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The Development of Three Tier Multiple Choice Test to Explore Junior High School Students' Scientific Literacy Misconceptions

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Abstract

Misconceptions of students scientific literacy can be overcome by knowing in advance the alternative concepts students have. One technique that can be used to trace students misconceptions is using multiple choice diagnostic tests. This research aim was developing three tier multiple choice test based on aspects of scientific literacy in science material. We used Research and Development (R&D) as the research method. The phase of method implementation analysis, design, development, implementation, and evaluation (ADDIE). The results of the study showed that the product of this research was 37 items three tier multiple choice test based on scientific literacy aspect. The product were developed in a reliable and valid category with a reliability value of r11>rtabel is 1,024>0,3061 and each expert give a validity score of 16, 13 and 14. Characteristics of items with difficulty levels mostly in the medium category. The distinguishing features in most categories is accepted. Each item is arranged based on aspects of scientific literacy with a comparison category A: B: C: D: E is 35%: 20%: 20%: 17.5%. Profil of misconceptions of scientific literacy the proportion of about 35,1 % knowledge aspect, 34,8 % about the competence in the investigation, 33 % about the science as a way of thinking, and 31,4 % about the science relations with technology, society, and the environment as a context and attitude to science. The results of developing this question can be used as teacher as an alternative item to identify misconceptions in students' scientific literacy.

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INTRODUCTION

Scientific literacy in the ability to use scientific concepts to apply them in everyday life, explain scientific phenomena and describe these phenomena based on scientific evidence (Yulianti & Rusilowati, 2014). Scientific literacy is an individual need because a country literacy skills are closely related to the economic level of the country (Windyariani, 2017). According to UNEP (2012) in PISA (2015) scientific literacy is important because humans will face major problems at the economic level, and in adjusting to future world changes. Scientific literacy is very important in preparing the skills that must be owned by the 21st century for students from elementary school to college level (Astuti, 2016).

Based on his research, Shofiyah (2015) students have difficulty using sciencetific evidence and making decisions on social science issues. Rusilowati et al. (2016) found that mastery of scientific literacy was still low on aspects of knowledge, competence, science as a way of thinking and application of science. The low level of scienctific literacy is influenced by misconceptions that occur in students. This is caused by the mastery of students conceptual science concepts. The source of errors in understanding concepts can be sourced from: wrong interpretation of students or errors that have occurred in the teacher that will be transmitted to students. Submitting information and understanding the correct concept will produce the right information. If initially the information received by the teacher is wrong then the information received by the student will also be wrong.

Misconceptions can occur because of differences in the development of the knowledge of each individual and his environment for example family, peers, community, teachers and teaching methods. Misconceptions that students have can be overcome by knowing in advance the alternative concepts that students have and where they are obtained. There are several ways to identify or detect such misunderstandings, namely through the presentation of concept maps, clinical interviews, class discussions and lab work.

Another technique that can be used to trace the state of student misconception according to Gurel et al. (2015) is using multiple choice diagnostic test. One of them is three tier multiple choice test. In his research, Cahya & Sanjaya, (2015) three tier multiple choice test has a very high reliability value so that it is effective in detecting student misconceptions.

Three tier multiple choice test diagnostic instrument consist of three parts. The first part of the MCQ (multiple choice question). The second part is the reasoning that refers to multiple choice answers. The third part is a question of students beliefs in answering the previous two sections (Monita & Suharto, 2016). Each part of the three tier multiple choice tes has its own function. The first part serves to diagnose weaknesses in mastery of students concepts based on student answer analysis; the second part serves to help improve understanding of concepts; the third part functions to measure the strengths and weaknesses of students (Abbas, 2016). In addition, valid three tier multiple choice tests are used efficiently with large numbers of samples, and can help researchers understand students reasoning in their answers to distinguish (Kirbulut & Geban, 2014).

Based on the problem above, this research will develop the three tier multiple choice test based on of scientific literacy aspects. The results of interviews with teachers in SMP N 6, SMP N 37, and SMP N 39 Semarang did not have teachers who developed diagnostic tests to explore misconceptions in scientific literacy. This allows students to misconcept the science material that has been taught.

METHODS

This research was conducted in three Semarang state junior high school. The research was conducted in Semarang state junior high school 37, Semarang state junior high school 39, and Semarang state junior high school 6. The

research subjects were 100 students from the three schools.

