Profile of Junior High School Students' Scientific Thinking Ability

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Abstract. The purpose of this study was to describe the profile of the scientific thinking ability of junior high school students. This type of research is descriptive research. The target of this study was 223 junior high school students (13-15 years old) in Ngawi, East Java. This research uses the Classroom Test of Scientific Reasoning (CTSR) developed by Lawson, the result of revision in 2000 which has been translated by Asnawi into Indonesian. The test has a reliability coefficient, calculated by the KR-20 formula, of 0.76. This instrument consists of 24 multiple-choice questions. The result of the research obtained is the profile of the level of scientific thinking ability of junior high school students is 89.24% of students at the concrete level, 8.97% of students at the Low Formal level, and 1.79% of students at the Upper Formal level.

1. Introduction
Science material learning for junior high school students consists of abstract concepts, so the stages of cognitive development that students must have based on age according to Piaget are formal operations (11 years and over). According to Suyono & Hariyanto [1] students with formal operational stages have several abilities, such as: (1) thinking about ideas, they are able to think of several alternative problem solutions; (2) they can develop generally accepted laws and scientific considerations; and (3) able to formulate hypotheses and make rules regarding abstract matters. In other words, students have been able to think hypothetically-deductively and inductively. With the ability, students can draw conclusions, interpret, and develop hypotheses. Therefore, students with the formal operational stage can work effectively and systematically, proportionally, and make basic generalizations [1].

Lawson [2] has an opinion that students with formal thinking ability have the ability, including: (1) operating high-order thinking patterns which include isolation and control variables, (2) combined thinking, (3) correlational thinking, (4) probability thinking, and (5) proportionally thinking. Lawson [3] argues that this formal thinking ability is a constituent of scientific thinking ability. In addition to the formal thinking ability he formulated, another constituent of scientific thinking ability is the ability of students to think hypothetically-deductively. It means, the formal thinking stages formulated by Piaget can also be called scientific thinking ability according to Lawson. A similar opinion has been expressed by Herron [4] and Ates & Cataloglu [5].

According to Suyono & Hariyanto [1], not all individuals have the same speed to reach every stage of Piaget's cognitive development. At the age of junior high school and equivalent, students should have reached the formal operational stage. However, based on the research results of Fitriyati, Hidayat, & Munzil [6] on 137 students who reported that the scientific thinking ability of junior high school students, only 3.73% of students were at the low formal thinking stage. Yedarani, Maison,
Syarkowi [7] reported that 100% of junior high school students in Jambi totaling 730 students are still in the concrete thinking stage. This shows that some students were found to experience delays in the stages of cognitive development.

Suyono & Hariyanto [1] state that the factors that cause differences in the speed of Piaget's cognitive development stages include: (1) maturity from within (maturity); (2) the individual experience in a particular person's environment grows, and includes certain stimuli that someone accidentally gets; (3) social transmission (socialization through school and outside education); and (4) internal self-direction and self-regulation.

Based on the description above, it is necessary to identify the scientific thinking ability of junior high school students to determine the profile of the scientific thinking abilities of junior high school students. The researcher proposes to use the Classroom Test of Scientific Reasoning (CTSR) instrument developed by Lawson as a result of revision in 2000. Therefore, the researcher proposes the title "Profile of Junior High School Students' Scientific Thinking Ability.

2. Method
The research design used in this research is descriptive. Descriptive research design to describe the level of scientific thinking ability. In a descriptive research design, the level of students' scientific thinking ability is presented in the form of a percentage. The study population was junior high school students in Ngawi. The sample of this research is SMPIT Harapan Umat and SMP Luqman Al Hakim in Ngawi.

In this study, students' scientific thinking ability were measured using the CTSR instrument. The instrument used was the CTSR developed by Lawson in the 2000 revision which Asnawi [8] has translated into Indonesian (Attachment 1). This instrument consists of 24 multiple choice questions. This instrument has been tested before by Asnawi on 27 senior high school students. The test results were calculated for the reliability of 0.76 (r count) which was calculated using the KR-20. The price of r table for sample 27 with a significant level of 5% is 0.381. So, the calculated r value is greater than r table, it can be concluded that the CTSR instrument is reliable or consistency to measure students' scientific thinking ability.

The process of collecting data was by giving students the entire sample CTSR test. The test is analyzed to categorize the level of scientific thinking ability. Determining the level of development of students' scientific thinking ability is known from the student's CTSR score. Scoring by means of giving a score of 1 if the student's answer is correct and 0 if the student's answer is incorrect. Then, the scores of the 24 items were added and categorized according to the criteria in Table 1.

Table 1. Criteria for the level of development of students' scientific thinking ability

| No. | Score | Category       |
|-----|-------|----------------|
| 1.  | 0-9   | Concrete       |
| 2.  | 10-14 | Low Formal     |
| 3.  | 15-19 | Upper Formal   |
| 4.  | 20-24 | Postformal     |

The number of students who have the same level of development criteria for scientific thinking skills is shown in the form of a percentage.

3. Results and Discussion
The distribution of the level of scientific thinking skills of junior high school students based on the results of the Classroom Test of Scientific Reasoning (CTSR) test results is given in Table 2.
Table 2. Distribution of Junior High School students based on the development level of scientific thinking ability

| Level of Scientific Thinking Ability | Number of Students | %    |
|-------------------------------------|--------------------|------|
| Concrete                            | 199                | 89,24% |
| Low formal                          | 20                 | 8,97%  |
| Upper formal                        | 4                  | 1,79%  |
| Post formal                         | 0                  | 0,00%  |
| Total                               | 223                | 100   |

Middle school students aged 13-15 years old should have reached the level of formal operation, namely low formal or upper formal. Based on Table 1 shows that the majority of junior high school students experience delays in the development of scientific thinking skills. This is shown by the data where out of 223 junior high school students, only 10.76% of students have reached the level of formal operations.

