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PERFORMANCE ASSESSMENT OF PRACTICUM WORK: MEASURING THE SCIENCE STUDENT TEACHERS' LOGICAL THINKING ABILITIES

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Logical thinking ability in scientific practicum is necessary to maintain the quality of education program of science student teacher. This study aims to assess logical thinking skills through practicum performance assessment instruments. This study describes the aspects of logical thinking as follows; formulating problems, developing hypotheses, collecting data, analysing data, constructing discussion, and drawing conclusions. The instrument validation was carried out in two ways. The education evaluators measured the construct validity, and the calculation of empirical validity was performed statistically using SPSS. Items for supporting logical thinking in data collection was invalid (sig > 0.05), while items in problems formulation, hypotheses development, data analysis, discussion construction, and conclusion drawing were valid (sig < 0.05). The new finding in this study is a valid evaluation instrument of practicum performance to measure logical thinking ability. It can be utilised by science educators of various levels to enhance the science practicum quality.

Keywords: Assessment of Practicum Work; Logical Thinking; Science Student Teacher.

1. INTRODUCTION

Developing logical thinking skills is one of the goals of science learning. Logical thinking is a process of thinking logically, rationally and reasonably (Lazear, 2004; Yaman, 2015). Also, words are the form of logical thinking as an expression of thought (Heinemann, 2007). Logical thinking is also associated with the function of all senses and all processed information, by means through logical thinking; students can distinguish, criticise, and process the knowledge in the form of words based on the phenomena. Therefore, they can discover the answer to each problem. Practicum work in science learning is a problem-solving method which requires logical thinking abilities (Hibbard, 2000). In the practicum, students apply logical thinking skills starting from observation, questioning, formulating hypotheses, conducting research, collecting data, processing and analysing data, and also for drawing conclusions. The whole process of the practicum work is carried out within the boundaries of logical, rational, and consistent principles. Logical thinking through practicum will foster the students' ability to conclude a phenomenon supported with valid and accurate evidence. The great impact is at the end where it will help the students to not to trust a conclusion without related experience or

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representativeness. Besides in the form of words, the characteristic of logical thinking includes having logical thinking pattern can be expressed in oral form.

Logical thinking skills are related to some variables such as mastery of concepts and designing the concept application through scientific work (Fah, 2009; Kincal and Deniz Yazgan, 2010; Busaidi *et al.*, 2007). A simple form of scientific work is a practicum or laboratory work. Previous researchers emphasise that the laboratory experience can help to master the concept as the results of reasoning using logical thinking abilities (Khaerunisa *et al.*, 2012; Basey *et al.*, 2014). Also, practicum enhances capacity to analyse the results obtained from logical thinking.

Susilaningsih (2012) discovered that many problems occur in most of the practicum work of science student teachers in Indonesia. Vani (2012) found that almost three-quarter of students in science learning process stumbled upon explaining the data obtained in food test practicum. The difficulties they experienced indicate that the students have a weakness in developing ideas expressed through the discussion. Yaman (2015) reveals that practicum can improve the students' ability to think logically if only their performance during practicum was measured through the reasoning and analysing activities. Therefore, one of the reasons of low students' ability in logical thinking is a weak assessment in practicum work. The absence of logical thinking skills evaluation in practicum profoundly affects its quality. Without proper evaluation, the student teachers express a low motivation for showing their reasoning and analytical ability. Thus, a useful assessment instrument is required to measure the performance of logical thinking during practicum work. Also, the whole process of practicum should have been done based on the logical, rational, and consistent principles. The ability to choose rational decision as well as to connect the problem and the data obtained through practicum could train students' logical thinking skills.

According to Sudrajat *et al.*, (2011), the assessment of logical thinking skills in science will be more precise when measured through problem-solving activities. Also, Sweet (2013) states that a satisfactory performance evaluation is effective to review a program and how well it is being conducted. There is a necessity to measure the performance of pre-service science teachers in logical thinking. According to Susilaningsih (2012), practicum work in the laboratory is a process to achieve the goal of the preparation program of science student teachers in which measuring their readiness in conducting practicum is a significant leap toward obtaining the expected competencies.

