Measuring metacognitive ability based on science literacy in dynamic electricity topic

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Measuring metacognitive ability based on science literacy in dynamic electricity topic

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Abstract. This study aims to produce an instrument of metacognition ability assessment based on science literacy on theoretically and empirically feasible dynamic electrical material. The feasibility of the assessment instrument includes theoretical validity on material, construction, and language aspects, as well as empirical validity, reliability, difficulty, distinguishing, and distractor indices. The development of assessment instruments refers to the Dick and Carey development model which includes the preliminary study stage, initial product development, validation and revision, and piloting. The instrument was tested to 32 students of class IX in SMP Negeri 20 Bandar Lampung, using the design of One Group Pretest-Postest Design. The result shows that the metacognition ability assessment instrument based on science literacy is feasible theoretically with theoretical validity percentage of 95.44% and empirical validity of 43.75% for the high category, 43.75% for the medium category, and 12.50 % for low category questions; Reliability of assessment instruments of 0.83 high categories; Difficulty level of difficult item is about 31.25% and medium category is equal to 68.75%. Item that has very good distinguishing power is 12.50%, 62.50% for good stage, and medium category is 25.00%; As well as the duplexing function on a matter of multiple choice is 80.00% including good category and 20.00% for medium category.

1. Introduction

The learning process that requires students to engage directly or actively participate can be applied in learning on science materials. Students are not only required to understand the concept of science, but also can apply the concepts in daily life so that the learning becomes more meaningful. Meaningfulness in science learning for students can be obtained if students have good science literacy skills [1].

Literacy of science is one's ability to solve problems by using science knowledge [2]. Literacy of science is very important to be developed because everyone needs information and knowledge to make choices and to solve problems faced every day [3]. Based on PISA 2015 results, students' literacy skills in Indonesia are still low. The literacy skills of Indonesian students are ranked 62nd out of 69 countries that follow PISA [4]. The low average science literacy of Indonesian students in PISA 2015 can be one of the illustrations that science learning conducted in Indonesia still needs improvement, so it is expected that the average science literacy of Indonesian students will be better.

Science is a human activity characterized by a thought process that occurs in the mind of anyone involved in it [5]. Tawil and Liliasari [6] states that in general thinking is a cognitive process, a mental

activity to gain knowledge. Thinking is produced from metacognition that is possessed by every human being [7]. Metacognition plays an important role in the learning process because metacognition is crucial in regulating and controlling the cognitive processes of a person in learning and thinking, so that the learning and thinking done by a person becomes more effective and efficient [8]. It may be stated that metacognition is a person's awareness of the monitoring process as well as maintaining and controlling his own thoughts and actions. Thus, metacognition is necessary for the thinking activity.

Metacognition skills need to be developed, so that students are trained to always design the best strategy in choosing, remembering, re-recognizing, organizing the information it faces, and in solving problems [9]. The importance of metacognition to be developed in learning because metacognition is a fundamental factor in learning and problem solving that can ultimately create a conducive learning experience [10], through the development of metacognition awareness, students are expected to always monitor, control and evaluate what he has done [11], besides, Rahman and Philips [12] proves that metacognition awareness has a significant relationship with academic achievement.

The development of metacognition capabilities in the learning process will only be effective if the teacher has a good and continuous monitoring mechanism. This may only be possible through an assessment process capable of providing meaningful feedback loops during the learning process [13]. Thus, the assessment process needs to be integrated throughout the learning process. At the time of metacognition assessment process required metacognition assessment instrument.

There have been many studies that examine the instrument assessment of metacognition ability. The instrument of metacognition ability first developed by Schraw and Dennison [11] is MAI (Metacognitive Awareness Inventory), the instrument is a questionnaire to measure adult metacognition. The MAI instruments were used further by researchers for various purposes [14, 15, 16, 17]. In fact, [8] of the MAI instrument was developed into an instrument of Jr MAI (Junior Metacognitive Awareness Inventory) for students in primary education, especially grades 3-9.

