Trial of design means-end analysis learning model based on local cultural wisdom to improve communication ability and mathematical abstraction of middle school students

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Abstract. Student's mathematical communication and abstraction skills were needed in learning mathematics. Another aspect of the student learning process was the need to know and to develop the wisdom of local culture in their daily to lived. This was because students were expected to be a smart generation and still respect their own culture that they will use as life guidance. However, the problem was how to be in still the wisdom of local culture in learning mathematics? Based on these problems, the researcher designed a mathematical learning model that incorporated the wisdom of local culture in mathematics learning. The purpose of this study was to test the Means-Ends Analysis learning model based on the local Cultural Wisdom that had been designed. This learning model was using the wisdom of local culture in mathematics learning. The purpose of this learning model was to improve communication skills and mathematical abstraction skills of students in grade 7. The subjects were Year 7 students of junior high school in the City of Berastagi and Perbaungan. The undertaking, students said that they found it was easier to understand mathematical concepts. Although, the teacher had difficulty in elaborating the problem of mathematical abstraction with the cultural, but the teacher said that the students become easy to communicate their mathematical abilities.

1. Introduction
Many students at this time who choose to play gadget individuals rather than playing with their friends, will have an impact on students' social lives. For example, students often say something harshly on social media, and act according to their wishes. This unfavorable behavior will contradict Indonesia's educational and cultural goals. Education is essentially a process of civilization and human empowerment in developing towards an independent person to build himself and his community [1]. To be able to build personal and community, education must be able to become "valuable" and "meaningful." The value of education in question is the ability to develop imagination, develop intuition, as well as the creativity and sensitivity of the students. To produce this valuable and meaningful education, one of the determining factors is the ability of teachers to innovate in learning.

Teachers must be able to create innovative learning models related to culture (local wisdom). The latest findings from [2], and the Master degree students of mathematics education programs, besides [3], [4], and [5] found that learning on students based on local culture can improve high-level mathematical thinking skills of junior high school students. However, nowadays the learning process of mathematics in schools, in general, is still not incorporate the local cultural wisdom maximally. That is the reason why researchers want to develop learning models that involve local cultural wisdom.
One of the activities in mathematics is an abstraction. In learning, mathematics abstraction is seen as a process of constructing the knowledge which is needed by students and also teachers to help students build their mathematical understanding. For teachers, the information about how students constructed their understanding is essential to consider the way and what strategies in helping the students. In addition to the abstraction ability, students’ mathematical communication skills are also the thing that needs to be improved in mathematics learning. Mathematical communication is the process of delivering mathematical ideas by students either orally or in writing. A person's mathematical understanding cannot be seen or heard, but mathematical communication facilitates students to "voice" what they think /understand their mathematical knowledge. "Encouraging students to think aloud and share their way of approach to mathematical problems with each other maybe especially in helping students feel confident and have a positive attitude within the classroom [6]". The explanation implies the mathematics learning that allows students to communicate mathematically can make students feel confident and have a positive attitude. To develop the ability of abstraction and mathematical communication, it is necessary to use a learning model that can facilitate an increase in both mathematical abilities.

One of the factors that determine success in learning mathematics is the strategy used to achieve learning goals. The Mean Ends Analysis (MEA) learning model is one of the learning models that are appropriate to use in mathematics learning because the steps (syntax) used in the MEA apply heuristic problem-solving steps. According to [7] in the MEA learning model students are allowed to use their strategies to support their knowledge to solve mathematical problems. This characteristic which student can build their knowledge is useful to improve the communication skills and to be mathematical abstraction. The results of the [8] study show that the application of MEA learning has a positive influence on improving communication skills and mathematical problem-solving abilities of Year 8 junior high school students.

Based on the research that shows the local culture-based learning can improve high-level thinking skills and the MEA learning model can improve students' physical communication, the researchers want to develop Mean Ends Analysis (MEA) learning models based on local cultural wisdom to improve mathematical communication and abstraction of middle school students. This paper is the result of a trial of the model developed, and it is limited to the feasibility of the developed learning model.