This study describes research to find the practicum performance assessment instrument which can construct the students' logical thinking abilities with the hope that the developed assessment instruments will give a benefit to assess

students' abilities in a proper way. This research is significant since the assessment instrument is necessary to prepare pre-service science teachers. The purposes of this study are to describe the practicum performance in embedding the logical thinking abilities to student teacher and also to develop a suitable instrument to assess logical thinking skills in practicum performance. In this case, the logical thinking abilities are formulating problems, developing hypotheses, collecting data, analysing data, constructing discussion and drawing conclusions.

2. MATERIALS AND METHODS

2.1 Population of Study

The study population consisted of all undergraduate students who participated in the course of Basic Science Practicum, General Biology Practicum and Biochemistry Practicum at the Science Education Program, Universitas Negeri Semarang. Each practicum course consisted of two classes. In this study, purposive sampling technique was performed to obtain samples from each practicum class. The students were determined at three different levels, *i.e.* first-year, second-year and third-year students. The number of students of Basic Science Practicum in each class was 24, whereas General Biology Practicum was 25, and Biochemistry Practicum was 19.

2.2 Construction of Assessment Instrument

The development of assessment instrument was conducted to measure logical thinking abilities, *i.e.* formulating problems, developing hypotheses, collecting data, analysing data, constructing discussion, and drawing conclusions through practicum performance. Validation of instruments was carried out in two methods. The education evaluators measured the construct validity, and the empirical validity was calculated with SPSS. The analysis was performed using descriptive qualitative method (Sukardi, 2012).

As proposed by Maloney *et al.* (2001), in rubric validation, the experts give the consideration toward every aspect of performance indicators, and it is completed with assessment rubric. Also, the experts validate the rationality of the instruments' format and substance as well as the suitability of each instrument. Then, it is subsequently used as construct validity (Azwar, 2010). The instruments were developed to assess the practicum work performance in 30 aspects. Six aspects were used to evaluate the skill of logical thinking. Likert scale with four different levels, 4 (very good), 3 (good), 2 (fair) and 1 (poor) was used for scoring. Practicum performance was categorised into those four scales after conversion into a value range of 0 to 100, with the criteria: poor (< 61), fair (61-70), good (71-85) and very good (> 86).

2.3 Research Stages

The stages of the research were conducted in sequence, *i.e.* construct validity of the assessment instrument of practicum performance by experts, and then continued by validation of the instrument. After that, the assessment instrument test was conducted. SPSS was employed for analysis to obtain valid items, analysis of logical thinking abilities of science student teachers through practicum, and reporting the practicum results.

2.4 Data Analysis

Data of instrument application was analysed by SPSS using Pearson Correlation method, the following results of testing criteria; H0 (indicators are invalid) and H1 (indicators are valid) with a significance level of 5% (0.05). The conclusion of the analysis was determined based on the sig, if sig < 0.05 then H0 is rejected and if sig > 0.05 then H0 is accepted.

3. RESULTS

At the first stage of research, the assessment instrument was developed to focus on the assessment of students' logical thinking abilities during practicum work. The developed practicum performance assessment instrument comprises 30 items. Six items are indicators of logical thinking abilities assessment. The experts gave some suggestions to improve the quality of the instrument before its application to assess practicum performance. The suggestions on the instrument are summarised in Table 1.

TABLE 1: SUGGESTIONS FROM THE EXPERTS TOWARD THE DEVELOPED ASSESSMENT INSTRUMENT OF LOGICAL THINKING ABILITIES DURING PRACTICUM WORK

No.	*Suggestions*
1.	The criteria of problem formulation should not only use "what," but also "how" to develop better logical thinking skills in practicum;
2.	The rubric of hypotheses construction must be connected to theories and results of previous studies;
3.	Data was collected using observation and measurement techniques;
4.	The rubric of practicum report discussion must link all variables, process the data correctly, and completely answer all of the research problems.

