Basic Physics 2 class that have been randomly selected and then tested assisted by a laboratory assistant.

Table 1. Research Instrument Reliability Test Results

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
Item1	56.88	35.693	.461	.897
Item2	56.96	33.623	.628	.892
Item3	57.00	33.917	.639	.892
Item4	56.56	34.673	.412	.899
Item5	56.92	36.243	.412	.898
Item6	56.76	34.523	.458	.897
Item7	57.00	33.917	.639	.892
Item8	56.92	34.577	.512	.895
Item9	56.72	35.543	.342	.900
Item10	56.56	34.673	.412	.899
Item11	57.08	33.910	.678	.891
Item12	57.00	33.917	.639	.892
Item13	56.68	34.977	.410	.899
Item14	57.00	33.917	.639	.892
Item15	56.76	35.023	.451	.897
Item16	57.00	33.917	.639	.892
Item17	56.92	34.577	.512	.895
Item18	57.08	33.910	.678	.891
Item19	56.88	35.693	.461	.897
Item20	57.04	34.290	.650	.892

Alpha Cronbach validity test results above, obtained Alpha Cronbach prices for all assessment items> r_{table} = 0.468 so it can be concluded that the ASIA-based laboratory skills assessment items are included in the valid category.

Tabel 2. Reliability Test Result

Cronbach's Alpha	N of items
0.900	20

Alpha Cronbach reliability test results in Table 5 . The above obtained Cronbach alpha value of 0.900> r_{table} = 0.468 so that it can be concluded that the laboratory-based skills assessment instrument ASIA reliable and can be used for research.

3.3. Deployment Phase

The purpose of the deployment phase is to disseminate ASIA-based laboratory skills assessment tools. After a limited trial and evaluation tools have been refined, the next step was dissemination. In this study only limited dissemination was carried out by disseminating and promoting this assessment tool limited to Basic Physics 2 practicum classes with 2 Supporting Lecturers, 3 Laboratory Assistants, and 25 Physics Education study program students majoring in Physics FMIPA UNNES.

3.3.1. Effectiveness of Using ASIA-based Laboratory Skills Assessment Instruments. At the stage of applying the ASIA-based laboratory skills assessment tool, obtained laboratory skills scores from students. The value is then analyzed with SPSS 21 to find the effective use of the assessment tool. Test the effectiveness of the ASIA-based laboratory skills assessment tool using a one sample t test with the following criteria:
H_0 : laboratory skills assessment tool is not effectively used as an assessment instrument
H_a : laboratory skills assessment tools are effectively used as assessment instruments

Significance degree 0 , 05 .

The basis for testing decisions is:
Reject H_0 if $t_{arithmetic} > t_{table}$
Accept H_0 if $t_{arithmetic} < t_{table}$.

Table 3. Effectiveness Test Results for ASIA-based Laboratory Skill Assessment One Sample Test

Test Value = 25						
	t	Df	Sig (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
Score	28,251	24	.000	34,880	32.33	37.43

In table 6 , it can be seen that the t value is 28.251 while the $_{calculated}$ t value = 1.174. This means that $t_{count} > t_{table}$ then H_0 is rejected so that it can be concluded that the laboratory-based skills assessment tool ASIA effectively used in the assessment of practical lab skills.

3.3.2. Response to Using ASIA-based Laboratory Skills Assessment Instruments. In the trial phase of usage, the data was obtained by filling out a questionnaire regarding the appropriateness of the equipment and the quality of the presentation according to the lecturers of the Physical Education study program on the performance assessment results of the development. At this stage, the lecturer and laboratory assistant gave responses to the developed instruments. The response rate was measured by using qualitative data explanation which responded to the statement made was applied in the form of a Likert scale . Based on the results of the responses it can be concluded that the respondents stated the laboratory skills assessment instrument included in the practical category because 85% gave a positive response. This is consistent with Hobri's statement which states that if 80% or more respondents give a positive response to the instrument then the practical instrument is used.

4. Discussion

The objective of this study is to develop an assessment tool based on Authentic Scientific Inquiry Assessment to measure laboratory skills. The categories of laboratory skills were divided into 5 skills and 20 aspects therein. Laboratory safety skills, practicum management, measuring, recording data and communicating results. This research-was based on Research and Development (R & D), which used 4 stages of development, namely 4D defining, designing, development and dissemination. The subjects of this study were the second semester students who took the Basic Physics Inquiry class 2 with two validators.

At the defining stage, the implementation of assessing skills in learning can be used to improve inquiry - based science education, support the development of skills in the 21st century, involve students in the assessment process, facilitate lecturers in finding important information in compiling instructions, and as a tool to increase professionalism. The definition stage is useful for determining and describing the needs or grids in the learning process as well as gathering various information related to the assessment tools to be developed. In this stage, it is divided into 2 stages, namely determining the objectives of the inquiry sensitivity process and determining the laboratory skills assessment tool grid.

