The analysis of junior high school students’ mathematical abstraction ability based on local cultural wisdom

I Dewi¹, N Siregar¹ and A Andriani¹
¹State University of Medan, Medan, Indonesia

E-mail: dewi_lubis62@yahoo.co.id

Abstract. Mathematical abstraction is widely used in everyday life. For example, pengeteret-eret ornaments derived from Tanah Karo culture, North Sumatera, Indonesia, are composite of a parallelogram resembling the image of a lizard that has two heads. This study aimed to develop a model of mathematics learning based on local cultural wisdom to improve communication and mathematical abstraction ability of junior high school students in North Sumatra. This paper examined the profile of students’ abstraction ability of year 7, that were used to develop mathematical learning models and tools. The data were obtained from observation, interview, and mathematical abstraction ability test from two regencies in North Sumatera, Tanah Karo and Mandailing Natal. The participants were 119 students in Year 7. The findings of this study showed that: (1) student could not bring up the abstraction process in solving problem, (2) students paid attention to the characteristics of the observed objects, however, they could not see the relationships among the observed objects, and (3) students noticed the characteristics of the observed objects but they have not done the actions that were supposed to be done on the objects to be manipulated. Therefore, it is necessary to develop a model of learning mathematics based on local wisdom that can improve students’ abstraction ability.

1. Introduction
Conceptually, local wisdom is human wisdom that is based on traditionally institutionalization of philosophical values, traditions, and behaviors. Philosophically, local wisdom can be interpreted as indigenous knowledge systems that are empirical and pragmatic. Empirical aspect means that the local societies leave the facts that occur in their lives, while pragmatic means that all the concepts constructed as a result of thinking in the knowledge systems that aim to solve daily problems.

Local wisdom becomes important and beneficial to society because the local people who inherit the knowledge systems are willing to accept and apply the culture to be the cultural values of their lives. Thus, local wisdom can be referred to as the soul of the local culture. It can be seen from the expression of local wisdom in daily life because it has been internalized well. From all these descriptions, it can be concluded that local cultural wisdom can not only be used as an educational product but also can be used as a bridge for students to be more familiar and closer to the cultural values in their region. These ideas are relevant to the educational objectives formulated in the regulation of the Indonesian ministry education and culture No. 20 Year 2006 on content standards that mentioned that education is both a form and a cultural product.

North Sumatra is one of the provinces in Indonesia which has various tribes, such as the tribe of Melayu, Batak Karo, Batak Toba, Mandailing, Nias and so on. These are some examples of ornaments used by the tribe of Karo, Melayu, and Mandailing in daily life.
The *Pengeret-eret* ornament is derived from the Karo culture; it has lizard shape with two heads facing left and right. This ornament is usually installed in front of Karo custom house, according to the belief serves as a force to resist the catastrophes and threats of evil spirits that threaten homeowners [1]. Regarding the ornament shape, the shape forms a combination of geometrical shapes.

The traditional ornament used in the lid of Sopo Godang (customary court hall) and Bagas Godang (the great house of kings). Mandailaing is called Bolang. In custom, Mandailing Bolang has the values, ideas, concepts, norms, rules and laws used in living life [2].

From these two symbols can be seen that since ancient times the process of abstraction has been attached and entrenched in daily life. When we look at the two symbols of those two regions, it is seen that although it has different shapes, both have the same philosophy that is the symbol of the force used to resist the catastrophe. It can be understood that the symbols of a region are the results and products of the mathematical abstraction process of abstract thinking, generalizing, and composing problems in daily life. Mathematical abstraction arises through a natural mechanism of the human brain in which complicated phenomena are compressed into what they call thinkable concepts [3]. Thus abstraction ability is an activity performed in daily life such that it needs to be developed in learning, especially in mathematical learning.

Based on the above descriptions, the activity of mathematical abstraction is an important thing to be developed in mathematical learning by using local cultural wisdom. In learning mathematics, abstraction is a fundamental process and have an important role in forming a concept. Through that process we can measure how far students have understood and built the concepts they have learned. On the other hand, due to the abstractness of mathematics, students often find difficult to learn mathematics. This is by the opinion which said to improve long-term conceptual learning, educators are aware of the abstraction process. The importance of abstraction ability can be enhanced in the learning process that gives students the opportunity to abstract by utilizing the local culture wisdom. Thus, it is required a learning model that can improve students' mathematical abstraction ability. The problem statement in this research is “how the profile of the abstraction of mathematics students' ability?”. Those students' mathematical abstraction profile will be used to develop mathematical learning models and tools. This research is the first phase of development to develop Mean-Ends Analysis (MEA) model based on local culture wisdom to improve students’ mathematical communication and abstraction ability of Junior High School (SMP) students in North Sumatra.

