An analysis of Generic Science Skills

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An analysis of generic science skills as 21st-century skills for preservice physics teacher at UIN Raden Intan Lampung

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Abstract: This study aimed to describe the generic science skills of students who were conducting experiments on the mechanics practicum. This research was qualitative descriptive research. The research subjects were the students of the Physics Education Study Program of UIN Raden Intan Lampung in the academic year of 2019 with a total of 130 students. The data collection technique employed was the non-test technique with the observation sheets and interview guidelines as the research instruments. Student activities were observed by 4 observers through direct observation, indirect observation, quantities scale awareness, logical framework, the law of cause and effect, observation, and conclusion. The indicators of the generic science skills in this research were based on the analysis of previous research related to the relationship between generic science skills and 21st-century skills. The percentage of generic science skills was analyzed using descriptive statistics. The results showed that the students' overall average generic science skills were 67% which was in the moderate category. The highest was in the direct and indirect observations with a percentage of 78% which was in the high category while the lowest was in the principle-compliant logic framework with a percentage of 59% which was in the poor category. Due to the poor research results in several categories, it is suggested that educators reaffirm generic science skills in learning considering the importance of these skills to support students' understanding and skills.

Keywords: 21st-Century Skills, Generic Science Skills, Mechanics Practicum

1. Introduction

Education has become the foundation for restoring, changing, and improving the quality of human life [1]. Up to this 21st-century, the world has experienced rapid changes in various areas of human life. The role of educational institutions is needed to prepare students who possess the 21st-century skills [2]. It is necessary to anticipate the changes by mastering the 21st-century skills. These 21st-century skills cover the critical-thinking, problem-solving, creativity, innovation, communication, and collaboration [3]. The 21st-century skills which cover the 4C are related to problem-solving so that they require adequate knowledge and skills [4]. The teacher training institutes or universities that nurture the preservice teachers must be able to produce graduates that are in line with the demands of the 21st-century. Structural changes in the economy, the nature of globalization, and technological advances have contributed to changing the nature of work which ultimately affects the skills demanded by the market. In this context, world organizations

such as APEC (Asia-Pacific Economic Cooperation) and OECD (Organization for Economic Cooperation and Development) call the developments with the terms of 21st-century skills, employability skills, and soft skills or generic skills as an international priority [5][6]. Students in Finland have realized the importance of the 21st-century skills for their future life by deciding the collaboration and skills as their top priorities [7]. 21st-century skills have become a hot topic lately. However, many questions arise regarding the method of how to measure the skills that reflect the framework of the 21st-century and how to scale and evaluate the 21st-century [8]. The current research regarding these matters is focusing on incorporating 21st-century skills with generic science skills [9]. Some research results have identified that the evaluation of the 21st-century skill has not been supported by appropriate instruments that can measure the 21st-century skills [10]

Research on the challenges in developing and implementing generic skills in higher education curricula found that several generic skills have been applied in higher education such as leadership and communication, collaboration and teamwork, globalization and cultural awareness, and entrepreneurship which is important to be mastered by students [11]. Generic science skills are skills to learn concepts and solve problems in science [12]. Generic science skills provide the expertise that can be used in various scientific works such as practicum so that there is a need for a strategy to develop students' generic science skills [13]. The practicum activities consist of three domains of educational objectives, the cognitive domain that can support the absorption of learning material outside of the classroom, the affective domain that can train scientific attitudes, and the psychomotor domain that can train the skills in using practicum tools in the laboratory. In teacher professional development, laboratory skills must be trained so that preservice teachers can develop their knowledge, understanding, and skills [9]. Generic science skills are basic skills that are necessary for every preservice physics teacher because these skills will become provisions in facing the world of education which not only demands good literacy skills but also adequate skills [11]. The indicators of the generic science skills consist of direct observation, indirect observation, quantities scale awareness, symbolic language, logical frameworks, logical inference, the law of cause and effect, modeling, and logical consistency [14]. The generic science skills are part of or similar to 21st-century skills. Therefore it is necessary to reaffirm the generic science skills in learning [9]. The observed activities consisted of direct observation, indirect observation, quantities scale awareness, logical framework, the law of cause and effect, modeling, and conclusion [9].