The experts suggested 4 points improve the instrument for assessing logical thinking abilities as shown in Table 1. After editing the instrument according to their suggestion, the experts validated 30 items of the practicum performance assessments. The validation scored 89 out of 100, meaning that the instrument was valid for research application. After validation, the instruments were then applied to measure the students' logical thinking abilities. Then, the results of instrument application were also being validated. Based on the validation results, those

30 items was re-tested. The results of SPSS analysis on practicum performance assessment results can be seen in Table 2.

TABLE 2: THE RESULTS OF SPSS ANALYSIS TOWARD 30 ITEMS OF PRACTICUM WORK ASSESSMENT

Item	*Sig*	*Criteria*	*Item*	*Sig*	*Criteria*
1	0.001	valid	16	0.070	invalid
2	0	valid	17	0.139	invalid
3	0	valid	18*	0.014	valid
4	0	valid	19	0.310	invalid
5*	0	valid	20	0.076	invalid
6*	0.029	valid	21	0.043	valid
7	0.053	invalid	22	0.013	valid
8	0	valid	23	0.001	valid
9	0.001	valid	24*	0.001	valid
10	0.004	valid	25	0.006	valid
11	0.031	valid	26	0	valid
12	0.046	valid	27	0.019	valid
13*	0.702	invalid	28	0.017	Valid
14*	0.002	valid	29	0.691	Invalid
15	0	valid	30	0	Valid

Based on Table 2, the signed* are the items for assessing logical thinking abilities. There is an item declared as invalid since sig value is > 0.05. The invalid item was data collection during the practicum. Based on the validity analysis of 30 items of practicum performance assessments, seven items were stated to be invalid because of sig > 0.05. Invalid items were not used for further research. After ruling out the invalid items, 23 items were ready to be utilised. Those 23 items were then applied to assess the practicum performance of science student teachers at three practicum courses, *i.e.* Basic Science Practicum, General Biology Practicum and Biochemistry Practicum. Results of students' practicum work are presented in Figure 1.

Figure 1: Results of Students' Performance Assessment of Three Practicum Courses.

In Basic Science Practicum, 11 students achieved good category, and seven students scored very good. In the subject of General Biology, eight students got a good score, and ten students reached very good category. In Biochemistry Practicum class, five students gained good grade, and six students belonged to very good category. Two students stayed in the poor category in Biochemistry Practicum. The average score of practicum performance results of all three practicums is shown in Figure 2.

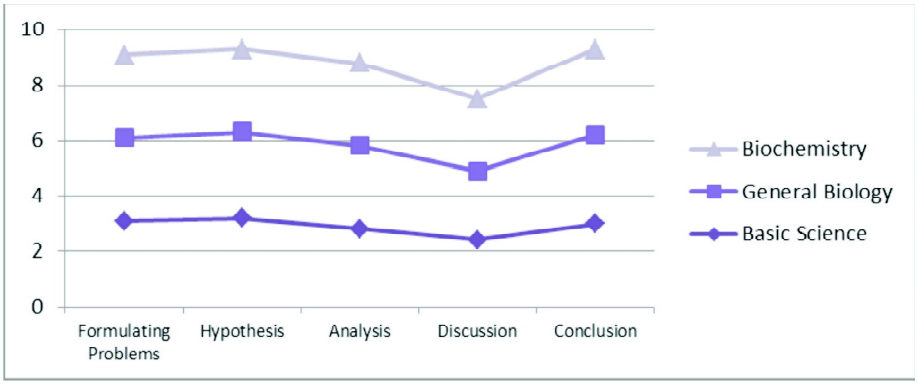

Figure 2: Results of Students' Logical Thinking Abilities Assessment

Figure 2 shows the five aspects of logical thinking at all three practicum activities. The average scores of 4 aspects, *i.e.* formulating problems, developing hypotheses, analysing the data and drawing a conclusion; were ≥ 3. They belonged to "good" category. While discussion aspect average score was < of 3, which means "poor." Analysis demands the ability to explain practicum results data and the relationship between them. Also, to account for the relationship between variables and propose an idea from practicum experience. Developing discussion based on the complexity of activities could be said as the primary factor of logical thinking in practicum activities. When a student teacher scored less than 3, it could be inferred that their logical thinking skill was still low. After assessing aspects of logical thinking to all five aspects, the evaluation was performed on their logical thinking based on the number of those who reached poor criteria onto those who belonged to the very good criterion. The result of logical thinking skills assessment based on the number of science student teachers is presented in Figure 3.