2. Research Methods

This research was development research, which was conducted in 2 Junior High Schools (SMP) in 2 different regions; they were namely Perbaungan, represent the Malay culture and Berastagi, and represent the Karo culture. The experiment was conducted in the first half of the school year 2018/2019, which was on 2 April 2019 until 27 April 2019. The reason to choose this study site, because the culture-based and teaching models and materials developed following the characteristics of local students. The subjects in this study were Year 7 students of junior high school. During the classroom learning all teachers and students, activities were observed by two observers and also recorded using a camera to produce learning pictures and videos. This recording aims to obtain more accurate data that might escape the attention of teachers and observers.

Data analysis of the implementation of Local Wisdom based Mean-Ends Analysis was gathered from the consistency of two variables; intended experiential (IE) which was gained from the assessment of experts and practitioners, and intended perceived (IP) which was obtained from the achievement of indicators/ the effectiveness of implementations based on field trial data analysis.

The effectiveness of mathematics learning implementation in the Intended Experiential (IE) group could be measured from the components of the provided model and media of learning. The experts and practitioners were chosen based on their mastery of concepts and experience to decide whether the learning model of Local Wisdom based Mean-Ends Analysis could be applied. After that, the average of the assessment results from the experts and practitioners were determined. The average of the
assessment results was referred to as the interval for determining the effectiveness of Local Wisdom based Mean-Ends Analysis as below.

| Interval | Category  |
|----------|-----------|
| $1 \leq IE < 2$ | very low  |
| $2 \leq IE < 3$ | Low       |
| $3 \leq IE < 4$ | Medium    |
| $4 \leq IE < 5$ | High      |
| $IE = 5$      | very high |

The Local Wisdom based Mean-Ends Analysis is stated to have a good IE if the IE level achieves at least a high category. When the IE level was below the high category, then a revision was needed based on input from the experts and practitioners. After the revision, the experts and practitioners would conduct a re-assessment for the effectiveness of the implementation. The steps were repeated until the ideal model of Local Wisdom based Mean-Ends Analysis learning is obtained based on IE's point of view.

The Intended Perceived (IP) of the learning model of the Local Wisdom based Mean-Ends Analysis was determined by the empirical data gathered in the field (face-to-face learning activities). The IP has three aspects of effectiveness; (1) syntax, (2) social system, (3) reaction and management.

3. Results and Discussions

Data analysis gathered from the experts and practitioners towards the local Wisdom based MEA learning model revealed that the learning model fulfills the validity criteria based on the theoretical strength (content validity) and the consistency of the components internally (construct validity). The average of content validity for the Local Wisdom based MEA learning model was 4.56. Meanwhile, the average of construct validity was 4.60. Thus, the Local Wisdom based MEA learning model was categorized into the high category, and the developed learning model was feasible to be tested on the field.

Assessment towards the Local Wisdom based MEA learning model implementation was based on three aspects; (1) syntax, (2) social system, and (3) reaction and management. The assessment results of the learning model came from three validators who were the experts and mathematics, education practitioners. The assessment results using media of learning (local wisdom based lesson plan, teacher book, student book, and student worksheets) in 3 times face-to-face learning could be seen in Table 1.

| No | Aspects                          | Average for every aspect | Final Score |
|----|----------------------------------|--------------------------|-------------|
|    |                                  | Meetings                 |             |
|    |                                  | I | I | III |             |
| 1  | Syntax                           | 4.3 | 4.4 | 4.6 | 4.43 |
| 2  | Social system                    | 4.2 | 4.4 | 4.5 | 4.36 |
| 3  | Reaction and Management          | 4.0 | 4.3 | 4.6 | 4.3  |

Since every aspect of IP has a high category, so the developed learning model can be implemented in the class.
The MEA learning model by [9] has four steps of learning; (1) introduction, a heuristic problem-solving approach was used to explain the concept of learning, (2) the concept of learning was elaborated into simpler sub-problems, (3) sub-problems were set into connectivity, and (4) strategy solutions were chosen. To solve a problem by using MEA learning model, a problem could be separated into some sub-problems. Before setting up the sub-problems, students have to understand and interpret the situation as well as the real condition of the country. After that, the students gather information from their prior knowledge and setting up the sub-problems to minimalize the difference between the current situation and targeted status.

