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ANALYSIS OF MISCONCEPTION TO SCIENCE LITERACY USING THREE-TIER MULTIPLE CHOICE TEST IN THE MATERIALS OF CHARACTERISTIC OF LIGHT

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Abstract

Mastery of science literacy is the main focus of education. A factor influencing low science literacy of Indonesian students is misconception. Recently, research of diagnostic scientific literacy aspects development regarding misconception of science literacy is very limited. Actually, there should be a correction to the learning system. Initial observation of Science class in SMP Negeri 05 Semarang showed that students had difficulty in understanding the materials of light. The evaluation tool used by teacher was not used to show the misconception of science literacy. In this case, this research was done to develop three-tier multiple choice (3TMC) scientific literacy aspects with science literacy aspect to unveil students' misconception of science literacy in the materials of characteristics of lights. The samples of this research were VIIIE and VIIIF using mix method with sequential explanatory strategy. The result showed that the instruments of 3TMC scientific literacy aspects with the aspect of science literacy produced 30 scientific literacy aspects items with 25 items which fulfill the criteria of valid, reliable, enough distraction level, and tolerable difficulty level. Meanwhile, the other 5 items did not fulfill the criteria. The result of interpretation showed that commonly, students had misconception of science literacy terms of understanding (A), competence of science investigation (B), science as the way of thinking (C), and the application of science to technology, society, and environment. Deep interview was done to 7 students who had highest score of misconception of science literacy. They got the misconception to the indicators of characteristics of light, process of vision, eye defects, and optical devices.

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INTRODUCTION

Science and technology is developing very quickly in 21st century. It raises the competition of every nation to show their quality and consistency through the development of science and technology (Ma'muroh, 2014). In details, it can be seen through the development of quality human resources to compete and face global challenges through the improvement of education (Rusilowati, 2013). Low science understanding can be identified through low students' science literacy (Rusilowati *et al.,* 2016).

International education currently focuses on the mastery of scientific literacy as the main goal of EFA (Education for All) by UNESCO (Udompong & Wongwanich, 2014). Students, as the citizen of the country and the important consumers, need to improve their scientific literacy in responding scientific issues as well as making decision responsibly (Alchin, 2014). Scientific literacy is an ability to combine issues and ideas related to science, relation between science and technology, competence to explain scientific phenomena, evaluating and designing scientific investigation, and interpreting data and scientific evidences as to become a reflective citizen (OECD, 2016).

Scientific literacy of Indonesian students has been in low position since 2000. It also happened in 2015 where the country was placed 62nd from 70 countries (OECD, 2016). In line to the research conducted by Rusilowati *et al.* (2016), scientific literacy of junior high school students in Kudus is low with overall aspects percentage below 50%. Moreover, the difficulty of learning science, especially in some physics material will lead to students' misunderstanding and misconception (Sari *et al.,* 2013).

Students have initial concept of daily experiences and knowledge which they bring to class (Franke *et al.,* 2013). Those initial conceptions which do not in line to theory made by scientists are called misconception (Clement *et al.,* 1989). Misconception is a big problem of science subject which needs serious handling. Since, it stays on students' mind if there is no any clarifying evidences of concepts (Taufiq, 2012).

The identification of misconception can be done by diagnostic test (Fariyani *et al.,* 2015). Initial observation and interviews in some school in Semarang showed that the schools' tests were in multiple choices or essay. The tests have never been done to identify misconception. Recently, teachers did not know the cause of students' low score, whether it came from misunderstanding or misconception.

The interview to teachers in SMP Negeri (State Junior High School) 05 Semarang showed that there is a difficulty to the materials of light. Only 53% students who passed the passing grade of daily exam, where the other 47% did not. The initial data showed that there were misconceptions to light materials done by IX grade students of SMP N 05 Semarang after the essay test. The evaluative learning tests used in school has not coped the overall ability of scientific literacy. It only measured the level of ability. Based on the problems above, the researcher conducted a research to analyze the misconception of scientific literacy using three-tier multiple choice (3TMC) test to materials of light. This instrument was added with the third level of asking students' confidence in answering and reasoning to questions; thereby, teacher can identify whether the students understand, misconcept, or only guessing (Gurel *et al.,* 2015).