Research conducted by Prabowo discovers that the generic science skills of the tenth-grade students of State Senior High Schools in Purworejo Regency were 48.5%, so it can be concluded that the students' generic science skills were in the moderate category [15]. In his research, Prabowo focused the generic science skills on the direct observation, quantities scale awareness, logical framework, the law of cause and effect, modeling, and conclusion. The highest score was on the modeling indicator with an average percentage of 87.49%. The post-test scores indicated that all students who had passed mastery of learning had a mean score of> 75 which indicated that they had acquired generic science skills as part of the 21st-century skills [9]. Based on the explanation regarding the importance of generic science skills as the part of the 21st-century skills, further research needs to be carried out at the Physic Education Study Program of the Tarbiyah and Teacher Training Faculty at Raden Intan State Islamic University of Lampung in the 2019/2020 academic year considering that so far there has been no research related to generic skills carried out there. That fact motivated the researchers to conduct research guided by the results of previous studies by distinguishing the subjects and materials.

2. Research Method

This research was qualitative descriptive research [16] to describe the generic science skills of students who were doing experiments on mechanics practicum. This research referred to the data analysis by Miles and Huberman by performing interactive and continuous qualitative data analysis until the data is

saturated [17]. The steps in data analysis consisted of data reduction, data display, and conclusion drawing or verification [17]. The research subjects were the second-semester students of the Physics Education Study Program of Tarbiyah and Teacher Training Faculty at Raden Intan State Islamic University of Lampung in the academic year of 2019/2020 which consisted of 130 students. The data collection technique used was a non-test technique with the observation sheets and interview guidelines as the research instruments. The observation sheet was utilized to observe the practicum process. The results of the observation sheet were calculated using the following formula:

$$NP = \frac{R}{SM} \times 100\%$$

Description:
NP: The generic skills score
R: The score obtained by students
SM: The maximum ideal score of the questions in each series[19]

After the data had been obtained and analyzed, the interviews with students were conducted to strengthen the results of previous data analysis [20]. The instrument used in this research was the adaptation of existing generic science skills instruments. From these existing instruments, the researcher then developed an observation sheet and interview guides which were then validated in terms of content and language by involving 4 experts. To collect the data, the students were divided into 4 groups. Before the experiment, each student was coded in the form of numbers to make it easier for the researchers to observe and assess them. Each group was observed by one practicum assistant observer who already had an understanding of the students' practicum abilities in the previous practicum. The percentage of generic science skills scores was assessed based on the criteria in the following table:

Table 1. The Scale Category of the Generic Science Skills

% Mastery	Grade	Value	Predicate
86 - 100	A	4	Excellent
76-85	B	3	High
60-75	C	2	Moderate
55- 59	D	1	Low
≤ 54	Not Passed	0	Poor

The following is the flowchart of this research:

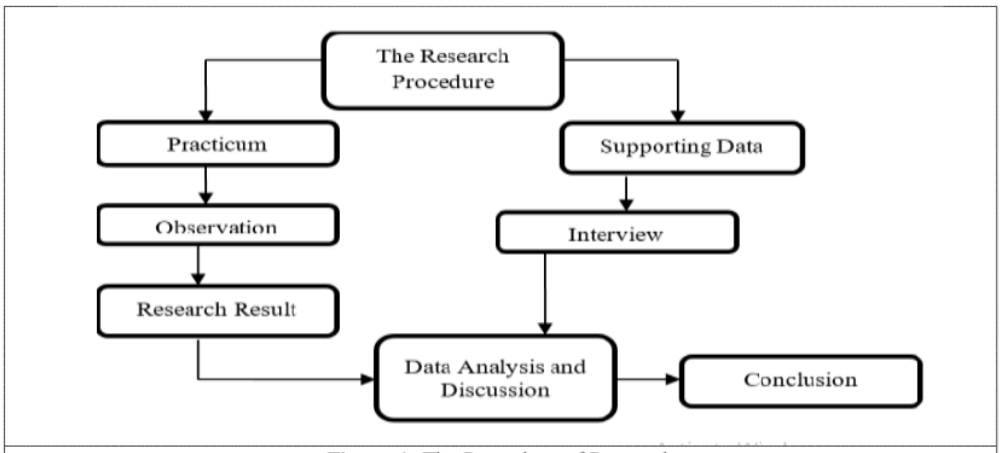

Figure 1. The Procedure of Research

3. Research and Discussion

Table 2. The Result of Generic Science Skills Observations of the Second Semester Students of Physics Education Study Program in the Student academic year of 2019/2020

