Profile of Students' Scientific Reasoning Skills in Traditional Physics Laboratory Activity

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Abstract. This research aims to reveal students' Scientific Reasoning Skills (SRS) in traditional physics labs activity. This research used one shot case study. The Lawson's Classroom Test of Scientific Reasoning Skills (LCTSR) instrument was used to explore 115 university students' SRS after completing traditional physics laboratory activity. The research shown that (1) 0.87% of students were in formal, 1.74% of students were in early transition, 22.61% of students were in late transition, and 74.78% of students were in concrete stage of cognitive development; and (2) students' conservation of mass and volume skill reached the highest score while students' proportional reasoning skill reached the lowest score. This results should be used as the database to improve students' laboratory activity.

1 Introduction

Scientific reasoning skills (SRS) are important skills to master in the 21st century. These skills are often associated with critical thinking skills, science process skills, creativity, and skills in carrying out inquiry activities [1]. These skills also have a strong correlation with problem solving skills and conceptual mastery. Therefore, reaching optimal achievement of these skills is one form of success in education.

Through tests using Lawson's Classroom Test of Scientific Reasoning (LCTSR), the facts show the low SRS achievement of students in Indonesia. The student population in Jambi [2,3] and the student population in one of the Islamic boarding schools in Pamekasan [4] show that the majority of students are still at the concrete level. These results provide a warning for education, that SRS is one of the skills that needs to be the main focus for improvement. Apart from the low achievement of students' SRS, this skill is also closely related to other important skills in the 21st century.

SRS are skills that support inquiry activities. These skills include conservation of mass and volume, proportional reasoning, control of variables, probabilistic reasoning, correlational reasoning, and hypothetical-deductive reasoning sub-skills. These skills are related to investigative activities, which consist of some activity, such as the formulation of scientific questions, the process of formulating hypotheses, experimental activities, and evaluating the resulting evidence [5,6].

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Traditional physics laboratory activities are a form of variation in learning with structured, hands-on practical activities, guided using manuals which are generally written in detail like cookbooks, therefore they are often called cookbook laboratories [7]. Traditional physics laboratory activities intersect with inquiry activities. Although guided in detail, traditional physics laboratory activities include activities such as carrying out experimental activities, writing down experimental data, analyzing experimental results, holding discussions and deliberations, and also continuing with drawing conclusions. This series of activities proves that there is a connection with inquiry activities.

Several studies [8,9] show that learning with an inquiry approach can improve students' SRS. Therefore, research needs to be carried out to provide empirical evidence of how SRS students carry out traditional physics laboratory activities. It is hoped that the results of this research can be a basis for policy making, whether modifications to laboratory activities need to be made or not.

2 Research Method

This research is a pre-experimental research with a one-shot case design. 115 First year students complete the Lawson's Classroom Test of Scientific Reasoning (LCTSR) [10] questions after following a series of traditional physics laboratory activities for 2 semesters. LCTSR is a two tier instrument, namely reasoned multiple choice. LCTSR explores several sub-skill, which were coded in this study (**Table 1**).

Table 1. Skills tested in LCTSR [10]

No	Sub-skills of SRS	Code	Number of questions
1	Conservation of mass and volume	SRS1	1-4
2	Proportional reasoning	SRS2	5-8
3	Control of variables	SRS3	9-12
4	Probabilistic reasoning	SRS4	13-16
5	Correlational reasoning	SRS5	17-20
6	Hypothetical-deductive reasoning	SRS6	21-24

The series of laboratory activities are explained in the results and discussion section, as well as student SRS profiles obtained through LCTSR work. The students' SRS profiles were analyzed twice, quantitatively descriptively, namely to obtain class average scores for each sub-skill on the SRS and class achievements at the students' level of cognitive development.

3 Results and Discussion

3.1 Laboratory Activity

The traditional laboratory activity resume is presented on Figure 1. As in Figure 1, in every semesters (2 semesters), there were 3 main activities in the series of traditional laboratory activities, namely pre-lab activity, lab activity, and after lab activity. There were 14 activity topics (titles) that have to be completed in a year. Students collaborated in a group consisted 5-6 students to complete the titles of activity, even though they have to write the lab activity report individually.

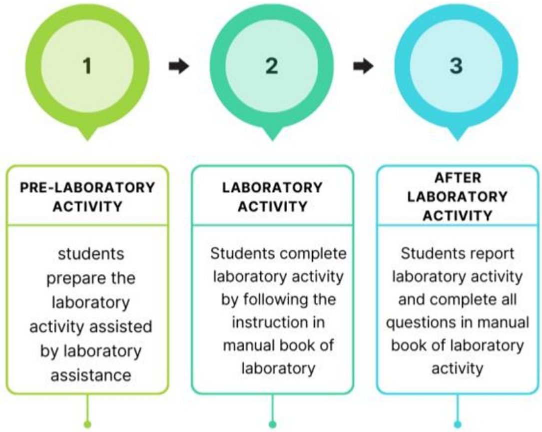

Fig. 1. Series of traditional laboratory activity

In pre-lab activities, students prepared themselves to take part in lab activities. The lab assistant ensured that students were ready to take part in lab activities, through question and answer activities held between the assistant and the students who would carry out the laboratory activities.