This research aimed to

(1) Develop diagnostic instrument of 3TMC test with scientific literacy aspects to analyse the misconception of scientific literacy.
(2) Discover students' misconception of scientific literacy.

METHODS

This research was done to VIII grade students in SMP N 05 Semarang which consisted of 8 class. Randomly, the researcher chose VIII E and VIII F class as the samples of the research which consisted of 61 students. This research used sequential explanatory mix method strategy. The strategy was applied in order to collect and analyze the first stage of quantitative data, followed by the collection and analysis for second stage of qualitative data which was built based on the first quantitative result (Creswell, 2014).

Stage I (Collection of Quantitative Data)

The documentation of daily exam in light materials done by VIII grage students in the academic year of 2015/2016; the final exam test

items for VIII grade students in second semester (the items about light which is difficult for students to understand); data of scientific literacy by PISA in 2015; the creation of essay test items and tested to IX grade students in academic year of 2016/ 2017 to obtain the data of misconceptions' possibility to students; and the creation of 3TMC test class with scientific literacy aspects.

The next step was content validation by experts (expert lecturer and two natural science teachers); try out of 3TMC test items with scientific literacy aspects; analysis of reliability, item discrimination, and the difficulty level of the item; the revision of the content of 3TMC test with scientific literacy aspects; step of fields trial to the samples; and analysis of fields trials (data of misconception of scientific literacy in each test item and each student). The evaluative questionnaires were given to samples of try out to know how students' evaluation is condering the construction and time allocation of doing the test. Meanwhile, fields trial was given as questionnaires of responses to know the responses to the construction and substance of 3TMC test with scientific literacy aspects.

Stage II (Collecting Qualitative Data)

Deep interview was done to some samples which were seven students with the most misconception. The recording of the interview was done to know the form fo students' misconception of scientific literacy in light material.

RESULTS AND DISCUSSION

(1) Product from the Development of 3TMC Test with Scientific Literacy Aspects

In this research, the development of diagnostic instrument of 3TMC test with scientific literacy aspects is used to unveil and discover the students' misconception of scientific literacy. The development of this test consisted of (1) the overview of the items, (2) the test items of 3TMC scientific literacy aspects, (3) answer keys, (4) answer sheet, (5) scoring guidance, and (6) the guidance of interpretation of misconception of scientific literacy. The result of the instrument had these following characteristics.

(1) Each test item was developed with four aspects of scientific literacy: scientific knowledge (A), competence of scientific investigation (B), science as the way of thinking (C), and the relation of science with technology, environment, and society (D). The comparison of each test item was made according to Wilkinson (1999) using aspect ratio of A: B: C: D = 2: 1: 1: 1. In this research, the aspect of scientific knowledge had the most appearance.

(2) Each test item was developed in three level. The first level is multiple choices themed scientific literacy with a key answer and three distractors. The second level is students' reasons in answering the questions with three choices of reason and one open reason. The third level is students' confidence in choosing the answer and reason in 6 scales (1= guessing, 2= very unsure, 3= unsure, 4= fairly unsure, 5= sure, and 6= very sure).

(3) The test of 3TMC scientific literacy aspects had 25 test items in which 6 items were from light subchapter and 9 were from indicators of learning process. The subchapter of lights consisted of characteristics of lights, mirror, lens, parts of eyes and their functions, eye defects, and optical devices.

(4) The guidance of scoring in 3TMC scientific literacy aspects consisted of scoring answer, choices of reason, and categories of confidence. The scoring of answers was with the terms of 1= correct answer and 0= wrong answer. The scoring terms were also applied for the reasoning. For the category of students' confidence, it was divided into low category (scale 1-3), and high scale (scale 4-6).

(5) The results of the students' test were analyzed and interpreted to know the profile of students' misconception of scientific literacy.
The interpretation of misconception of scientific literacy can be seen in Table 1.

There were 30 items of 3TMC with scientific literacy aspects. In this research, the testing of 3TMC with scientific literacy aspects was validated by three validators to accept the suggestion for the correction of the instruments. The result of the instrument's analysis was the instrument was very good. It means that the test can be used for trials. The scoring of validator can be used for the revision of instrument form the readings, sentences of the items, choices of answers, and choice of reasons.