The method used Research and Development (R&D). The phase of method implementation analysis, design, development, implementation, and evaluation (ADDIE). The five phase are interreliated and structured systematically (Aldoobie, 2015). The research phase includes: (1) analyse students of test results to find out the initial conditions of students and interview students to find out learning difficulties, (2) Design related to three tier multiple choice test based on scientific literacy aspects, (3) Making three tier multiple choice test to explore the misconception of scientific literacy and the test validation measured using validation sheet by the content experts, (4) includes a small scale test on 20 students; large scale test in 30 students; and field tests where the final product was tested on 100 students, (5) in the form of formative feedback evalustion to revise the three tier multiple choice test. In addition, summative evaluation to find out the feasibility of the products used. That is summative evaluation in the form of an assessment of the three tier multiple choice test result that are used to determine the misconception of scientific literacy.

Data analysis included validity, reliability, distinguishing features, level of difficulty, questionnaire analysis, interpretation of three tier multiple choice test result based on scientific literacy aspect. Reliability testing uses alpha formula. Validity testing using the Aiken (1985) method. The interpretation of the result can be seen in Table 1.

Table 1. Interpretation of results of 3TMC

Responses Type						
The answer	Score	Reason	Score	Confidence In answers and reasons	Score	Category
Right	1	Right	1	High	1	Understand
Right	1	Right	1	Low	0	Don't undestand
Right	1	False	0	Low	0	Don't undestand
False	0	Right	0	Low	0	Don't undestand
False	0	False	0	Low	0	Don't undestand
False	0	False	0	High	1	Misconception
False	0	Right	1	High	1	Misconception
Right	1	False	0	High	1	Misconception

RESULTS AND DISCUSSION

Three tier multiple choice test validity based on scince literacy aspects

The final product produced is 37 items. The qustions developed are validated first before being tested. In this reseach used content validity by three expert validators, namely two lecturers and one science teacher to receive suggestions and improve the qustions developed. Criteria for assessing qustions include material, language, and construction which are made into 12 assesment questions. Three tier assessment analysis based on scientific literacy aspects included in very valid criteria means that the qustions can be used to be tested with slight revision. The result of the three tier content validity based on scientific literacy aspects can be seen in Table 2.

Tabel 2. Results of Three Tier Multiple Choice Test validity based on scientific literacy aspects

Statement	Expert 1	Expert 2	Expert 3	Criteria
1	4	3	3	Valid
2	4	3	4	Very valid
3	3	4	3	Valid
4	3	3	3	Valid
5	2	4	3	Valid
6	3	3	3	Valid
7	3	3	4	Valid
8	3	3	3	Valid
9	3	4	4	Very valid
10	4	3	4	Very valid
11	4	3	4	Very valid
12	4	3	4	Very valid

Three tier multiple choice test reliability based on scintific literacy aspects

A test can be said to have high level of trust if the test can provide fixed result (Arikunto, 2007). The reliability three tier multiple choice test was obtained from the results of large scale trial analysis. Calculating of reliability using alpha formula. The calculation result are then compared with r_{tabel}. Test qustions are said to be reliable if the price is $r11>r_{tabel}$. reliability analysis of three tier multiple choice test questions obtained r11 reliability of 1,024. Price r_{tabel} for the number of sample 30 with a significance of 5% adalah 0,3061, so it can be concluded that about the three tier multiple choice test reliability with very high reliability criteria.

Three tier multiple choice test characteristics based on scince literacy aspects

Good qustions must be valid and reliable. In addition, it must have a level of difficulty and a good distinguishing features. Characteristics of items about three tier multiple choice test based on scientific literacy aspects as follows:

Difficulty level analysis is used to determine the items classified as easy, medium, difficult. The number of questions for testing the level of difficulty is 40 qustions. The results of the analysis of the difficulty level are 9 questions classified as easy questions 27 moderate questions, and 4 difficult questions. distinguishing features analysis is used to find out whether the question can distinguish smart and less intelligent students. The qustions developed consist of 40 indicators. Based on the results of the discriminating analysis of the qustions obtained 3 qustions including the category of discarded qustions, 10 received with improvements.

The level of difficulty is mostly in the medium category. A good test is the moderate level of difficulty (Fariyani et al., 2015). Moderate level of difficulty is needed so that students who are not smart are not too difficult in working on the problem. If the questions given in the easy category smart students will be too easy to do the qustions. If the problem in the category is difficult, students who are less intelligent will have difficulty in working on the problem.

The distinguishing features in most categories is accepted. Questions that need improvement before being tested on the final field subject. Questions with good distinguishing features can distinguish smart students and students are not very smart. A good questions item must be able to distinguish students who really master the material with those who don't (Nugraeni et al., 2013).