Regarding the above description, a research on the development of metacognition ability assessment instruments based on science literacy on dynamic electrical materials was conducted. This research aims to produce metacognition ability assessment instruments based on science literacy on dynamic theoretical material that is valid theoretically and empirically, and describe the validity of theoretical and empirical assessment instruments. The benefits of this research are to contribute to the teacher as one alternative assessment instrument that can be used as a tool for collecting data and tools to obtain information about students' metacognition ability; to help students know their metacognition ability; and to be a reference for other researchers to conduct a research on the development of metacognition ability assessment instruments.

2. Methods

This study used the research method adopted from Dick and Carey [18]. The research and development activities undertaken were assessing the needs to analyze objectives, perform learning analyzes, analyze the characteristics of learners and the context, formulate specific objectives of learning, develop assessment instruments, design and implement formative evaluations. The instrument was tested on 32 students of class IX in SMP Negeri 20 Bandar Lampung, using One Group Pretest-Postest Design. The sample was chosen through purposive sampling. Data collection used validation sheet, metacognition ability test, and student response questionnaire. Theoretical validity is obtained from 3 validators. The data of theoretical validity results were calculated by using the equation (1):

$$\%\, Ji = \sum_{i=0}^{n} \frac{\mathrm{Ji}}{\mathrm{N}} \ \mathrm{X}\ 100\% \qquad (1)$$

Information:
% *Ji* = percentage of achievement of the ideal score for each of the *i* aspects.
ΣJ = Percentage of achievement of the ideal score for each of the *i*-th aspects provided validator.
N = maximum score (ideal score).

Empirical validity was analyzed by calculating the validity of the item and the reliability of the item. The validity of the item was calculated by Product Moment Pearson correlation formula by correlating between the scores obtained by the students on an item with the total score obtained. The equation (2) used:

$$r_{xy} = \frac{N\sum XY - (\sum X)(\sum Y)}{\sqrt{(N\sum X^2 - (\sum X)^2.(N\sum Y^2) - (\sum Y)^2}} \quad (2)$$

Information:
r_{xy} = correlation coefficient between variable X and variable Y
N = many test takers
X = value of variable X
Y = value of variable Y

The reliability of the item was calculated using the Alpha Cronbach formula. The equation (3) used:

$$r_{1i} = \left[\frac{n}{n-1}\right]\left[1 - \frac{S_i^2}{S_t^2}\right] \quad (3)$$

Information:
r_{1i} = instrument reliability coefficient
n = number of items.
S_i^2 = the number of variance scores per item.
S_t^2 = total score variance.

The degree of difficulty, distinguishing factor, and distractor index of the items were analyzed by the ITEMAN formula.

3. Results and Discussion

The development of metacognition skills assessment instruments based on science literacy on dynamic electrical materials applied Dick and Carey development model with the data collection instrument were in the form of validation sheet, metacognition ability test, and student response questionnaire. This study produced primary and secondary data. The primary data were assessment instrument development process, theoretical validity, empirical validity, reliability, difficulty level, distinguishing factor, and distractor index. The secondary data were in the form of student responses to instrumental assessment of metacognition ability developed.

Primary data were obtained from the result of instrument development in the form of metacognition ability assessment instrument, theoretical validity data obtained from the validation sheet of expert, empirical validity data obtained from the students' metacognition ability test which then were calculated the validity, reliability, difficulty level, distinguishing factor, and instrument distractor index developed. Secondary data in the form of student response were obtained from questionnaire of student response to metacognition ability assessment instrument developed. The theoretical validation results of the assessment instruments are presented in Table 1.

Table 1. Expert rating results

Validation	Aspect	Validator I, II, III	%	Category
Content / material	Compatibility of content/material with KI-KD	Average	91.11	Very valid
Construction/ Instruments	Construction in accordance with indicators of metacognition and science literacy	Average	95.83	Very valid
Language/ Legibility	The language is in conformity with Indonesian grammar	Average	99.38	Very valid

Based on the data in Table 1, the theoretical validity for the assessment instrument was 95.44% which belongs to a very valid category. Then the metacognition ability data of assessment instrument was tested. Based on the results of the experiment the obtained empirical validity were presented in Table 2.

Table 2. Percentage of category of validity item problem.