The 3TMC with scientific literacy aspects was tested to 30 respondents which had got received the materials of lights. The results of the trial test were then analyzed on its reliability,

difficulty, and item discrimination. The results of the analysis showed that the items of 3TMC with scientific literacy aspects was reliable with the score of 0.773 or had high reliability.

Table 1. The Guidance to Interpret Misconception of Scientific Literacy

Response Types						Categories
Answers	Score	Reasons	Score	Confidence	Score	
Correct	1	Correct	1	High	1	P
Correct	1	Correct	1	Low	0	TP
Correct	1	Wrong	0	Low	0	TP
Wrong	0	Correct	0	Low	0	TP
Wrong	0	Wrong	0	Low	0	TP
Wrong	0	Wrong	0	High	1	M
Wrong	0	Correct	1	High	1	M
Correct	1	Wrong	0	High	1	M

Note: P= Understand, TP= Not Understand, M= Misconception

If the instrument was given to the same subject in different time, it will give the same result (Arikunto, 2012). Reliability stated how far is a result of measurement can be trusted (Matondang, 2009). It means that 3TMC with scientific literacy aspects had a consistence in unveiling students' misconception of scientific literacy in lights subchapter.

Table 2. Categories of Item Difficulty Level

Level	Number	Total
Easy	2, 7, 11, 14, 20, 24, 27, 30 1, 3, 4, 5, 6, 8, 9, 10, 12, 13, 15,	8
Medium	18, 19, 22, 23, 25, 26, 28	18
Difficult	16, 17, 21, 29	4

The analysis of test difficulty showed that the difficulty level of the tests included 27% easy items, 60% medium items, and 13% difficult items. Most of the items were in medium criterion. A good criterion of diagnostic test was not really easy or difficult (Arikunto, 2012; Fariyani *et al.,* 2015). An easy test cannot stimulate the students to try harder while difficult items make students surrender to do the test (Arikunto, 2012).

Table 3. Category of Item Discrimination in the Test

Discriminator	Number	Total
Good	1, 2, 5, 6, 10, 11, 13, 14, 22, 24, 27, 28, 30	13
Fair	3, 4, 7, 8, 9, 15, 18, 19, 20, 23, 25, 26	12
Bad	12, 16, 17, 21, 29	5

The test with fair and good items where the items can unveil which students master the item or not (Arikunto, 2012). The analysis showed that from 30 items, there were four items with bad items discriminators. This kind of item should not be used in the trial.

The analysis of content, reliability, difficulty, and discrimination in 3TMC with scientific literacy aspects were used to determine which items which can be used for trial. The items used to analyze students' misconception of scientific literacy were valid, reliable, had fair or good distractors, and medium or easy item difficulty. The diagnostic test of Udompong & Wongwanich (2014) was good in terms of reliability, item difficulty, item discrimination, and validity.

The result was 25 items can be used for trial from 30 items. The aspect of science knowledge had 10 items. Meanwhile, 5 items were used to way of thinking, competence of scientific investigation, and scientific application with technology, society, and environment. A revision was done to 25 items based on the construction or content. The score from students' questionnaire were mostly good and very good. It means that the 3TMC with scientific literacy aspects can be used without further revision.

(2) MISCONCEPTION OF SCIENTIFIC LITERACY

a) Interpretasi misconception of scientific literacy

3TMC with scientific literacy had been revised to check the misconception of scientific literacy for 61 students. The test was given to the samples in the end of light subchapter. The result was analyzed to distinct the students who understand, do not understand, or misconception. The table of misconception of scientific literacy of each student can be seen in

Table 4 as follows.

