Development of mathematical literacy ability through the learning tools based CLT (cognitive load theory)

A S Asmara1*, S B Waluya2, H Suyitno2, I Junaidi2, T Suparman1 and A G Prawiyogi1

1Faculty of Teacher Training and Education, Buana Perjuangan Karawang University, Indonesia
2Postgraduate Mathematics Education Program, Semarang State University, Indonesia

*Corresponding author: andes@ubpkarawang.ac.id

Abstract. Indonesia has always been ranked the bottom 10 (2009-2015) in literacy capabilities under the OECD. Based on that the students still use a lot of memory in the process to memorize. For the purpose of this study is to see the support of increased learning effectiveness, it is necessary to reduce the unnecessary cognitive load in working memory. Based on the above study, the authors are interested to develop the Development of Mathematical Literacy Ability through the Learning Device Based CLT (Cognitive Load Theory). The type of research undertaken in this research is development research, with stages in the research process based on the modified Thiagarajan development model, namely: defining stage; design stage; development stage. Based on the research in getting results that the development of learning mathematics-based CLT can create a more enjoyable and effective learning atmosphere for students; students are more active in the learning process in the classroom; modules are made with illustrations of color and design are clear and interesting, and the presentation of the problem is also in accordance with the level of ability of students, the language used communicative so easy to understand.

1. Introduction

One of the problems of education today is that there is a wide gap between the knowledge and the attitudes and behaviors of students. Many students know or memorize the subject matter of mathematics, but are not able to apply their knowledge to improve the quality of life. Though based on the scope of literacy, students are not only in demand to have a cognitive understanding, but rather an active and psychomotor. When observed, the process of learning science by the students to learn more about (learning about think) rather than learning to be (learning how to be). For example, students learn about healthy living, but students do not learn how to behave in a healthy life (changing behavior).

Indonesia has been ranked 10th in the bottom (2009-2015) in literacy according to the OECD PISA assesses literacy skills based (Program for International Student Assessment), the average score is 500 international literacy (level 3), while the average score of literacy Indonesian students was 375 (level 1), level 1 is the lowest level of the six-level literacy skills set by PISA and the highest level that can be achieved is a level 3 Indonesian students [1-3]. The objectives of the 2013 curriculum that apply in Indonesia include character, competence, and literacy. In line with that when we refer to 21st century skills consisting of four main domains, namely: literacy, inventive thinking, effective communication and high productivity [4]. Thus we know that the literacy is greatly enhanced for the moment.
Working memory is responsible for processing information and following up on information in a limited capacity. Working memory can only store about four items on one element of information [5] and when processing information (organizing, showing differences, and comparing), humans can only manage two or three items of information simultaneously, depending on the type of processing needed [6]. So that new information stored in working memory if not trained will be lost and the information is short term memory, unless the information is familiar so that the information entered is received into long term memory [7]. So we need a way to optimize the complexity of the information received to be able to enter into long term memory.

Support for increased learning effectiveness, need to reduce the cognitive load that is not necessary for working memory (working memory) [8-10] stated that according to cognitive load theory is caused by three sources, namely: intrinsic cognitive load, extraneous cognitive load, and germane cognitive load [10-12]. Intrinsic cognitive load depends on the level of difficulty of the material, but with good presentation techniques and does not make it difficult for students to understand, the intrinsic cognitive load will be managed. Extraneous cognitive load depends on the presentation of the material. Whereas germane cognitive load is a relevant or beneficial burden imposed by teaching methods that lead to better learning outcomes. In learning, cognitive overload depends on the level of difficulty of the material studied according to intrinsic cognitive load. If the material studied by the intrinsic cognitive load is high, learning design must be organized so that extraneous cognitive load can be minimized as much as possible. Based on the above study, the authors are interested in developing Mathematical Literacy Capability Development Through Learning Tools Based on CLT (Cognitive Load Theory).

2. Methods

This research is development research, which is better known as Research and Development (R & D). Research Development is a process or steps to develop a new product or refine an existing product that can be accounted for. In this study a learning device is produced that fits the needs through several consistent cycles. The test site used by the author in SMK Negeri 1 Cikampek West Java Province academic year 2016/2017.