Generic Science Skills Indicators	%	Category
Direct observation	78	High
Indirect observation	78	High
Quantities scale awareness	66	Moderate
Principle-compliant logic framework	59	Low
The law of cause and effect	61	Moderate
Modeling	65	Moderate
Conclusion	64	Moderate
Total Average	**67**	**Moderate**

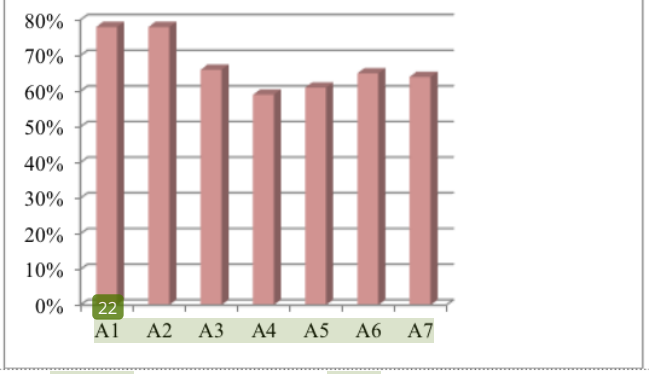

Figure 2. The Total Average of the Generic Science Skills

Description:
A1: Direct observation
A2: Indirect observation
A3: Quantities scale awareness
A4: Principle-compliant logic framework
A5: The law of cause and effect
A6: Modeling
A7: Conclusion

Table 3. The Result of Interview on Generic Science Skills

Predicate	Respondent	The Result of the Interview
Excellent	LF	Based on the results of the interview, LF did not experience any difficulties in the aspects of direct observation and indirect observation. The obstacles experienced were less thorough or unfocused in observation which caused an error in the experiment. However, it was immediately realized by LF. For the aspect of quantities scale awareness, LF often experienced difficulties because she did not understand the unit. In the logic framework aspect, LF did not know that one physical phenomenon can be studied by more than one scientist. In the law of cause and effect, modeling, and conclusion aspects, LF did not experience any obstacle at all.

Predicate	Respondent	The Result of the Interview
High	MFA	MFA did not experience difficulties in the aspect of indirect observation. However, in the direct observation aspect, MFA made a mistake in observation but it was immediately realized and corrected. MFA had no difficulty in changing the scale or unit in the experiment. However, in the aspect of the logic framework, MFA could not find a logical relationship between the two principles because MFA did not realize that there were other rules applied to one phenomenon. In the law of cause and effect aspect, MFA was able to observe the experiments to look for causes and effects from experimental procedures although MFA was not able to describe what was known. In the aspect of modeling and conclusions, MFA did not experience any problem in reading graphs or tables and concluding.
Moderate	EP	In the aspect of indirect observation and direct observation, EP did not experience any difficulties. In indirect observation, all experiments used the same measuring instrument, namely a ruler. For the aspect of quantities scale awareness, it was difficult for EP to write scientific notation in the form of rank which resulted in the incorrect calculation. EP also could not find a logical relationship between the two rules because EP was only aware of one rule in one physics phenomenon. In the law of cause and effect aspect, EP knew what to observe when looking for the law of cause and effect in the experimental procedure. However, the experimental results were illegible so that it can make understanding the law of cause and effect incorrect. In the modeling aspect, the EP did not use graphs to read and express experimental results. EP was only able to reveal phenomena in writing. In the conclusion aspect, EP made the conclusions from the observational notes. However, some errors can be found in the results.
Low	M	Indirect observation, M did not experience any difficulties. However, M experienced difficulties to describe the reason behind the events observed. This proved that M had not been able to understand the law of cause and effect in experiments. In using a measuring instrument to assess the direct observation aspect, M did not experience any problems because of the experiments using the same measuring instrument, namely a ruler. M also had not been able to understand the ratio to equalize the units, especially the units in derived quantities. M also did not know any other rules which stated the same phenomenon. In the modeling aspect, M had difficulty in reading graphs but M was able to read tables. Finally, in looking for conclusions, M only looked for conclusions from the calculations without observing the law of cause and effect of the experimental procedure.