Number	The average moment person correlation coefficient	Category Validity	Number of Problems	%
1.	0.70	High	7	43.75
2.	0.46	High enough	7	43.75
3.	0.37	Low	2	12.50
		Amount	16	100,00

Based on the data in Table 2, there is an equation of the number of questions that has high category validity with high enough and has the same percentage, there is a high degree of category validity level and high enough level of 0.24. The figure is obtained from the average high coefficient correlation moment person of high category.

Table 2 shows that most of the questions are of high validity and are quite high category. That is, the developed problem can be used to measure students' metacognition and literacy skills. Based on the measurement results, the highest average score of students' metacognition ability is found in the declarative knowledge component and the lowest score is in the conditional knowledge, moreover, the average score of the highest science literacy ability is at nominal level, while the lowest is at the multidimensional level.

The empirical validity of most of the high and high categories in some of the assessment instruments was caused by the manufacturing process that has met the theory of problem-building steps and is based on basic competence indicators, metacognition indicators, and science literacy indicators adapted to dynamic electrical material concepts, it is also supported by the use of language that is easily understood by students. In line with [20], in order that the instrument has a high validity, then in making the instrument must be based on basic competence indicators and indicators of student competence to be achieved. Most developed instruments have high and high empirical validity, meaning that the developed instruments can be used to measure students' metacognition and literacy capabilities validity.

Based on the measurement result, the highest metacognition ability of students is found in the component of declarative knowledge and the lowest value is in the component of conditional knowledge. The high value of declarative knowledge of students is caused by the effect of learning, so that students have already known and understood about the facts (phenomena) associated with electricity. This is in accordance with the opinion of [21] who states that in the learning process, students experience a change in behaviour in the form of newly acquired knowledge, understanding, skills, and habits.

The lowest metacognition of students is in conditional knowledge. The lack of conditional knowledge of students because the students cannot provide the right reasons to apply the knowledge and skills possessed. Here is an example of students, answer in providing unappropriated reasons in applying the knowledge they have.

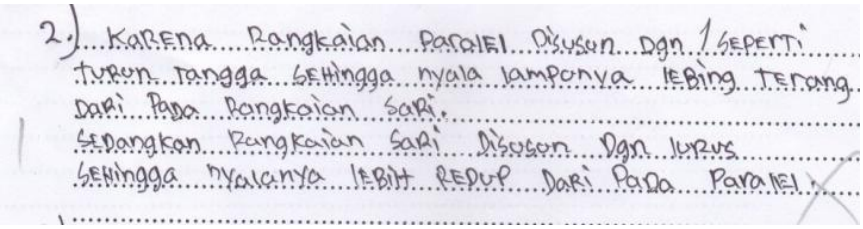
2.) Karena Rangkaian Paralel Disusun Dgn 1 seperti turun tangga sehingga nyala lampunya lebih terang dari pada Rangkaian Seri.
Sedangkan Rangkaian Seri Disusun Dgn lurus sehingga nyalanya lebih redup dari pada Paralel.

Figure 1. An example of students answer.

Based on the results of the measurements the average literacy ability of the highest student science was at the nominal level (level 1). Similarly, the results of the study of [22] on the analysis of students 'science literacy skills on the concept of IPA, it turns out that students' science literacy skills are mostly at the first level of the nominal. At this level, students have only vocabulary, concepts, context, and cognitive ability to identify questions scientifically. This is in accordance with the results of PISA 2015 which states that the average literacy skill of Indonesian students is at level 1.

The lowest level of students' literacy ability is at a multidimensional level (level 4). The results of the study [23] produce the same thing, it turns out the ability of science literacy students at multidimensional level was included in the low category. The cause of the low level of multidimensionality is that students have not been able to combine a broader understanding of science beyond the subject concept and scientific inquiry procedures. In line with [3], which states that only a small proportion of students answer multidimensionality, students have difficulty in integrating material in a global context. In addition, students also have difficulty in applying science in everyday life.

