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Using Integrated Assessment Level of Inquiry (LoI) in Developing Formal-Post Formal Operating Reasoning Prospective Teachers

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Abstract

Understanding of 21st century learning is a demand for teachers as a pedagogical framework in the learning process. Schools must also implement competencies not only focusing on mastering the content of the main subjects, but also academic content at a higher level. In general, science learning in the classroom emphasizes practical work rather than involving students in the thinking process. The ability to reason can have important educational implications. The need for developing important competencies for 21st century learning outcomes through various types of reasoning that are appropriate to the situation. This study aims to determine the use of the Level of Inquiry (LoI) integrated assessment of the formal-post-formal operational reasoning possessed by prospective teacher students. The research sample used included 24 students who contracted invertebrate zoology practicum lectures for the 2019/2020 Academic Year. The research instrument used in the form of 14 questions of formal-post-formal operational reasoning and observation sheets. The results showed that the use of the LoI integrated assessment had a significant effect in developing formal-post-formal operational reasoning. Students have different formal-post-formal reasoning on each indicator. The indicator of the highest formal-post-formal operational reasoning of students is in proportional reasoning and the lowest is in metasystematic reasoning.

Keywords: Integrated assessment Level of Inquiry (LoI), formal-post formal operating reasoning, prospective teacher

Introduction

Reasoning is a person's cognitive ability (Markawi, 2015). Reasoning is an important representation of learning outcomes, because it is needed to train individuals to become critical thinkers and effective problem solvers. The development of the reasoning aspect should be a concern because it is in line with educational reforms regarding the learning process which not only emphasizes the content of science, but also trains and develops reasoning skills (Bybee & Fuchs, 2006); Purwanto *et al.*, 2013). The reasoning ability of students is currently considered low. The low reasoning ability of students is caused by the lack of teachers in applying reasoning skills in classroom learning. According to Tobin and Capie (Valanides, 1996) formal reasoning includes five students' intellectual formal reasoning in thinking, namely the ability to think proportionally, control variables, probability, correlational, and combinatorial. Further Commons *et al.* (1982) argues that post-formal reasoning includes systematic, metasystematic, paradigmatic, and cross-paradigmatic reasoning. Both formal reasoning and post-formal reasoning are important for students.

The results of a preliminary study conducted on biology education students at LPTK Kopertis IV class of 2016/2017 using the test of logical thinking which can be used for study purposes, data obtained as many as 85 students from two four classes who will program lectures In general, general biology consists of 38% of students who have concrete thinking skills, 29% of students have transitional thinking skills, and 33% of students have formal thinking skills (Juhanda et al., 2019). Several empirical studies on the teaching and learning of systemic reasoning have yielded mixed results. Hokayem (2016) mentions researchers think that systematic reasoning is difficult for middle, high, and even grade students.

The results of interviews with lecturers who teach courses obtained information that lecturers have never developed an assessment that equips students' reasoning abilities, both formal and post-formal. The assessments that they often use in learning so far have only been used to monitor the progress of learning outcomes which are more focused on measuring the progress of cognitive aspects and tend to ignore the reasoning abilities of their students. The implementation of assessment and evaluation is only carried out on the Mid-Semester Examination (UTS), Final Semester Examination (UAS), as well as tasks given impromptu in the form of homework for understanding cognitive aspects. One of the weaknesses of the assessment used in UTS and UAS cannot be used accurately for the purpose of improving ongoing learning because it is only used as material for evaluating the learning outcomes of prospective teachers in lectures.

So far, the learning of subjects in the Biology Education study program which is often carried out by one of the LPTKs (Institutions for Education of Education Personnel) in Kopertis Region IV tends to be dominated by the expository method (results of preliminary studies). This method is often used in learning because it has convenience at the operational level. The inquiry learning approach has its own characteristics in the learning steps. One of these approaches has been developed by Wenning (2011) who introduced the level of inquiry learning in science in a structured sequence. These levels of inquiry include discovery learning, interactive demonstration, inquiry lesson, laboratory inquiry, real world application, and hypothetical inquiry. Each of these levels of inquiry has a varying degree of student intellectual involvement. The lowest level of intellectual involvement of students is at the level of discovery learning and subsequently has the highest increase in intellectual involvement at the level of hypothetical inquiry. Each level of science learning inquiry also has its own types of science process skills. Therefore, the teacher's role is highest at the discovery learning level and the lowest at the hypothetical inquiry level.