3.1 Direct Observation

Direct observation was done at the start of the process of assembling the experimental instruments so that there were no mistakes in the series of experimental procedures. Based on the categories obtained, the students as a whole were able to observe experimental procedures well and did not experience much difficulty in the observation process.

3.2 Indirect Observation

In indirect observation, the observers observed the use of measuring instruments to measure the results of the experimental procedure. In the mechanics practicum, the measuring instrument used was a ruler so that students did not experience any difficulties in making measurements so that it was able to promote generic indirect observation skills.

3.3 Quantities Scale Awareness

Students discussed with each other to achieve the results of the experiment by changing different units. Generally, group members knew the difference of each physics quantity. However, the students experienced difficulty in calculating the scientific notation and measurement scale so that the calculations made were incorrect.

3.4 Principles-Compliant Logic Framework

Many scientific phenomena have been studied by several scientists which resulted in different opinions. The differences must be mediated by other theories that discuss similar matters but have a broader explanation such as the difference between Aristotle's and Galileo's theories of motion which was then mediated by Newton's theory of motion. Lack of awareness regarding the differences in laws of physics made students experience difficulty in linking experimental results with relevant theories. Many students did not realize that one phenomenon in physics can be studied by several different scientists with different results. In physics, existing theories continue to develop over time.

3.5 The Law of Cause and Effect

In every quantity produced or related to the experimental procedure, the value of each quantity will be mutually influenced if one of them is changed or maintained. Either it is proportional or inversely proportional to its value with the changed quantity. The students were able to determine the variables for which the value should be sought and able to find the problems even though some students were still guided in finding the purpose of doing the practicum. The variables required students to describe the variables to be observed so that they can interpret the results of their observations based on the procedures. In the law of cause and effect, it was necessary to pay attention to several external factors that can affect the experimental tool so that the experimental results have a little misconception with the applicable theory that can make the experiment fail. However, in general, physics education students had been able to realize several error factors so that they can minimize errors in the experimental procedure.

3.6 Modeling

To explain the observed phenomena, mathematical modeling is needed so that the tendencies of the relationship between variables or changes in a natural phenomenon can be easily predicted. The students understood the comparison and the results of the experiment by observing notes in the form of written experimental data rather than reading graphs. This happened because students were unable to analyze the meaning of the graphs because reading the graphs was too difficult. However, for some experiments where graphs and tables had been provided in the experimental module, the students were able to read the results of the experiment because they only needed to enter the data into the tables or graphs provided.

3.7 Conclusion

In this aspect, the conclusions of the observations were based on the changes in motion or shape of objects. There were no obstacles when observing the experimental procedure because the existing objects changed automatically so that it was easy to observe and conclude the affecting factors. The conclusions can be made by observing the experimental results that had been previously recorded which then analyzed to conclude. Most of the students were able to draw conclusions based on the experimental procedure without any errors. There were only minor errors in determining the results of the experiment to be calculated and concluded.

Previous research on generic science skills had unsatisfactory results[21,15] Leaning that overall students' generic science skills were low so that affirmation and renewal in learning should be made so that the generic science skills could be improved to bring out the 21st-century skills that are needed. Based on literacy studies conducted the researchers, there have been no specific measurements to determine a person's readiness to master 21st-century skills. The assessment that has been carried out is to emphasize certain learning methods and learning approaches that are expected to improve the 21st-century skills, such as the higher-order thinking skill and collaborative problem solving[22-24] or use the 21st-century terms to understand the consequences of digitization in terms of individual job skills [25]. It would be better if some of the mastery criteria of the 21st-century skills can be relevant to skills that can be measured in the learning process so that the skills in learning could be optimized.

4 Conclusion

The generic science skills of the students of the Physics Education Study Program of UIN Raden Intan Lampung in the academic year of 2019/2020 were in the moderate category with a percentage of 67%. Some weaknesses found during the practicum processes, namely students were unable to focus during the practicum, study fewer physics phenomena, incorrect mathematical calculations, and difficulty in formulating practicum results based on tables and graphs. The generic science skills are important for students considering these skills do not only focus on knowledge but also students' skills. The researchers hope that the generic science skills can be maximized in learning through further research on generic science skills and their relationship with 21st-century skills.

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