Based on the data in Table 2, there are 12.50% of questions that have low category validity. This low validity can be influenced by factors from the problem itself, that is the problem including difficult categories so that students cannot answer the question. [24] has similar opinion which states that some factors that affect the low validity of the item are the factors of the problem itself, among others, too easy, so the answers can be predicted by the students, the allocation of time is too short to do the problem, has a bad distinguishing power, and the degree of difficulty of the problem does not match with the material already taught.

Reliability is the level of consistency of the developed instrument. Based on the calculation result, the reliability assessment instrument metacognition ability of 0.83 are included in the high category. The degree of reliability of the high category instruments, indicates that the students were consistent in providing a relatively high response [25]. This means that the developed instrument has a high degree of consistency to measure students' metacognition ability. In line with the opinion of [26] which states that the instrument is said to be reliable, if it is used to measure the same object/subject by the same or different people will produce relatively similar data.

The high reliability of the instrument is influenced by the student's response to the language aspect and guidance on the problem. According to most students, telling the language and instructions on how to work on the assessment instrument is clear and easy to understand, so that students can correctly answer the questions on the instrument.

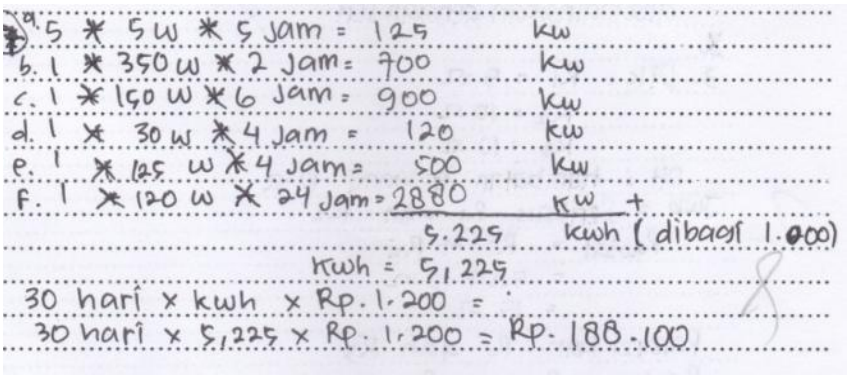

Figure 2. An example of students answer on the problem of electrical problems in a household.

Based on the description of student answers, it indicates that students easily understand the language in the problem, so students can determine the steps that must be done to solve the problem correctly. This is what causes students to answer the problem correctly. The difficulty level of the item is the proportion of test participants who answered correctly [27]. Description of the degree of difficulty and distinguishing factor of the item can be seen in Table 3.

Table 3. Percentage of different levels and distinguishing power.

Number	Category of Tribunal	%	Distinct Power Category	%
1.	Difficult	31.25	Very good	12.50
2.	Medium	68.75	Good	62.50
3.	Easy	0.00	Enough good	25.00
4.			Ugly	0.00
	Amount	100.00	Amount	100.00

Table 3 shows that the difficulty level of the items developed was mostly in the medium category and a few difficult categories. This means that most students can answer correctly. The problem-solving power of the item is the ability of a matter to distinguish between high-ability students and low-ability students [13]. The differentiating grains of questions that developed most of the categories are good and few are very good and good enough category (Table 3). This means that the items developed can be used well to distinguish the students who can answer correctly the items tested with students who cannot answer correctly.

In the multiple-choice items, there is an alternative answer that functions as a liar. Based on the results of functionality analysis of 80.00% good category and 20.00% category good enough. This indicates that the choice of answers works well, so it can outwit the students who do not understand the concept of choosing an answer. Similarly, the opinion of [13] who says that a deception can be said to work well if the deceiver has a great appeal for test followers who lack understanding of the concept or lack of control of the material.