In addition, each item developed has the theme of scientific literacy aspects consisting of four aspects, namely aspects of science knowledge (A), competence in inquiry (B), science as a way of thinking (C), and the relationship of science to technology,

environment and society (D). Comparison of every aspect of scientific literacy developed with aspects A: B: C: D = 2: 1: 1: 1. In this study the knowledge aspect (A) has a greater number than the other literacy aspects. The characteristics of the problem have a comparison of aspects A: B: C: D: E is 14%: 20%: 20%: 17.5%. This composition is almost in accordance with the characteristics of teaching materials that contain components of scientific literacy in a balanced manner. In addition, the questions are integrated between physical, chemical, and biological matter. So that it is expected to help students to better understand the integration between the concepts of physics, chemistry, and biology.

The final test question after testing was 37 questions. The questions developed consisted of 37 indicators. The sub topics used in the question are the effect of heat, temperature, heat transfer, the form of substances, elements, compounds, mixtures, changes in physics, chemical changes, the scale of the thermometer, photosynthesis, the effects of chemicals.

Profile of Students Misconception of scientific literacy

Three tier multiple choice test diagnostic instruments with revised scientific literacy aspects were used to test misconceptions of scientific literacy in 100 students of Semarang A, B, C state junior high school. The result were analyzed to distinguish students who understood, did not understand and misconceptions. The questions that have been implemented are analyzed by giving scores on the items, then interpreted on what aspects of the misconceptions of scientific literacy experienced by students.

The results of item analysis from each school were used as the basis for conducting interviews with students who experienced misconceptions in scientific literacy. Interviews were conducted to reconfirm the answers given, reasons, and levels of confidence when working on the test.

After analyzing the students' answers, interviews were conducted on 21 students from three schools, namely SMP N A, SMP B, and SMP N C. The purpose of the interview was to find out where the misconception of science literacy was to students, knowing the causes of misconception in scientific literacy. According to Linuwih (2013) that interviews were conducted to clarify students' answers and reveal the background of the occurrence of alternative conceptions. Students are asked to explain the concept that he understands and from where the knowledge is obtained. the interview activities to find out the validity of the question is in accordance with the assessment of validity in the opinion of material experts. Description of the misconception of scientific literacy in each aspects as follows:

Misconceptions of scientific literacy on scientific knowledge aspects (A)

The result showed misconception of scientific literacy in State Junior High School of Semarang students on the aspect of knowledge classified as high compared to other aspects is 35 %. Although science learning in schools places more emphasis on the knowledge aspect, in reality the mastery of the student's concept is still low. There are demands for the completion of teaching materials by teachers according to the curriculum target, forcing students to accept that are nott fully understood. This makes the misconception experienced by students. The learn just memorizing, so that the concept is easily forgotten.

Students responses to science issues tend to be confident or not sure, but student have difficulty answering when asked to give scientific explanation. Based on the results of interviews with students several factors that led to the emergence of misconceptions, one of which is the initial assumption of students in everyday life. Students bring the initial knowledge of various scientific phenomena they get in class (Lestari & Linuwih, 2014).

The misconception finding are classified as high in aspect A of the sub concept of substance classification, students consider salt solutions to be classified as compounds. According to students the compound of salt consists of a combination of two or more elements resulting from the merger which still

has the same properties as the original. The correct concept, salt solution is an ion because it can be ionized perfectly to produce positive and negative ions so that it can conduct electricity.

In addition to the concept of heat transfer, according o students when boiling water the procee of heat transfer that accurs is conduction because the heat energy will flow in the water and will rise up without the displacement of the water particles. The correct concept is the transfer of heat by convection because at the time of boiling water accompanied by displacement of water particles.

Studets also misconception of high scientific literacy in the sub concepts of photosynthesis. Students assume in photosynthesis that chemical reactions occur namely oxygen and water which will be converted into sugar and carbon dioxide with the help of ligh the sun, while respiration occurs inhaling the procces of breathing oxygen and carbon dioxide and removing carbohydrates and water. The correct concept in photosynthesis of chemical reactions tha occur is carbon dioxide and water will be changed into carbohydrates and oxygen with help with sunlight, while respiration occurs in the process of breathing oxygen and starch and removing carbon dioxide and water vapor

Misconceptions of scientific literacy on competence in investigation aspects (B)

The result showed misconception of scientific literacy in State Junior High School of Semarang students on the aspect of competence was higher than aspects A, C dan D is 35,3 %. Students critical thinking ability is still low in relation to the reasoning of fact analysis, investigation and scientific calculations, causing the highest misconception in aspect B. student learning process which is still just memorizing theories and formulas so that it does not emphasize the investigation process. Students should be able to do it directly involved in activities such as class discusions problem solving, or experimenting, not just being a passive object by memorizing concepts and science formulas (Mundilarto, 2013).