The average of logical thinking scores obtained from the assessment of 5 aspects, mostly were in the moderate category for all practicum classes. Unfortunately, some students achieved poor criterion. At the end of the practicum, student teachers were required to write a report in groups. Each group consists of three to four students. Then, the report assessment results are presented in Table 3.

Figure 3: Assessments of Logical Thinking Skills of Science Student Teacher in 3 Practicums.

TABLE 3: ASSESSMENT OF PRACTICUM REPORTS

	Number of Groups		
Score	*Basic Science*	*General Biology*	*Biochemistry*
< 60	–	–	–
61 – 70	5	4	4
71 – 85	2	1	2
> 86	1	3	–

Most of the groups obtained scores between 61 to 70; 5 groups in Basic Science, four groups in General Biology and four groups in Biochemistry. Not a single group scored < 60 on all three practicum classes. Based on the analysis of practicum reports, we acquired several facts. First, student teachers had difficulty in explaining practicum results data accounted in the discussion of reports. Their explanation had not been able to link the formulation of the problem, hypothesis, and obtained data. They were also weak in exposing the relationship between variables. The contents of the discussion mostly traversed on how they collected data. They are troubled with developing adequate sentences in the discussion became evident of their lack of reasoning ability. As a result, the outcome of post-test after practicum was also affected. Results of the analysis of 3 practicums showed that students' average post-test scores were less than 85 out of 100.

5. DISCUSSION

Conceptually, thinking is the ability to analyse, criticise, and create conclusions based on the reference or careful consideration. Thinking also means using intelligence to consider and decide on something. A human can develop knowledge by the ability to think in a particular framework. Most research came to the same conclusion in which logical thinking is mainly influenced by concept mastery and

the capacity to connect between concepts. In this study, the instrument of practicum work performance was designed to assess students' logical thinking abilities. The experts gave the valuable suggestions to achieve an effective instrument. Then, the suggestions from the experts had been applied to improve the content of assessment instrument. The improvement was particularly in part of logical thinking assessment. The experts advised four items to assess logical thinking, *i.e.* the formulation of the problem must apply a critical thinking word such as "how". Also, the hypotheses must encourage the students to formulate the connection among theories with the discussion of previous studies. Moreover, data collection must employ the observation and assessment of practicum reports. Finally, the discussion rubric requires the students to link all variables, to process the data accurately and to answer all of the present problems. Those suggestions were used to improve the instrument quality.

After ensuring that the suggestion had been properly applied to improve the instrument materials, the experts validated the instruments, and then they declared that it was ready for research application. It is common in research that a development of instrument could utilise experts' suggestions to improve its quality (Adam and Carl, 2010; Peniati, 2013).

In this study, as validated by the experts, the instrument was suitable for the application. It means that the items of practicum performance assessment fulfilled the standards. Then, 30 items of practicum performance assessment were tested. Based on the results of validity analysis, seven items were classified as invalid. One of them is the item for assessing logical thinking, "analysing data". The invalid items were no longer engaged in measuring the practicum work performance of student teachers in this study.