4. Conclusion

The metacognition ability assessment instrument is considered feasible theoretically with theoretical validity percentage of 95.44% and the empirical validity of 43.75% for the high category, 43.75% for the medium category, and 12.50% for low category question; Reliability of assessment instruments of 0.83 high categories; Difficulty level of difficult question item is about 31.25% and medium category is equal to 68.75%; Items that has very good distinguishing power is 12.50%, 62.50% for good, and medium category is 25.00%; As well as the duplexing function on the multiple choice 80.00% including good category and 20.00% for medium category

References

[1] Arlianovita D, Rachmadiarti F and Setiawan B 2016 *Jurnal Mahasiswa Teknologi Pendidikan* **4** 3 pp 1-7
[2] Imaningtyas C D, Karyanto P, Nurmiyati N and Asriani L 2016 *Jurnal BIOEDUKASI* **9** 1 pp 4-10
[3] Soobard R and Rannikmae M 2011 *Science Education International* **22** 2 pp 133-44
[4] OECD 2016 PISA Results in focus. [Online] Tersedia http://www.oecd.org/pisa/keyfindings/pisa-2015-results-overview.pdf
[5] Maryuningsih Y 2013 *Jurnal Scientiaeducatia* **2** 1 pp 1-19
[6] Tawil M and Liliasari 2013 *Berpikir Kompleks dan Implementasinya dalam Pembelajaran IPA* (Makasar, Badan Penerbit UNM) p 4
[7] Nurmahanani I 2015 *Jurnal Metodik Didaktik* **10** 1 pp 57-68
[8] Muhali 2013 *Jurnal Kependidikan Kimia "Hydrogen"* **1** 1 pp 1-7
[9] Haryani S 2015 Pengembangan model pratikum kimia analitik instrumen berbasis masalah untuk meningkatkan metakognisi mahasiswa calon guru *Disertasi* Universitas Pendidikan Indonesia pp 3-4
[10] Urena S S, Cooper M M, and Stevens R H 2011 *International Journal of Science Education* **33** 3 pp 323-40
[11] Schraw G and Dennison R S 1994 *Contemporary educational psychology* **19** 4 pp 460-75
[12] Rahman S and Philips J A 2006 *Jurnal Pendidikan* **31** 2 pp 21-39
[13] Arikunto S 2016 *Dasar-Dasar Evaluasi Pendidikan* (Jakarta, Bumi Aksara) p 281
[14] Gassner L 2009 Developing metacognitive awareness -a modified model of a PBL-tutorial *Thesis* Malmo University p 7

[15] Young A and Fry J 2008 *Journal of the Scholarship of Teaching and Learning* **8** 2 pp 1-10
[16] Balcikanli C 2011 *Electronic Journal of Research in Educational Psychology* **9** 3 pp 1309-32
[17] Yildirim S and Ersozlu Z N 2013 *Eurasia Journal of Mathematics, Science & Technology Education* **9** 4 pp 411-5
[18] Sperling R A, Howard B C, Miller L A, and Murphy C 2002 *Contemporary educational psychology* **27** 1 pp 51-79
[19] Dick W and Carey L 2002 *The Systematic of Decision of Instruction Third Edition* (New York, America Harper Collins Publisher) p 6
[20] Noviyanti L, Indriyanti D R and Ngabekti S 2015 *Lembaran Ilmu Pendidikan* **43** 1 pp 32-9
[21] Trianto 2009 *Mendesain Model Pembelajaran Inovatif Progresif* (Jakarta, Kencana Prenada Media Group) p 9
[22] Odja A H and Payu C S 2014 Analisis kemampuan awal literasi sains siswa pada konsep IPA *In* Prosiding *Seminar Nasional Kimia* 20 September pp 40-7
[23] Ardiansyah A A I, Irwandi D and Murniati D 2016 *Educhemia (Jurnal Kimia Dan Pendidikan)* **1** 2 p. 149-61
[24] Syamsiah S, Puspitawati R P dan Widodo W 2016 *Jurnal Pendidikan* **4** 3 pp 1-5
[25] Azizah U, Suyono dan Suyatno 2015 Desain dan validasi instrumen untuk mengukur keterampilan metakognitif mahasiswa dalam materi larutan *Prosiding Seminar Nasional Kimia* Jurusan Kimia FMIPA Universitas Negeri Surabaya, 3-4 Oktober 2015 pp 59-65
[26] Sugiyono 2015 *Metode Penelitian & Pengembangan* (Bandung, Alfabeta) pp 179-80
[27] Jihad A dan Haris A 2013 *Eveluasi Pembelajaran* (Yogyakarta, Multi Presindo) p 182