2. Research methods
This research was conducted on February 2018 in two regencies in North Sumatera that can represent North Sumatra culture. The subject of this study was students in Year 7 which were 60 students from junior high school 1 and 59 students from junior high school 2.
The data were obtained from 2 problems of the validated abstraction abilities test, i.e. to measure the ability to identify the manipulated object (indicator 1), and to transform the problem (idea) in symbol form (indicator 2). The development method used adapted from Plomp [4]. This paper is a research on the assessment stage of students' mathematical ability based on local wisdom.

Table 1. The rubric of scoring test

| Score | Criteria |
|-------|----------|
| Score 4 | The information/explanation given is correct and complete. |
| Score 3 | The information/explanation given is correct but not complete at the end of the completion. |
| Score 2 | The information/explanation given is complete but there is still an error at the end of the completion. |
| Score 1 | The information/explanation given is correct only at the beginning of completion and cannot be developed. |
| Score 0 | No information/explanation at all |

3. Results and discussion

The results of students’ mathematical abstraction ability of junior high school 1 and school 2 can be seen from Figure 3.

![Figure 3. Graphic of the average score of students’ abstraction ability](image)

The Average Score of Students' Abstraction Ability

| SCHOOL 1 | SCHOOL 2 |
|----------|----------|
| 0.377    | 0.557    |
| 0.328    | 0.361    |

Figure 3 shows the indicator 1 (identifying the manipulated object) of the average score of students’ abstraction ability that school 1 obtained 0.377, while in school 2 the average score of 0.557. The problem of indicator 2 (transforming the problem (idea) in symbol form) the average score of abstraction ability that school 1 obtained 0.328, while school 2 obtained the average score of 0.361. The data showed that the students’ ability to identify the manipulated mathematical object both schools was better than the students’ ability to transform the problem (idea) in symbol form. This result led to an analysis of why students have difficulty in transforming ideas into symbols (indicator 2). The problem given for viewing this indicator 2 in Figure 4.

![Figure 4. The problem given for viewing indicator 2](image)
There were profiles of students' observable answers: (1) student did not provide the answer at all, (2) student just guessed the answer without any argument, (3) students answered by using incorrect formula. Table 2 shows the pattern of answers given by the students.

| Answers Profile     | Students school 1 | Students school 2 |
|---------------------|-------------------|-------------------|
| No answer           | 2                 | 3                 |
| Guessing            | 18                | 38                |
| Incorrect/Mistake formula | 39               | 19                |

*Table 2. Analysis of students’ answers profile*

![Image](Image)

*Figure 5. Profile of student’s answer by guessing*

From Figure 5, can be seen the students just wrote “the area of the black is 2.5 cm” without giving any argument toward the answer given.

The next profile is students making the formula in solving the problem but the formula used does not lead to completion.

![Image](Image)

*Figure 6. Profile of student’s answer used formula is not correct (7 cm x 4 faces = 28 cm)*

From Figure 6, student looks just "7 x 4 faces = 28 cm”. Although the student has given the argument the formula used was not correct and did not lead to solving the problem. In general, no student obtained score 4 even many students who did not understand that the area of the black is the
area of the square reduced by the area of a circle. The results of this data analysis suggested that when solving the problem given, the students failed to generate the process of abstraction. According to [5], in mathematical learning, there are three circumstances that could lead to the process of abstraction, including: 1) the students' abstraction process arises from observing the observed characteristics of the object, 2) it arises when focusing attention on the actions to be performed on objects that lead to symbols and then manipulated, and 3) it arises when a student formulating a theoretical set of concepts to construct a concept that can be thought through a series of mathematical proofs.

In line with the ideas, the situation students did not give an answer means that all the abstraction process did not appear in solving a problem. The researchers did not see this issue was caused by time limitation, since the time given was sufficient and even some students submitted the answers before the due time.