In the second stage, students carried out lab activities following the instructions in the manual book of laboratory activities. The instructions in the manual book were written in detail, step by step, like a cookbook. Therefore, the manual book in this lab activity is usually called the cookbook lab manual. For each lab activity title, this manual book lab consisted of activity objectives, theoretical basis, lab activities (tools and materials, activity procedures), observation results, data processing, and questions related to the lab activity title.

As for the final stage, namely after the lab activity, students prepared a lab activity report. Students wrote a report consisting of an introduction, theoretical basis, methods, results and discussion, conclusion (conclusions and suggestions), bibliography, answers to questions in the manual book lab, and attachments. Apart from that, students also completed the questions in the manual book. This question asked about concepts in the lab activities that have been carried out.

3.2 Profile of Students' Scientific Reasoning Skills

Students' Scientific Reasoning Skills are presented on Figure 2. Figure 2 presents that SRS1 (conservation of mass and volume) is the sub-skill that reached the highest score in the class, while SRS2 (proportional reasoning) is the sub-skill that reached the lowest score. Conservation of mass and volume is the basic skill in scientific reasoning skills. It is the skill to determine that the amount of mass in a system remains constant and that the volume of an object remains constant if it is poured into different containers. As the basic skill in scientific reasoning skills, it is reasonable that this skill reached the highest score.

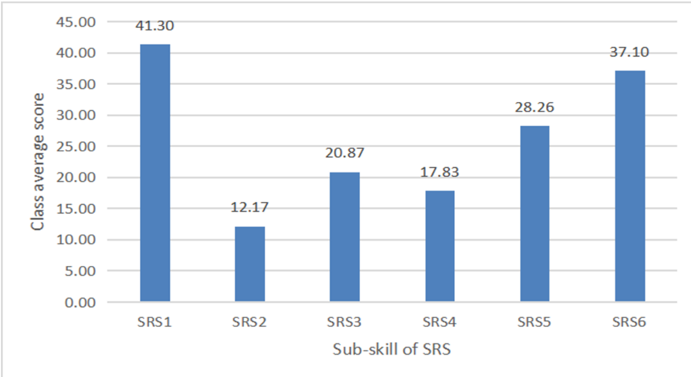

Fig. 2. Class average score of SRS sub-skill

Proportional reasoning is the skill to understand of two quantities and how they change together. This skill is usually needed in mathematics. Based on Figure 2, this skill needs to be the main focus to be developed in students. Some studies [8,9] show that one of the solution is by enriching STEM/inquiry in class activity. Modifying traditional lab activity is needed, to reach better score of students' SRS. Students' SRS need to be improved, because these skills, scientifically have positive correlation with some other important skills, such as problem solving skill [11] and course achievement [12]. Improving SRS is kind of shortcut to be succeed in learning.

Class achievement at each level of cognitive development are presented on Figure 3.

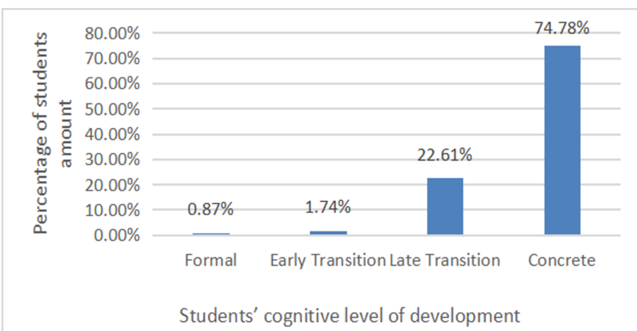

Fig. 3. Percentage of students at each level of cognitive development

Based on Figure 3, only 0.87% of student in the class reached formal stage of cognitive development, while 74,78% of students were still at concrete stage of cognitive development. This finding indicates that there should be the improvement on the laboratory activity. Based on Piaget's theory, student could reach formal stage of cognitive development level at the age of 11-12 years old [13]**.** This finding contradicts with the theory.

4 Conclusion

Most of the students were still at the concrete level, as many as 74.78%. The students' conservation of mass and volume sub-skill got the highest score (41.3 out of 100 scale), while the proportional reasoning sub-skill got the lowest score (12.17 out of 100 scale). The student's SRS profile indicated the need for modifications to the traditional physics laboratory activity, so that it is hoped that it can improve the student's SRS.

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