At the design stage, researchers compiled indicators for ASIA-based laboratory skills assessment instruments. The researcher determined the skill grid using seven categories that have been modified by Tweedy and Hoese and five basic concepts of laboratory skills compiled by Lintern [6, 9]. From these two sources, five skills categories were obtained in the laboratory with 20 indicators. The categories of skills used in this study were safety skills in the laboratory, practicum management skills, measuring skills, data recording skills, and communication skills.

At the development stage, the initial design was validated by the experts to determine the level of validity of the device. The validation was carried out by 2 basic physics lecturers II as expert validators. The results of the validation of the device by experts obtained an average score of 4 , 3 and included in the valid criteria. Based on the results of the validation, the device was suitable to be used in a simulation class or limited trial to determine the readability of the instrument for the assessment of skills by lecturers and teaching assistants. The validation and revision results were used to test the validation of the instruments used by lecturers in physics practicum in the laboratory with 25 students in the Basic Physics Practicum 2. The laboratory skills are used to test the validity and reliability of Alpha Cronbach using SPSS 21 with criteria if $r_{arithmetic} > r_{table}$, then the instrument is valid.

In the test the validity of indicators, it used r_{tables} at 0.468 and all indicators point gained value $r_{count} >$ 0.468. It means that all indicator items contained in the ASIA-based laboratory skills assessment instrument are included in the valid category. Alpha Cronbach reliability test results obtained Alpha Cronbach r_{count} value of 0.900> r_{table} = 0.468 so it can be concluded that the ASIA-based laboratory skills assessment instrument is reliable and can be used for research.

Data and information obtained at this stage of development were used for improvement, so an ASIA-based laboratory skills assessment instrument was produced which can then be used at the deployment stage. At the deployment stage, ASIA-based laboratory skills assessment instruments were used by lecturers and teaching assistants in physics practicums in laboratories with 25 students in the Basic Physics Practicum 2. The deployment phase was conducted to determine the effectiveness and practicality of using ASIA-based laboratory skills assessment instruments.

The effectiveness test of ASIA-based laboratory skills assessment instruments was done by one sample t test with SPSS 21. Arikunto states that if the value of t> table is 5% significance, then the instruments used are included in the effective category. One sample t test results obtained t_{count} of 28.251 while the $_{calculated}$ t value = 1.174. This means $t_{hitiung} > t_{table}$ so that it can be concluded that ASIA-based laboratory skills assessment tools are effectively used in the assessment of laboratory practicum skills. This is consistent with the results of Pamela's research in her research journal which states that all practicum participants obtain knowledge and knowledge-based inquiry skills that are considered important. The results of the effectiveness of ASIA-based laboratory skills assessment instruments are also in accordance with the statement of Herman, who conducted research using the Inquiry-based LKPD on Physics practicum in high school. Herman stated that the assessment instruments with scientific skills were very effective to be used in the Physics practicum in the Laboratory [10].

The effectiveness of assessment instruments in practicum activities would greatly affect the activities of lecturers / teachers (as subjects of assessment) and students / students (as objects of assessment), especially on psychomotor aspects. The use of ASIA-based laboratory skills assessment instrument is to meet these needs. This is consistent with the results of Adam's research which states that almost all teacher respondents agree that inquiry learning in the classroom and scientific discovery skills in practicum are very important to do. Susilaningsih also stated that laboratory skills assessment activities can help teachers determine the laboratory skills of students. Authentic assessment is intended to measure laboratory skills directly more easily so that the data obtained are more valid [7].

Practicality test aims to determine the quality of a measuring instrument classified as good or not. According to Hobri if 80% or more respondents gave a positive response to this ASIA assessment tool, then the instrument was declared practical to use. In the practicality test results, Based on the response results above, it can be concluded that the respondents stated the laboratory skills assessment instrument included in the practical category because 85% of members responded positively. This is in accordance with Hobri who stated that if 80% or more respondents gave a positive response to the instrument then the practical instrument was used.

5. Conclusion

This research and development method is used in the 4D development method through 4 stages of development, namely stage defining by looking at the initial instruments in school, designing stage to design laboratory performance assessment instruments based on Authentic Scientific Inquiry Assessment as an initial format , developing stage instruments that have been designed through the validator stage until the instrument is declared valid, and stage of distribution for small-scale deployments.

The skills assessed in the Authentic Scientific Inquiry Assessment -based assessment tool to measure laboratory skills are laboratory safety and health skills, practicum management skills, measuring skills, data recording skills and the ability to communicate results.

Practicum assessment instruments produced are included in the valid category in the validity and reliable test. Practicum assessment instruments produced are also classified as effective for assessing skills in practicum in the Basic Physics laboratory and practically used by lecturers and laboratory assistants in practicum assessment.

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