In situations where the students guess only the answer, the researchers estimate that the students have considered the characteristics of the observed object (even some students measured the image using a ruler) but they did not see the relationship between the observed object. Thus, students could not solve the problem correctly. In situations students gave answers with a mistake formula, they did not lead to completion means students already pay attention to the observed characteristics, i.e. square. But to solve the problem, students did not do the actions that are supposed to be done on the object to be manipulated. As a result, students did not see that areas that were outside the black area are four of \( \frac{1}{4} \) circle area, which means students could not construct the formula used in solving the problem. The material used in this research is geometry. According to [6], students’ scores in geometry always decreased. Geometric objects are considered abstract by students so that they have difficulty to understand the geometry concepts. In this case, students could identify the mathematical object but they found difficulty in writing symbols or into the language of mathematics. Similarly, [7] argues that the process of student abstraction in solving geometry problems belongs to empirical abstraction which emphasizes the representing mathematical objects into mathematical languages.

With regard to the students’ age at year 7, ranging from 12-13 years old, students still could not do the abstraction perfectly yet. According to [8], children learn things based on manipulation and observation of specific objects. Therefore, it might be difficult for children to apply abstraction to learning. Despite having difficulty in abstraction, this abstraction activity can be developed in schools by giving students’ activities of theoretical models such as schematization activities that make up special experiences. Furthermore, a concept is the final product of abstraction [9]. Thus, abstraction abilities can be developed by giving students the abstracting activities associated with their daily lives. This resulted in a student’s ability to link his own experience of mathematical ideas to a better and lasting understanding of mathematics because he can see the interrelationships between a concept in mathematics, with non-mathematical contexts, and with daily life experiences [10].

4. Conclusion
This research examined the mathematical abstraction ability of junior high school students who come from two different regions of language and local wisdom in North Sumatra. The profile was used to develop mathematical learning models and tools to improve students’ mathematical abstraction ability. The different profile of students’ mathematical abstraction led to learning models and materials that appropriate with the characteristics of each region. The results of this research showed that the profile of students’ mathematical abstraction evidently the same. The profiles are: (1) student could not bring up the abstraction process in solving problem, (2) student paid attention to the characteristics of the observed object but they did not see the relationship between the observed objects, and (3) students noticed the characteristics of the observed objects but they have not done the actions that were supposed to be done on the objects to be manipulated.

The results of this research indicated that students’ abstraction ability was not influenced by the local cultural wisdom of a region. Mathematical development occurred because of the life challenges and the ability of human beings to abstraction. Every culture and local wisdom develops mathematics
according to the needs of its own society. Therefore, mathematics is a cultural product of the result abstraction of the human mind, as well as an activity done in daily life. Thus, it is necessary to develop mathematical learning models and tools that can improve students' abstraction ability based on culture and local wisdom.

References
[1] Roy G.T 2014 Inspirasi Gerhana: Ornament Tradisional Suku Karo Retrieved on February 2017 from http://inspirasigerhana.blogspot.co.id/2014/03/ornamen-tradisional-suku-karo.html.
[2] Nasution E 2010 Bolang-Ornamen Tradisional Mandailing APAKABARSIDEMPUAN Retrieved on February 2017 from https://www.apakabarsidimpuan.com/bolang-ornamen-tradisional-mandailing/
[3] Gray E and Tall D 2007 Abstraction as a Natural Process of Mental Compression Mathematics Education Research Journal, 19(2) pp 23-40
[4] Plomp T 1997 Educational and Training System Design. (Enschede: University of Twente).
[5] Tall, D. 1991. Advanced mathematical thinking. Mathematics Education Library. Dordrecht: Kluwer Academic Publishers Group
[6] Utami, A K D, Mardiyana, and Pramudya, I 2017 Analysis of Junior High School Students’ Difficulty in Resolving Rectangular Conceptual Problems. AIP Conference Proceedings 1868, 050008 (2017); Retrieved from https://doi.org/10.1063/1.4995135
[7] Nurhasanah J, Sabandar J, and Kusumah Y S 2013 Abstraction Processes in Learning Geometry Using GSP. ResearchGate Retrieved from https://www.researchgate.net/publication/263199291.
[8] Hong J E and Kim M K 2015 The Solving od III Structured Problem of Elementary School Student in Korea. Eurasia Journal of Mathematics, Science & Technology Education, 12(2), 267-281
[9] Ferrari P.L 2003 Abstraction In Mathematics The Royal Society Publishing retrieved in April 2018 from http://rstb.royalsocietypublishing.org/content/358/1435/1225
[10] National Council of Teachers Mathematics (NCTM) 2000. Principle and Standards for School Mathematics. Reston: NCTM.