3. Result and Discussion

3.1 Result

In this study, the stages in the research process are based on the modified Thiagarajan development model, namely (1) defining stages consisting of preliminary analysis, student analysis, conceptual analysis, and the formulation of learning objectives; (2) design stage consisting of test preparation, media selection, selection of learning strategy, selection of initial format and design; (3) development stage consisting of expert assessment and field trials.

Instruments in this study were (1) learning device validation sheets, used to measure the validity of the developed product; (2) questionnaire of student response, used to know student response to product used in learning activity; (3) observation sheets, consisting of student activity observation sheets and teacher activity; (4) learning result test (THB), is used to know about the achievement of predetermined learning objectives.

To know the validity, effectiveness and effectiveness of learning tools of mathematics developed then there are several criteria. These criteria are: (a) learning devices are said to be valid if at least have valid criteria $Va \geq 3.25$; (b) learning tools developed are said to be practical (applicable) if the level of teacher activity achievement in managing learning in class $> 80$%; (c) the effectiveness of the resulting learning is said to be good if: (1) percentage of student activity at learning $> 80$%; (2) students' positive responses $> 80$%; (3) THB results show that at least 75% of students reach the level of mastery of the material or are able to achieve the minimum completeness established by the school. In this study, the minimum completeness of SMKN 1 Cikampek.

The validity test of the validator result analysis meets the validity criteria shown by the validity coefficient of each learning device developed, the result for the RPP is 3.65 which is included in the valid category and the 3.78 module included in the valid category. The device has previously performed
several stages of repair or revision through the suggestions and corrections of the validators until it reaches to the validity. Three validators provide suggestions that have been presented previously as a reference researchers in revising the learning device.

Test the practicality by analyzing teacher activity. The results of teacher analysis is at the first meeting obtained a percentage of 84.85% included in both categories and at the second meeting obtained a percentage of 87.76% included in either category. At the first meeting and the second meeting there was an increase indicating that the second meeting got a better percentage of the first meeting. At the second meeting there was an increase of 2.91% indicating that the learning tools developed have met the criteria of mastery practicality mastery and the teacher is able to manage the learning in the class well.

The effectiveness test of CLT-based mathematics learning tool uses the result of student activity analysis, student learning result test analysis and student response questionnaire analysis. In analyzing all three, the researcher is guided by the research method mentioned earlier. There are seven criteria to measure, namely: (1) listening to or paying attention to teacher's explanation of apperception and learning objectives; (2) listen to or pay attention to teacher or friend's explanation of material discussion; (3) read or observe the problems in the module; (4) actively discussing with his group; (5) ask or convey ideas or opinions to friends or teachers; (6) solving problems in the module either individually or in groups; (7) make a conclusion about the material being taught.

From the diagram above, it can be explained that at the first and second meeting have the percentage of student activity more than 80%. Of the seven types of student activities, there are several types of activities that have increased and decreased. The types of student activities that have increased from the first meeting to the second meeting are 4 types of activities, namely: listening or paying attention to teachers' explanation of apperception and learning objectives; actively discussing with his group; ask, convey ideas or opinions to friends or teachers; solve the problems that exist in the module either individually or in groups. Activities that have decreased are 3 types of activities: reading or observing problems that exist in the module; listen or pay attention to teacher or friend's explanation of material discussion; make a conclusion about the material being taught. Overall, the student's activity in

---

**Figure 1. Student Activity Percentage Chart**

From the diagram above, it can be explained that at the first and second meeting have the percentage of student activity more than 80%. Of the seven types of student activities, there are several types of activities that have increased and decreased. The types of student activities that have increased from the first meeting to the second meeting are 4 types of activities, namely: listening or paying attention to teachers' explanation of apperception and learning objectives; actively discussing with his group; ask, convey ideas or opinions to friends or teachers; solve the problems that exist in the module either individually or in groups. Activities that have decreased are 3 types of activities: reading or observing problems that exist in the module; listen or pay attention to teacher or friend's explanation of material discussion; make a conclusion about the material being taught. Overall, the student's activity in
following the learning activity meets the criteria, that is a good category with the first and second meeting average value is 82.23% and 87.08%. The result of thoroughness analysis of Tests on Learning Result shows that most students are able to reach the level of mastery of the material and able to understand the learning materials that Trigonometry well because > 75% of students have reached the minimum mastery score with the percentage of mastery of 78.85%.