Currently, the assessments carried out in several lectures are tailored to the needs such as formative assessments, summative assessments, and performance assessments. This assessment is carried out separately from lectures and emphasizes the cognitive aspect. However, there has never been an assessment that is integrated with learning known as embedded assessment. It was taken in connection with the implementation of the assessment during integrated learning.

Materials and methods

The research method used in this study was pre-experimental with a one-group pre-test post-test design. In this design, before and after being given treatment (intervention) in the form of practical learning, an integrated Level of Inquiry (LoI) assessment was used. In the research sample, pretest and posttest were carried out to determine the increase in students' formal-post-formal operational reasoning.

The research sample used included 24 students who contracted invertebrate zoology practicum lectures for the 2019/2020 Academic Year. Sample selection was done by using convenience technique. Practical activities are carried out cooperatively in small groups. Data collection was carried out using 14 questions of formal-post-formal operational reasoning that had previously been validated and tested for reliability. The formal reasoning developed adopts Tobin and Capie (Valanides, 1996) which includes five formal intellectual reasoning students in thinking, namely the ability to think proportionally, control variables, probability, correlational, and combinatorial. While post-formal reasoning is limited to systematic and metasystematic reasoning (Commons *et al.*, 1982). Based on the results of expert judgment, the questions used in this study have construct and content validity. Meanwhile, based on the results of reliability analysis using SPSS, this question has a reliability coefficient of 0.78 which indicates that the conception test instrument used in this study has high reliability. Data analysis was carried out by adopting Hake. The research hypothesis proposed is "HA: There is a significant difference in formal-post-formal operational reasoning through the use of an integrated Level of Inquiry (LoI) assessment".

Results

The results of the formal-post-formal operation reasoning of prospective teacher students who contracted invertebrate zoology practicum lectures were seen from the difference in the pretest and posttest scores during the learning process. The maximum score for students' ability in answering questions of formal-post-formal operational reasoning is 14. The recapitulation of the results of students' formal-post-formal operational reasoning data can be seen in the following table.

Table 1. Recapitulation of N-Gain Calculations, Normality Test, and Hypothesis Testing for Students' Formal-Post Formal Operational Reasoning Ability

Calculation	**Description**	**Score**	**Information**
Normalized Gain	Pretest Mean	32.14	Medium
	Posttest Mean	52.85	
	N-Gain	0.30	
Normality Test *(One sample Kolmogorov-Smirnov Test)*	Description	Asymp.Sig. (2-tailed)	Normally distribution
	Pretest	.008	
	Posttest	.000	
Hypothesis Test (*Paired Samples Test)*	95%Confidence Interval of the Difference	Asymp.Sig. (2-tailed)	Significantly different
	Lower (-20.45300)	.000	
	Upper (-14.79700)		

Based on the N-Gain calculation, it can be seen that there is an increase in the average pretest and posttest obtained by students so that the N-Gain obtained is in the medium category. The increase in the average pretest and posttest was due to the LoI integrated assessment learning, teacher candidates were given feedback in the form of comments on the tasks that had to be done by them. This encourages prospective teachers to have the opportunity to improve their assignments so that they can improve student learning progress. After calculating the pretest and posttest scores from the treatment class, to prove whether the integrated LoI assessment learning has an effect on formal-post-formal operational reasoning, statistical tests are carried out which include normality tests and hypothesis testing. The results of the calculation of the normality test using the One sample Kolmogorov-Smirnov Test show that the data is normally distributed. Subsequently, the hypothesis was tested using the Paired Samples Test and showed significantly different results. The existence of these test results proves that the use of an integrated Level of Inquiry (LoI) assessment can improve students' formal-post-formal operational reasoning in invertebrate zoology practicum.

In this study, the formal-post-formal operational reasoning test was given to prospective teacher students seven times, where in each meeting a pre-test and post-test were carried out after implementing the LoI integrated assessment. The development of formal-post-formal operational reasoning obtained from the pretest and posttest can be seen in the N-Gain results for each indicator in Figure 1.

