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ASSESSMENT OF SEVENTH GRADE STUDENTS' CAPACITY OF LOGICAL THINKING

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ABSTRACT

The objective of this research was to quantify the logical thinking capacity of seventh grade students in Tuban, East Java, Indonesia. This research was conducting using the quantitative descriptive method and 119 students in the seventh grade of secondary school in Tuban during the Academic Year 2016/2017. The data was collected by using Logical Thinking Test (LTT) which comprises of six different kind of reasonings; namely conservational reasoning, proportional reasoning, controlling variables, combinatorial reasoning, probabilistic reasoning, and correlational reasoning (source). Based on LTT, scores are categorized into three levels; concrete operational levels, transitional levels, and formal operational levels (source). The results of the research display that (88.21%) of the seventh grade are classified at the concrete operational level, (10.08%) at the transitional level, and (1.68%) at the formal operational level. After conducting this research, teachers are now able to design teaching tactics and have a better understanding of secondary school student's cognitive development and behavior.

Keywords: logical thinking, concrete operational, formal operational

INTRODUCTION

Logistical thinking is a though process using logic, rationality and reason (source). Logic is defined as the discipline that examines the assembly of information and differentiates it between right and wrong reasoning (source). Logic can also be identified as the tool of correct thinking, the key to the processes of mental reservation and complex problem-solving (source). This means it have the capability to solve problems by using mental operations or one's ability to range principles or rules by making confidentgeneralizations or ideas (Yaman, 2005; Fero et al., 2009; Şengül & Üner, 2010). Logical thinking is one of the ways used in acquiring advanced mental activities (source). This ability is an application level activity that depends on the knowledge and understanding levels of the objective's cognitive stage (source). Also, Logical thinking is used in evaluating ideas, experiences, and information. Our logic produces results relate to the topic we are interested in, and then it converts these to memory.

Piaget, a Swiss psychologist who is known for this work on child's development, defines lo-

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gical thinking as an ability that is observed in the concrete and abstract operations stage (source). When students are in the concrete operations stage, they can use logical thinking abilities in solving concrete problems (source). In the abstract operations stage, students obtain the level of adults in terms of rational thinking. According to Demirel & Coşkun (2010) and Lee & Bednarz (2012)'s study, logical thinking includes effective use of numbers, finding scientific solutions to problems, differentiating among concepts, classification, generalizing, calculations, and providing hypotheses. Roadrangka states three developmental stages by utilizing the logical thinking levels including concrete, transitional, and formal (Roadrangka, 1995). It can also be referred to as providing us with information about an individual's cognitive development level (source).

The important question to ask is "Why is logical thinking important in science learning?" After several research studies, data shows that there is a significant relationship between abstract thinking and scientific process skills and success in chemistry (Oloyede, 2012). Students using abstract thinking tend to be more successful compared to those who do not because low-level reasoning will bring low-level performance (Oloyede, 2012; Piaget & Inhelder 2013). Science requires the skills of collecting and analyzing data to solve problems, to formulate hypotheses, to control variables and to define them operationally (source). Such processes require a high level of logical thinking ability. Proportional reasoning is important in the quantitative aspect of chemistry, specially to understand the origin and use of many useful relationships in chemistry, such as the development and interpretation of tabulation and graph data (Ruiz & Lupiáñez, 2009). In addition, correlational reasoning plays an important role in the formulation of hypotheses and data interpretations that needed to consider relationships between variables. The controlling variable has an important role in planning, implementation, and interpretation (source).

Before designing the learning process in the classroom, the teacher should know the level of the students' logical thinking abilities (Gómez, 2007). It is necessary for teachers to be able to design a learning strategy in accordance with the level of logical thinking ability of their students. As Othman et al. (2010) stated, many people fail to realize that logical thinking is among the most important factors in determining the qualifications of students in learning programs (Othman et al., 2010). Program development specialist have an important role to play by making special efforts to have a better understanding of the world for children and offer academic experience based on the children's curiosity and demand (Simatwa, 2010). Assessment of the logical thinking capability can also be used as a basis for measuring the mastery of science materials (Fah, 2009). The mastery of science materials can be predicted based on logical thinking ability. This opinion is in line with the results of Oliva's research (2003), students with high logical thinking ability can change their alternative conceptions more easily. Moreover, logical reasoning of learners makes a thinking style impact on the ability to solve Physics problems (Bancong, 2013; Etzler & Madden, 2014; Rakhmawan & Vitasari, 2016).

However, the researcher often encounterst-hat teachers rarely measure students' logical thinking skills before designing learning strategies to be undertaken. Therefore, the ability of logical thinking level of seventh grade students is examined. This study is very important in relations to defining logical thinking levels of students. This is useful for education experts and program development specialists because it affects various characteristics such as; the acquisition of scientific concepts, three-dimensional thinking, and scientific process skills (source). The researcher motivation for the study was to inspire and assist teachers in design learning strategies in the classroom. The researcher aims to answer the following research question: What is the fundamental difference found between the formal operational students, transitional students, and concrete operational students?