The result of a questionnaire of student response to the learning is good with the average percentage of each response of >78% of students give a positive response to the aspect asked. Based on the results of the criteria already mentioned, learning tools can be said to be effective.

3.2 Discussion

The development of CLT-based mathematics learning tools on class X trigonometry materials of SMK Cikampek has been through a series of modified Thiagarajan model development stages, consisting of 3 stages: defining, designing, and development stage. The learning tools of mathematics developed in helping teachers create more effective and interesting classroom learning. The lesson plan is the guidance of teachers in learning that is used as a guide in implementing teaching and learning activities. The module is used as a source of learning support in the learning process used by students.

In the process of developing the device and at the time of trial there are constraints that the author faced, including The first obstacle when designing RPP and CLT-based modules, because it must pay attention to the CLT, ie Intrinsic cognitive load, extraneous cognitive load, and germane cognitive load it takes a long time to design the RPP and finally the module creation. The second constraint at the beginning of the trial runs, the learning process is noisy and less conducive because students are not familiar with the use of unusual learning strategies, so it takes time to adjust, because of their tendency to use expository learning methods in every teaching and learning process.

The above paragraph describes the constraints, but in this study there are also advantages of device products developed by researchers, among others; namely (1) can create a more enjoyable and effective learning atmosphere for students; (2) can make students more active in classroom learning activities; (3) can facilitate teachers in achieving good and effective learning in the classroom; (4) modules made with stunning illustrations and designs are clear and appealing, and the presentation of the problem also fits the level of the student's ability, the language used communicatively so that it is easy to understand.

4. Conclusion

Based on the process and the result of developing the learning tool of CLT-based mathematics, it can be concluded that the learning tools that have been made (RPP, module) included in the use of the strategy at the time of learning has met the criteria of validity, practicality, and effectiveness so it is perceived for learning mathematics-based CLT empowering the ability of mathematical literacy, which is full of context and process.

Based on the discussions and conclusions that have been described, there are some suggestions and inputs for similar research or research using the learning process nuanced CLT. Since CLT includes the intrinsic cognitive load, extraneous cognitive load, and germane cognitive load, it is optimized for the effectiveness of other students' level of knowledge in the implementation of trials, especially students with low knowledge level and passive inclination.

Acknowledgements

Our thanks to all parties who have been willing to read and work together in completing this study carefully assessing, evaluating and reflecting so that suggestions and input for research can be developed that can be further developed based on this research.

References

[1] Asmara A S 2017 Scholaria 7 135
[2] OECD 2014 OECD Publications 1 5
[3] Wardono, Waluya S B, Mariani S and Candra D S 2016 J. Phys.: Conf. Ser. 693 1
[4] Turiman P, Omar J, Daud A M and Osman K 2012 *Procedia Soc. Behav. Sci.* **59** 110
[5] Cowan N 2014 *Educ. Psychol. Rev.* **26** 197
[6] Kirschner P A, Sweller J and Clark R E 2006 *Educ. Psychol.* **41** 75
[7] Paas F and Ayres P 2014 *Educ Psychol Rev.* **26** 191
[8] Garvey, Anne M, Gonzalo-Angulo, José Antonio and Parte Laura 2017 *Revista Ciências Empresariais Jurídicas* **28** 5
[9] Ragland L and Reck J L 2016 *Adv. account.* **34** 77
[10] Sweller J, Ayres P and Kalyuga S 2011 *Measuring cognitive load*. In J. Sweller, P. Ayres, & S. Kalyuga (Eds.), *Cognitive load theory: explorations in the learning sciences, instructional systems and performance technologies* (New York: Springer)
[11] Plass J L, Moreno R and Brunken R 2010 *Cognitive Load Theory* (Cambridge: Cambridge University Press)
[12] Sweller J 2010 *Psychology Educ. Rev.* **22** 123