Table 4. The Analysis of Misconception of Scientific Literacy

Code PD	Total Misconception of scientific literacy A	B	C	D	M	P	TP
B1	2	1	2	2	7	7	11
B2	4	0	0	0	4	6	15
B3	7	2	2	2	13	8	4
B4	4	2	3	1	10	15	0
B5	4	2	2	3	11	6	8
B6	1	0	0	0	1	3	21
B7	8	2	1	1	12	6	7
B8	5	2	4	0	11	13	1
B9	2	0	3	0	5	9	11
B10	3	1	2	0	6	14	5
B11	1	4	1	2	8	14	3
B12	3	2	3	2	10	10	5
B13	5	2	2	1	10	11	4
B14	3	2	0	1	6	10	9
B15	7	2	3	3	15	10	0
B16	7	2	1	2	12	7	6
B17	7	0	4	4	15	3	7
B18	2	2	2	1	7	11	7
B19	2	3	2	1	8	17	0
B20	1	2	1	1	5	7	13
B21	4	1	1	1	7	8	10
B22	6	3	3	1	13	7	5
B23	3	0	0	1	4	15	6
B24	3	0	1	1	5	7	13
B25	4	2	1	1	8	4	13
B26	6	2	2	1	11	9	5
B27	9	3	2	2	16	7	2
B28	1	1	1	1	4	14	7
B29	1	0	2	1	4	4	17
B30	3	1	0	1	5	6	14
B31	2	3	1	2	8	13	4

Code PD	Total Misconception of Scientific literacy A	B	C	D	M	P	TP
C1	7	4	3	3	17	8	0
C2	0	1	1	0	2	7	16
C3	5	1	4	0	10	4	11
C4	3	2	2	2	9	12	4
C5	7	2	4	5	18	2	5
C6	4	0	1	0	5	4	16
C7	7	2	2	2	13	10	2
C8	7	3	3	2	15	7	3
C9	3	2	2	1	8	7	10
C10	4	0	0	1	5	10	10
C11	2	0	1	0	3	9	13
C12	5	1	1	1	8	4	13
C13	1	1	1	1	4	4	17
C14	2	1	0	0	3	8	14
C15	2	0	0	0	2	9	14
C16	2	0	0	0	2	4	19
C17	3	2	2	2	9	7	9
C18	2	1	1	0	4	11	10
C19	2	0	1	0	3	6	16
C20	2	1	1	0	4	12	9
C21	5	2	0	2	9	7	9
C22	4	3	3	4	14	8	3
C23	0	0	1	0	1	1	23
C24	5	4	2	1	12	9	4
C25	5	2	2	2	11	10	4
C26	6	3	5	3	17	8	0
C27	3	2	1	4	10	5	10
C28	3	4	2	2	11	10	4
C29	2	1	2	0	5	3	17
C30	4	1	2	2	9	9	7

Note: M= Misconception, P= Understand, TP= Not Understand

Table 4 showed that the students with misconception happened to all scientific literacy aspects. The misconception of scientific literacy in term of scientific knowledge (A) was caused by it deemed as the part of science (Chiappetta *et al.,* 1991; Boujaoude, 2002; Dani, 2009; Budiningsih *et al.,* 2015; Rusilowati *et al.,* 2016). Thus, teachers should complete the learning materials with basic knowledge of science.

Misconception of scientific literacy happened to scientific investigation (B) and science as the way of thinking (C). Teacher should include the skills of scientific investigation in the learning process to make the students develop their scientific skills and way of thinking (Maturradiyah & Rusilowati, 2015). A scientific investigation will grow the critical thinking ability of students. If their competence to investigate is low, the critical thinking ability is also slow.

Science in school mostly emphasize the students in cognitive sense, instead of the development of critical thinking. It means that the transfer of knowledge had less competence in investigation and critical thinking for students. Students' science processing skills can also be grown by practicum and presentation (Hindarto, 2009). The laboratory activity can develop students' scientific literacy in terms of processing skills (Permatasari *et al.,* 2014). It is important to teach science in balance in terms of abstract conceptualization and active experimentation (Rusilowati, 2014).

Misconception in aspect B and C happened because the students (1) rarely do laboratory activities; (2) do not understand some scientific investigation terms, like dependent and independent variables; (3) have more time to memorize than learning (Rusilowati *et al.,* 2016). Learning science should emphasize on the activity and active learning to students, emphasizing the processing skills and concept formulation, lessening memorization, and involving many activities on the laboratory or the fields (Leonard, 1993 in Maturradiyah & Rusilowati, 2015). Habituating students to analyze items with scientific literacy, discussion, analyzing scientific evidence, evaluating data, and making conclusion to improve students' critical thinking skills (Permatasari *et al.,* 2014; Odja & Payu, 2014).