The delay in the development of the scientific thinking skills of junior high school students was found very much, even reaching 89.24%. This can be caused by several things, one of which is a lack of intellectual stimulation during learning. Less stimulation tends to occur if the applied learning is oriented towards direct instruction rather than concept formation. The learning that students receive during school is the main factor that intellectual stimulants get. Learning that is explaining without inviting students to construct knowledge results in students not being accustomed to thinking in a formal / abstract way.

Table 3. Details of Lawson CTRS questions

| Dimensions of Scientific Thinking Ability | No. Question | Task                                                                 |
|------------------------------------------|--------------|----------------------------------------------------------------------|
| Conservation of weight                   | 1, 2         | Vary the shape of two identical clay balls.                          |
| Conservation of volume                   | 3, 4         | Examine the volume displacement of two cylinders that are inserted into marbles of different densities. |
| Proportional reasoning                   | 5, 6, 7, 8   | Pours water on a wide and narrow cylinder and predicts its volume level. |
| Control variables                        | 9, 10        | Designing experiments to test the effect of rope length on the pendulum period. |
| Control variables                        | 11, 12, 13, 14 | Use fruit flies and tube to examine the effect of red / blue light and gravity on the fly response. |
| Probability reasoning                    | 15, 16, 17, 18 | Predicting the likelihood of pulling colored wooden blocks from the sack. |
| Correlation reasoning                     | 19, 20       | Predict the emerging correlation between rat size and tail color through the data presented. |
| Hypothetical-deductive reasoning         | 21, 22       | Design experiments to find out why water gets into the glass after the candle has gone out. |
| Hypothetical-deductive reasoning         | 23, 24       | Design experiments to find out why red blood cells become smaller after adding a few drops of salt water. |

Analysis results of the lesson plans, lesson materials, the form of assignments carried out by students, and the evaluation model used by the teacher as well as interviews with junior high school students used as research targets show that learning so far teachers tend to explain the material in
class. If there is a practice, the implementation will prove the concept of the previously taught material. According to Pavelich & Abraham [10] such learning is called verification learning. These discovery indicate that learning carried out by teachers tends to be oriented towards direct instruction or verification learning. The same trend may also occur when the research target students study in SD. This shows that the learning received by the object of research so far has less frequency of intellectual stimulation. This is supported by the discovery of Fitriyati, Hidayat, & Munzil [6] on 137 students who reported that the scientific thinking skills of junior high school students, only 3.73% of students were at the low formal thinking stage. Yediarani, Maison, & Syarkowi [7] reported 100% of junior high school students in Jambi total 730 students are still in the concrete thinking stage.

This study uses CTRS developed by Lawson [2] revised edition. This test is designed to determine several dimensions of scientific thinking skills consisting of: (1) conservation, (2) proportional reasoning, (3) variable control, (4) probability reasoning, (5) correlation reasoning, and (6) hypothetico-deductive reasoning. The details of the questions are broadly shown in Table 3.

Based on the dimensions of scientific thinking skills, a profile of students' scientific thinking ability is obtained as shown in Figure 1.

![Figure 1. Student’s answer based on dimensions of scientific thinking ability](image.png)

Based on the Figure 1 shows that the best student's average ability is the ability of correlation reasoning, while the worst ability is proportion reasoning and probability reasoning. Lawson [3] defines correlation reasoning, that is, the pattern of reasoning used to identify and determine the extent to which two variables in a diverse sample. In the CTSR test, students were asked to predict whether the correlation between rat size and tail colour appeared through the data presented. This shows that the ability of students to determine the relationship between variables is an ability that is easily accepted by students. This ability is easier to have because students are exposed to real objects of observation. Therefore, in science learning the teacher should present a real object of observation even though it is only a picture or a replica.

Proportional reasoning is related to Piaget's formal operational stage. According to Roth and Milkent [12] many Piaget and neo-Piaget researchers identify formal operational stages in subjects by having them perform tasks that require the use of ratios and proportions. Proportional reasoning ability on the items of scientific thinking ability asks students to predict the volume level of liquid poured into two different cylinders, namely wide and narrow cylinders. In the learning process, proportional reasoning is recognized as a fundamental reasoning construct needed for mathematics and science achievement [13]. Krajcik & Haney [14] analyzed the American Chemical Society Examinations and
found that more than 50% of the test tasks involved required proportional reasoning. This suggests that proportional reasoning is the main constructor of reasoning needed to be successful in learning science, and that the complete development of these skills is essential to achieve an understanding of various formal concepts related to content [11].

Students' probability reasoning ability is closely related to the probability situation. Han [11] argues that a probabilistic situation is a situation in which the fraction of the number of repetitions of a particular process that produces a certain result when repeated in an identical state several times. In other words, the magnitude of the probability that occurs in certain circumstances. Students' probability reasoning abilities were tested by predicting the probability of drawing colored wooden blocks from the sack.

Based on the above statement, it shows that the student's ability related to student calculations or algorithms is very low. If this is allowed, students will find it difficult to learn science which is related to calculations such as measurement, determining the number of atomic components, predicting the number of offspring in Mendel's law, and so on. Thus, the need for classroom learning interventions that can trigger students 'intellectual stimulation so that it can increase the development of students' scientific thinking skills. Therefore, learning such as guided inquiry and discovery learning are recommended learning models to improve students' scientific thinking skills.

4. Conclusions

Conclusions on this research is the profile of the level of scientific thinking ability of junior high school students is 89.24% of students at the concrete level, 8.97% of students at the low formal level, and 1.79% of students at the upper formal level.

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