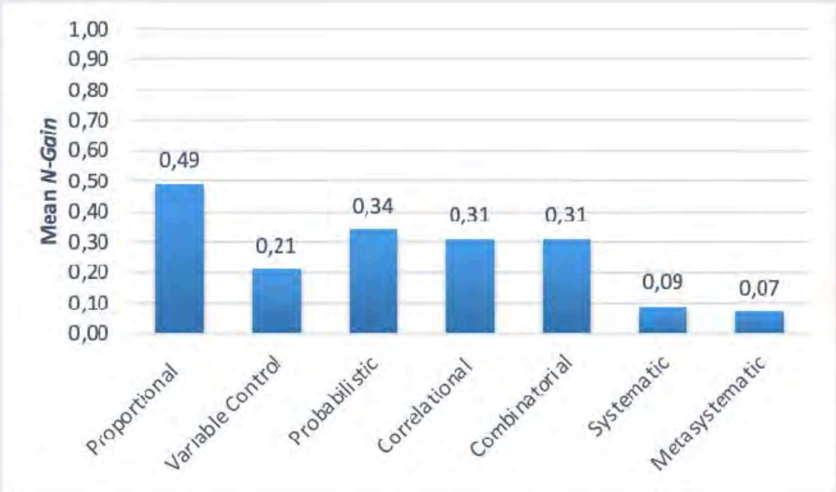

Figure 1. Development of Students' Formal Post-Formal Operational Reasoning Indicators in Invertebrate Zoology Practicum

Based on Figure 1, it is known that the development of the highest formal-post-formal operational reasoning indicators for students is in proportional reasoning and the lowest is in metasystematic reasoning. The indicators for formal-post-formal operational reasoning with the acquisition of the N-Gain category are being obtained in proportional, correlational, probabilistic and combinatorial reasoning. Meanwhile, for the low N-Gain category, there are control variables, systematic and metasystematic reasoning.

The formal-post-formal operational reasoning is also not only captured through tests, but can also be seen from the results of observations of the LKM filled out by students. The results of student work contained in the LKM can show the performance of students' formal-post-formal reasoning operations. Table 4 shows the results of the formal-post-formal operational reasoning measurements that have been categorized based on the context of the practicum material.

Table 2. Development of Student's Formal-Post Formal Operational Reasoning from Observation Results of Invertebrate Zoology Worksheets

Student Worksheet	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Context	Protozoa	Porifera	Coelenterata	Vermes	Mollusca	Arthropoda	Echinoderms
N	24						
Min	14.29	14.29	14.29	14.29	28.57	28.57	42.86
Max	85.71	85.71	85.71	85.71	100.00	100.00	100.00
Median	35.71	57.14	57.14	57.14	71.43	71.43	71.43

Student Worksheet	1	2	3	4	5	6	7
Context	Protozoa	Porifera	Coelenterata	Vermes	Mollusca	Arthropoda	Echinoderms
Mode	14.29	14.29	71.43	71.43	71.43	57.14	57.14
SD	27.13	26.62	25.96	24.80	22.26	20.63	17.86
Average	43.45	48.81	49.40	52.38	72.62	68.45	74.40

Based on the results of observations on the worksheets done by students, it can be seen that there is an increase in the average score related to the development of formal-post-formal operational reasoning. The average score of the seven measurements taken showed a positive development. The existence of feedback in the form of written comments on each worksheet that is done proves that students can reflect on improvements in the next worksheet assignment. However, the minimum and maximum values obtained by students began to increase when studying the context of molluscs to echinoderms compared to protozoa to vermes which showed constant results. This is possible because the characteristics of each invertebrate context have different difficulties. However, the development of formal-post-formal operational reasoning from the observation results of this worksheet proves that learning integrated assessment of LoI can develop students' formal-post-formal operational reasoning abilities in invertebrate zoology practicum.

Discussion

The results showed that the use of the LoI integrated assesaasment was able to develop post-formal operational reasoning for prospective teachers in the invertebrate zoology practicum course. This can be seen from the hypothesis testing carried out, namely there is a significant difference in reasoning from formal-post-formal operations after learning using an integrated Level of Inquiry (LoI) assessment. In learning using the LoI integrated assessment, students learn in order to develop their intellectual abilities (Wenning, 2005). Piaget (1964) argues that the intellectual development of each individual is adjusted to his age. This intellectual development consists of formal-post-formal operational reasoning (Commons et al., 1982).

In this study, LoI learning was applied starting from the lowest to the highest level, namely discovery learning, interactive demonstration, inquiry lesson, laboratory inquiry, real world application, and hypothetical inquiry (Wenning, 2011). In practice, assessments for learning are carried out at each level of inquiry with the aim of improving formal-post-formal operational reasoning. The assessment given is in the form of written feedback on each worksheet assignment that is done by students. In addition, formal-post-formal operational reasoning indicators were developed at each appropriate level of inquiry. Based on the results of N-Gain, it is known that each indicator of formal-post-formal operational reasoning has a different value. The proportional indicator has the highest N-Gain value in the medium category. In this indicator, student teachers are required to be able to develop a proportional relationship between weight and volume, transfer proportional reasoning from two dimensions to three dimensions, use proportional reasoning to estimate the proportional size of an unknown population (Nickerson, 1985). Meanwhile, the metasystematic indicator has the lowest N-Gain value. This shows that student teacher candidates are still not optimal in acting on the system, such as comparing, contrasting, changing, and synthesizing systems (Commons et al., 1982); (Commons, 2008); (Commons & Richards, 2016).