METHODS

This study uses the quantitative approach with non-experimental research designs in the form of surveys (Creswell, 2009). This survey method is used to obtain data in certain places where the datataken consists of natural data without treatment as well as experiments (Sugiyono, 2008).The sample that was used in this study was of 119 students (61 male and 58 female students) from a private junior high school in Tuban, East Java, Indonesia during the academic year 2016/2017.

The instrument that was used in this research is Logical Thinking Test (LTT) which was revised from the Group Assessment of Logical Thinking (GALT). GALT was created to measure six different kind of reasonings; namely conservational reasoning, proportional reasoning, controlling variables, combinatorial reasoning, probabilistic reasoning, and correlational reasoning (Roadrangka et al., 1983). The test was formed to uses multiple answers while an image is inserted for each item to help visualize the problem (source). In order to acquire a valid and reliable research instrument, the researcher tested cogency and consistency of LTT. LTT has been validated by experts who are English Linguists, psychologists, science teachers, ad mathematics teachers. Efforts were made to confirm the content face validity of the adapted and translated version of the instrument. When the results were translated into Indonesian (the national language called Bahasa Indonesia) so that the respondents could then understand the items and choose the best results. LTT also administered a reliability test. The coefficient of reliability (KR-20) of the LTT is 0.83. Thus, the selection of question originating from a valid and reliable instrument resulted in the measurement of students' logical thinking ability to be valid and reliable.

The research sample was given LTT to be completed in 50 minutes. Students answer LTT on the answer sheet provided. Each type of operations is represented by each of the two questions, in which five types of reasonings in the form of multiple choices are accompanied by reasons. As for the type of combinatorial reasoning, participants must explain each possible answer. The answer for the item of LTT number 1-10 is correct if both the answer and reason are correct. For items number 11 and 12 (combinatorial reasoning), the students are required to write down the answers. The answer in the minimum score is 0. Next, the score is classified as follows; scores 0-4 are ground in concrete operational levels, 5-7 scores are grouped in transitional levels, and 8-12 are formal operational levels.

RESULT AND DISCUSSION

After the students have completed the LTT, the answer sheets are scored according to the scoring guidelines. Furthermore, the scores are derived from the three levels. If students attain a score of 0-4, then they are grouped into the category of concrete operational levels. If students score 5-7, they are grouped into transitional levels, and students are grouped into formal operational levels if they score 8-12. Based on the LTT that has been completed by the students, the writers obtain data, as shown in Table 1

Table 1. Logical Thinking Ability Levels of Seventh Grade Student at a Private Junior High School In Tuban, East Java, Indonesia

Level of Logical Thinking	Number of Student	Percentage
Formal Operational	2	1.68 %
Transitional	12	10.08 %
Concrete Operational	105	88.24 %

Based on Table 1, (1.68%) of the seventh students were at theformal operational level, (10.08%) were at the transitional level and the remaining (88.21%) were at theconcrete operational level. The results of this study are consistent with the results of research from previous researchers. Bitner (1991) found thatseventh Grade students (n = 156), (5%) were at formal operational levels, 33% were at transitional levels, and 62% were at concrete operational levels. On the other hand, Promo and Fahey (1982) reported the results of their research, indicatingthat (3.5%) of seventhgrade students are at the formal operational levels. Similar results were also distint in the literature (Biber et al., 2013; Bulut et al., 2009; Şenlik, Balkan,& Aycan, 2011).

Based on the measurement of students' logical thinking ability classified according to the gender division of male and female, the results are presented as shown in Figure 1.

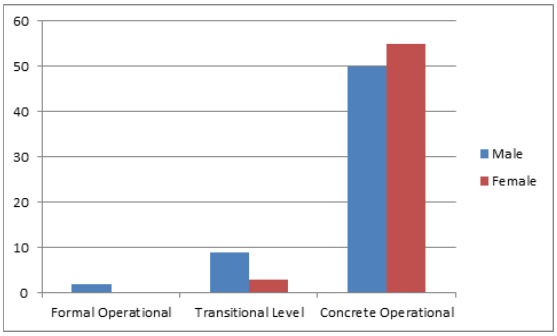

Figure 1. Logical Thinking Ability When Viewed Based on the Gender of Male and Female of Seventh Grade Student at a Private Junior High School in Tuban, East Java, Indonesia

Based on Figure 1, the number of students who are at the formal operational levelsconsist 2 male students only. While at the transitional level there are 9 male and 3 female students. At the oncrete operational levels there are 50 male students and 55 female students. Based on the results of this study, the proportion of logical thinking ability between male and female students is similar. Researchers Yaman, Fah, Kincal and Tuna indicated that based on the gender variable, that was no major change in the mean for this variable (Yaman, 2005; Fah, 2009; Kıncal et al., 2010; Tuna et al., 2013). As an example, Fah (2009) in his research to investigate the logical thinking ability of Sabah Malaysian students whose population is 16 years old, (97.2%) of male respondents and (98.7%) of female respondents are classified as the transitional operational stage. This is consistent with the results of researcher Kincal, who declared that logical thinking when it came to gender variable that there was no major difference (Kincal et al., 2010). However, when it came to the variables of the different type of school such as; academic success, socio-economic background and socio-cultural background that there was a major different between the scores (Kincal et al., 2010). After all this research and data, it is safe to conclude that the gender variable provides a feeble and unreliable measure for any decision of logical thinking.