Misconception of scientific literacy also happened to application of science or relation of science, technology, society, and environment (D). Students did not understand the relation of science application to technology, society, and environment based on the right moral and behavior. Udompong & Wongwanich (2014) states that students had misconception of scientific literacy in terms of context, which in PISA 2009 was included as the application of science and related to SETS. Science application (D) is included as a multidimensional ability to utilize different concept and ability to relate concept and daily life, understand that science, social, and technology is related and influence one to another (Odja & Payu, 2014).

Students' responses to 3TMC with scientific literacy aspects were very good and good, meaning that the instrument can be used to analyze the misconception of scientific literacy.

b) Misconception of scientific literacy in subchapter of light

The misconception of scientific literacy in each test item was divided as high, medium, and low (Fariyani *et al.,* 2015). The category of misconception of scientific literacy can be seen as:

Low Misconception: $0\% \leq M < 30\%$
Medium Misconception: $30\% \leq M < 60\%$
High Misconception: $60\% \leq M \leq 100\%$

The result was seven students had the highest misconception who were B15, B17, B27, C1, C5, and C8. Those students had deep interview to know their misconception to the material. The interview showed that the students had misconception of scientific literacy in terms of (a) reflection of light in plain surface; (b) reflection light on rough surface had reflection ray ≠ incident ray; (c) the helping line or normal line always face up, not intersecting the the reflected surface; (d) block of iron in a pond seem closer due to refraction; (e) light which passes two medium must be deflected; (f) refraction happened if the light is intersecting the surface; (g) the more closer a medium, the speed of light will be faster; (h) air is a medium with highest density; (i) students' perception in considering light's dispersion; and (j) light has dispersing activity, like in lamp, flashlight, and sunlight.

Reflection of light was the most occurred misconception which was the same to Fariyani *et al. (*2015) and Aydin (2012). Caleon & Subramaniam (2010) prove that the characteristics of refraction is the indicator of misconception.

Students' misconception of scientific literacy also happened when the light comes through eyes and reflected to thing; the color is owned by the thing instead of reflected by the light. It is in line with the research of Djanette & Fouad (2014) which state that color is owned by thing and eyes give color to it.

Another misconception of scientific literacy is about eye defects regarding students' understanding on myopia (near-sightedness / the sight in front of retina) and hypermetropia (far-sightedness / the sight before retina). It is the same with Fariyani *et al.* (2015) who states that shadow in front of retina is the sign of hypermetropi yang menyatakan bahwa bayangan akan jatuh di depan retina pada penderita cacat mata hipermetropia.

The misconception of scientific literacy to optical device of lens were to biconcave lens and the function of loop to see miscroscopic substance. Meanwhile, the misconception of scientific literacy in terms of function of eyes and part of them is diaphragm is the part of eyes; pupil is smaller in a minimum light condition; diaphragm and pupil have the same function; insects have a couple of eyes; eye lens is thickened by the relaxation of cyliaric muscle in maximum accommodation power; eye lens is thinning due to the contraction of cyliaric muscle in minimum accomodation; contact lens is the substitute of chornea; chornea has color pigment.

CONCLUSION

The development of diagnostic 3TMC with scientific literacy aspects focuses on 25 items with the ratio of 2: 1: 1: 1. Every item consists of

three level. The first level is a question with four answer choices. The second one is three choices of reasons and one open reason. Meanwhile, the third level is the level of confidence with the scale of 1= guessing, 2= very unsure, 3= unsure, 4= fairly unsure, 5= sure, and 6= very sure. The analysis and validation of items showed that 3TMC with scientific literacy aspects were valid, reliable, had good level of difficulty with averagely in medium, and had good distractors.

The interpretation of misconception showed that students had misconception of scientific literacy in terms of scientific knowledge (A), competence of scientific investigation (B), science as the way of thinking (C), and the relation of science with technology, environment, and society (D). The interview to 7 students with highest misconception showed that the misconception happened to the materials of charactersitics of light, process of vision, eye defects, and types and function of optical devices.

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