The second highest N-Gain indicator is achieved by probabilistic reasoning with a moderate category. In this indicator, prospective teacher students are expected to be able to use information to decide whether the conclusion may be true or may not be true (Nur, 1991). Nur further stated that this reasoning starts from the development of the idea of opportunity. The concept of probability is fully mastered by students who are already at the stage of formal operations, which is characterized by being able to distinguish between things that are certain to happen and things that are likely to happen from the calculation of probabilities.

The third highest N-Gain indicator is achieved by correlational and combinatorial reasoning. In correlational indicators, student teacher candidates are asked to determine the strength of the reciprocal relationship or inverse relationship between variables (Lawson, 1979). This reasoning involves identifying and verifying relationships between variables. Someone who is at the stage of formal thinking can identify the relationship between variables. Meanwhile, on combinatorial indicators, student teacher candidates are required to consider all possible alternatives in a certain situation. Someone who is in the formal operations stage when solving a problem will use all combinations or factors that may have something to do with the problem.

The fourth highest N-Gain indicator is the control variable. Variable control reasoning is the ability to control certain variables of a problem. Inhelder & Piaget (1958) argue that formal thinkers can define and control certain variables of a problem. Based on this statement, students belonging to formal operations can control all variables that can affect the response variable and only change one manipulation variable to find out how the manipulation variable influences the response variable.

The fifth highest N-Gain indicator is systematic reasoning. In this reasoning, student teacher candidates can understand that the logical structure of each problem must be examined as a whole or an integral structure (Commons *et al.*, 1982). In representing the structure of each problem, one can choose one of two possible programs. A schematic representation of each of the systems can be generated and these representations correspond to their deviations from each other.

The results of the observations show that the LoI integrated assessment shows positive developments. This is due to the habituation of students in working on worksheets which can develop post-formal operational reasoning. Habituation is an important learning method to form a certain ability (Barrie, 2007). However, the increase in the minimum and maximum scores did not occur in every meeting, it was possible that students had difficulties in studying invertebrate contexts. Tamba *et al.* (2020) stated that in general invertebrate material is very difficult and has a very broad and unfamiliar scope. Therefore, students need to study these contexts beforehand before practicum learning is carried out.

At the inquiry level learning, intellectual intelligence using LoI on an ongoing basis can increase from discovery learning to hypothetical inquiry (Wenning, 2005). Therefore, by going through the stages of the spectrum of inquiry, prospective teacher students will gain a comprehensive understanding of the material from all scientific and intellectual process abilities. In addition, Trianto (2011) states that the main target of inquiry learning activities is maximum student involvement in the process of learning activities, logical and systematic direction of activities on learning objectives, and developing self-confidence in students about what is found in the inquiry process. The LoI integrated assessment is a learning that includes formative assessment in it. This can be seen by providing feedback in the form of written comments that can help students to do the worksheets correctly. This feedback can also create a meaningful experience for students so that students can correct mistakes and shortcomings made when working on worksheets. Giving feedback is an important aspect for students in mastering lessons with tiered material characteristics (Aini *et al.*, 2016). Furthermore, according to Popham (2008) formative assessment is a process used by teachers and students during learning that provides feedback to organize learning and continuous learning in order to improve the achievement of learning outcomes.

Conclusion

The Level of Inquiry (LoI) integrated assessment has a significant influence on the development of formal-post-formal operational reasoning of prospective teachers. The achievements of developing teacher candidates' formal-post-formal operational reasoning indicators after using the integrated LoI assessment show different N-Gain results. The indicator of the highest formal-post-formal operational reasoning of students is in proportional reasoning and the lowest is in metasystematic reasoning. The indicators for formal-post-formal operational reasoning with the acquisition of the N-Gain category are being obtained in proportional, correlational, probabilistic and combinatorial reasoning. Meanwhile, for the low N-Gain category, there are control variables, systematic and metasystematic reasoning. The results of the worksheet observations also show a positive development. The need for habituation related to the use of integrated LoI assessment in other practicum lectures in order to equip the development of formal-post-formal reasoning for prospective teachers.

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