However, when viewed per item matter, male students are superior to female students when it comes tocorrelational reasoning and probabilistic reasoning. By contrast, female students are superior to male students in this type of combinatorial reasoning.The results of the LTT analysis by the research subjects for each type of reasoning are presented in Table 2.

Table 2. Logical Thinking Ability of Seventh Grade Students at a Private Junior High School In Tuban, East Java, Indonesia for Each Type of Reasoning

Operation No.	Type of Operation	Item No.	Theme	Number of Students with Correct Answers	Percentage
1	Conservation	1	Piece of Clay	38	31,9 %
		2	Metal Weights	21	17, 6 %
2	Correlational Reasoning	3	Glass Size	15	12, 6 %
		4	Scale	22	18, 5 %
3	Proportional Reasoning	5	Pendulum Length	20	16, 8 %
		6	Ball	25	21 %
4	Control Variable	7	Squares and Diamonds #1	13	10, 9 %
		8	Squares and Diamonds #2	20	16, 8 %
5	Probabilistic Reasoning	9	The Mice	8	6,7 %
		10	The Fish	6	5 %
6	Combinatorial Reasoning	11	The Dance	86	7, 2 %
		12	The Shopping Center	45	37,8 %

Based on Table 2, the result indicates that combinatorial reasoning attains the highest average score, while reasoning reason has the lowest average score. Fah showed similar results, namely that the lowest are probability reasoning scores, but the highest scores can be found in the category of combinatorial reasoning (Fah, 2009). Yenilmez et al., (2005) and Sezen & Bülbül, (2011) scored highest in the reasoning of variable control, while the lowest was found in correlational reasoning (Yenilmez, 2005).This difference shows that the development of logical thinking ability of each student isdifferent, and obviously influenced by the environment that shaped it.

There is a fundamental difference found in the results of the study between theformal and operational level of the students and the level of non-formal operations. In the case of proportional reasoning, concrete and transitional level operational students tend to use intuitive and additive reasoning rather than using rational reasoning in solving problems. In the problem of controlling variables, students in the categories oftheconcrete operational levels and transitional levels do not show an understanding of the relationship between manipulation and control. In solving probabilisticproblems, students at the concrete operational level and transitional level focus only on one or two dimensions of the problem (*i.e.*, geometric rhombic shape and number of diamonds). They are unable to observe the characteristics of the object and understand the relationship between these characteristics on the problem of correlational reasoning. Students who are at the non-formal operational level (concrete and transitional operational level) have not been able to show the pattern and cannot solve all combinations in the problem of combinatorial logic.

Roadrangka stated there is a correlation between formal operational reasoning capabilities and the student's achievement in biology, physics, and chemistry (Roadrangka, 1995). At the formal operational stage, students scored higher in science, material science and science tests which was different for those who were a definite operational stage and understudies at the transitional operational stage (Roadrangka, 1995). This was declaring that students were unable to expand this understanding of theoretical ideas. Therefore, students who are successful in science would be certain by using different modes of formal operational reasoning (Tsaparlis, 2005; Tai et al., 2005; Lewis & Lewis, 2007; Fabelo et al., 2011). Lewis and Lewis highlighted the important needs to include a focus on the development of formal beliefs as well as content review in the way to help at-risk students in general chemistry classes (Lewis & Lewis, 2007).

Therefore, in science and mathematics learning, bridges are needed to reduce the gap between formal operational and non-formal operational stages. Science and mathematics learning can make use of concrete learning media in order to make the abstract concept easier for students to understand. Interactive multimedia can encouragesuccess anda more advance thinking skill for science students today (Melida, 2014; Alimah, 2012; Hartini et al., 2017). In addition to using the media, teachers could apply cooperative learning methods. Cooperative learning methods will be improving the students' logical thinking levels thus improving their performances (Othman et.al., 2010; Eskandar et al., 2013; Glen, 2013).

CONCLUSION

Assessment of students' logical thinking at a private junior high school in Tuban, East Java Indonesia taken during Academic Year of 2016/2017 which consisted of 61 male and 58 female students had the following outcome; (1. 68%)are at formal operational levels, (10.08%) are at the transitional levels and (88.24%) are at concrete operational levels. The proportion of logical thinking among male and female students is similar. However, there is a difference between formal operational students and non-operational formal students (transitional students and concrete operational students) when it comes to relative thinking, control factors, probabilistic thinking, correlational thinking, and combinatorial thinking.

It is important to recognize that since majority of the students that participated in this research are in the concrete operational period, there may have been influence from cultural variables, educational framework, and reading behaviors. Also, keeping in mind the grade level impact of coherent reasoning which could be from instructions and instructive dimension are in this manner likewise vital in intelligent reasoning.

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