Science as knowledge that is systematic or organized regularly, generally accepted, and in the form of a collection of data from observations and experiments (Nofiana & Julianto, 2017). Science is obtained through collecting data with experiments, observations, to produce an explaination of reliable symptoms (Nugraheni *et al.,* 2017). Conducting experiments directly students can observe directly the changes that occur, in the end can find their own concepts to learn, more learning meaningful (Nawawi *et al.,* 2014).

Misconception findings are high in aspects students do not understand formula concepts more. Students cannot distinguish between the concept of calculating melting heat and total heat. In additions, students cannot distinguish subtances that release heat and receive heat in the black principle concept.

Students also experience misconception of high scientific literacy on the concept of density, according to students ice cubes put in water will sink into the water because the density of ice is greater than water. The correct concept is ice cubes float in water because the density of ice is smaller than water.

Misconceptions of scientific literacy on science as a way of thinking aspects (C)

The result showed misconception of scientific literacy in State Junior High School of Semarang students on the aspect aspect C is 32%. Science as a way of thinking using thinking, and reasoning in building science knowledge based on the work of scientists; use deductive reasoning in science; explain causal relationships between facts and science experiments linking scientific advdence; ensure the empirical nature and objectivity of science; explain how scientists experiment (Chiappeta *et al.,* 1991).

Students skills in thinking causal analysis in observing a scientific phenomenon causes the occurrence of misconceptions in scientific literacy aspects C. The process of acquiring knowledge involves less competence in science investigation and critical thinking skills. The accurrence of misconceptions in this aspect is because students rarely carry out laboratory

activities, do not understand the terms in some investigative activities, more time is spent memorizing (Rusilowati *et al.,* 2016). Laboratory activities in science learning should be carried out at the level of education, especially those that must be applied to students at the elementary school level (Windyariani, 2017) .

The finding of misconception is high in aspect C is sub concept of temperature. Students consider when the body is cold because the body temperature is lower than the air temperature. The correct concept is than the body temperature is higher than the air temperature so that the body releases heat into the air. Students also experience high misconceptions on the concept of condensing phenomena, students assume arising water points outside glass is caused by ice condensation stone because the air around the glass receives heat from ice in a glass. The correct concept of air around the glass releases heat into the glass through the glass pores.

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Misconceptions of sciencetific literacy on science relations with technology, society and the environment aspects (D)

The result of the research profile of the misconception of science literacy in State Junior High School of Semarang level on aspect D is 32,2 %. Explain the use of science and technology for society; outlines the negative effects of science and technology on society; explain social issue or problems releated to science or technology; explain work in the science field and technology (Chiappeta *et al*., 1991).

D aspect refers to situations in everyday life that become the land for process applications and understanding of science concepts. In PISA the application of science is categoriezed into 3 groups, namely life and health, earth and environment, and technology (Nofiana & Julianto, 2017).

Learning in State Junior High School of Semarang level in science learning is still done separately, as result the science concept received by students is also separate. This caused difficult in working on science problems. In addition, the tendency of teachers to provide material withouth linking it with real life causes students to have difficulty connecting the knowledge that has been obtained with real life situations. This can be seen from the answers to student answers that are still very theoretical in accordance with the material concepts taught and have not been able to aply the material concepts to solve scientific problems when asked to explain. Science in class should require students to be literate about science and technology (Ariningtyas *et al.,* 2017).

The finding of misconceptions is high in the aspect of the concept of chemical change. Students assume that the wood chimney that is burned will produce. Charcoal is chemical change because the shape of wood before and after is different. The correct concept is the shape and nature of wood before and after different.

In addition, students experience misconception of high scientific literacy on misconception of high scientific literacy on the concepts of temperature and heat. Students assume, heat in the cooler will preserve food because the heat in foods with higher pressure will be absorbed by freon so that the food becomes cold and does quickly stale.

CONCLUSION

The validity of the three tier multiple choice test instrument based on scientific literacy aspects for each item is valid. The test problem is declared reliable because the price of r11> rtable is 1,024> 0,3061. The three tier multiple choice test problem with scientific literacy aspects has the characteristics of items with difficulty levels mostly in the medium category. The distinguish features in most categories is accepted. Each item is arranged based on scientific literacy

aspects with a comparison of aspects A: B: C: D: E is 35%: 20%: 20%: 17.5%. Profil of misconceptions of scientific literacy of about 35 % knowledge aspect, 35,5 % about the competence in the investigation, 32 % about the aspect of science as a way of thinking, and 32,2 % about the science relations with technology, society, and the environment as a context and attitude to science. Based on interviews students can provide an overview of the suitability of the results of tests that have validity obtained based on the validation of content experts.

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