According to the results, the main problem experienced by students in practicum work was the discussion part in their report. It became an obvious evidence that students' logical thinking was still weak, especially in analysing and explaining the obtained results. The lack of logical thinking ability could lead to giving severe impact on the competence level of the science student teachers after they graduate. This study is significant to contribute as part of practicum works assessment of student teachers to measure their logical thinking skills. Logical thinking abilities were calculated to ensure all standards were achieved. Logical thinking could be interpreted from the cooperation among students during practicum work. Based on the observation during the practicum, there was an undistributed performance of each student in the group. Practicum work which is done in small groups provided broader opportunities for all members of the group to understand what is being practised (Lanang, 2003; Crone *et al.*, 2011; Melville, 2014). Based on the analysis of the test results, the dominant students during practicum turned out to have a better understanding of the practicum work. The effect of imbalance role and

performance in the group occurred to not all students in each group experienced the same phenomenon. In the end, practicum work was done in groups led to which each member of the group contributed unequal participation. The smarter students would become dominant in team works. The fact mentioned above supported how important for participants to possess sufficient logical thinking abilities.

The five valid assessment items of logical thinking abilities were: formulating problems, developing hypotheses, analysing data, constructing discussion, and drawing conclusions. The use of practicum performance assessment instrument had given a clear picture of every aspect assessed. The performance of science student teachers in all stages of the practicum needs to be improved. In this study, further assessment of logical thinking skills during the practicum work was performed. In Figure 2, it can be described that students tend to have low logical thinking skills in all three practicum courses, especially in their discussion part. The students' problem was occurred in constructing discussion. The students found it difficult to arrange a discussion. Based on the theory, discussion of the results of the practicum must include the experts' opinions (Basey *et al.*, 2014). The discussion should have been arranged to explain the data by connecting between variable and also the original idea of the experts. A good discussion should also contain their idea strengthened by supporting theories. Based on the assessment of the discussion of practicum reports, students were still not able to break down the relationship between variables. They had difficulty in connecting between variables to be assembled into a logical explanation, showing that they had not understood the material well. Practicum variables should be comprehended by the practitioner to link between variables and became logical construction for any obtained data and facts. The discussion they wrote still had several drawbacks such as they only described the process of practicum works. Also, they repeated the stages of obtaining the data. Moreover, they simply reiterated the obtained data and facts in which the compiled explanation had not been emphasised or supported by experts' opinion or any strong basic theory. Furthermore, the content of the discussion between paragraphs had not yet been presented orderly. However, besides their limitation, the student teachers were able to formulate problems, develop hypotheses and analyse the data very well. Those three aspects were compatible intertwined and precisely formulated.

Answering the problems that were tested through practicum as part of a logical thinking skill was also measured in this study. Decisions were taken in the form of answers to the problems and conclusions. Some students still had a problem in outlining the discussions, as well as forming ideas that affected on the concluding the result of practicum works. Azarpira *et al.* (2012) state that the idea as the part of thinking skills when written based on collected data was a notion that someone

understood what he or she had done. According to Wisborg and Ringsted (2011) when the idea was not able to be put into written report, practicum work would merely function as proving concepts, rather than scientific testing. The practicum performance which could build logical thinking is those that based on the following aspects: formulating problems, developing hypotheses, analysing data, constructing discussion, and drawing conclusions. The rubric used to assess those five issues contained the elements of logical thinking: logical, rational, reasoning ability, connecting practised variables, expressing ideas, and deciding conclusion according to the data. Logical thinking was assessed through observation during the practicum processes and by evaluating the practicum reports on the five aspects of logical thinking. The ability to think logically has a major role in students' academic performance and constructing concepts (Atay, 2006; Fah, 2009; Boyle, 2012; Abrahams *et al.*, 2013). Therefore, based on the discussion, this research had found a valid practicum performance instrument to assess logical thinking and got the intended result.

6. CONCLUSION

After analysing the discussion and findings in the practicum report, student teachers showed to have difficulties in developing logical thinking skills. The inability to break down the explanation of practicum data was due to their incapability in explaining the relationship between tested variables within practicum. Their discussion part in practicum report and their incapacity as mentioned earlier illustrates the lack of understanding of the concept. Based on the evaluation of the instruments used in this study, it can be concluded that the assessment instrument is valid and it can be utilised by any science educator of various levels to elevate the students' logical thinking abilities.

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