There are several steps of the local Wisdom based MEA learning model used in face-to-face mathematics learning. Some students and teacher activities, as well as the difficulty of learning model implementation by the teacher, will be explained in every step of learning. The first category of problems used in the local wisdom MEA learning model is intended for encouraging students to respect their own culture and implement it in their daily lives. The second characteristic is that the problems provided are close to students' daily life, so they can imagine and communicate their thinking according to their intelligence level. Thus, the given problems are in the students' zone proximal development (ZPD). The teacher's activity in this stage is to provide local wisdom based problems. Furthermore, the social impact of this step is that the students could respect their own culture.

In the first step, the teacher displays a slide show (Picture 1) related to a traditional game called "tam-tam buku," which needs group cooperation.

![Figure 1: The “Tam-tam Buku” game](image)

The teacher utilizes the game illustrated in Figure 1 for the problems related to Angle by observing the two hands of the players acting as the guard in the game. This helps the teacher to guide students to discover the definition of angles.

![Figure 2: Students' answer in solving problems related to the angle](image)
Figure 2. It shown that two students' answers. In Figure 2a (the above one) the student only illustrated the shape of the players' two hands as an angle, while in Figure 2b. (the below one) the student also draws it as a triangle. Thus, it can be indicated that students see the shape of the guard players' hands differently. The difference is not a problem because the figure is enough for the teacher to guide the students to find a definition of the angle. The use of material contexts that are close to students' real lives has a positive impact on their learning. The positive impacts of using contexts that relevant to students' field of study. [10][11]

Next, the students were required to work together in mutual in a group to solve the problems given. The teacher encouraged students to work together and to help each other in solving problems. The teacher also supervised each student in their groups to avoid them from work individually. The social impact expected after the learning was that students can work as a team in solving a problem. This activity greatly benefited the teacher in accelerating the transfer of knowledge among the students and facilitating them in solving problems as the groups formed consisted of students of different ability levels. [12] Suggested that students who were heterogeneous in terms of mathematics performance should work together and help each other in a group. Elsewhere [13] said the purpose of learning mathematics was to equip learners with the ability to think logically, analytical, systematic, critical, and creative, as well as the ability to work in a team? So working together in groups was also one of the goals of mathematics learning.

Next stage was the teacher provided mathematical problems associated with local culture (in the student worksheet). The teacher distributed two copies of student worksheets (LKS) to each study group. Copies of the worksheet should be done by each group, one copy was submitted to the teacher as a group work report, and another copy was for each study group. Each student was also asked to write the results of their group discussion in their notebook.

The teacher provided scaffolding to each study group (classically) based on the problems they experienced. Scaffolding is relevant to the view suggesting that mathematics learning requires a lot of interaction, between teacher and students, students with students, and students with the learning materials; thus, students can develop mathematical knowledge and strategies to work on the mathematical problems provided [14]. The learning situation in this stage guided students to create mathematical models to solve the problems. This indicates that each study group experiencing such a process of problem-solving will be guided to formulate and abstract the concepts and mathematical principles they are expected to achieve.

Figure 3 illustrated the example of a teacher and student activities elaborating on mathematical problem-solving into local cultural wisdom. The teacher designed a question showing the roof of a Malay traditional house and proposed a few questions for students.[15]

![Figure 3: The Roof of Malay Traditional House](image_url)

Figure 3 is the roof of Malay traditional house formed of the joint of two sides, the two logs meet at one point and form an angle, as presented in the student worksheet, the teacher used the figure to provide scaffolding. The following is the interview excerpt between the teacher (G) and the student (S).

G : What kind of figure can be formed from the roof of a Malay traditional house?
S1: Triangle, Miss.
S2: Triangle, Miss
G: What is your reasoning?
S1: Because the figure has 3 angles
S2: Because the figure has 3 angles, i.e., Angle A, B, and C that is the acute angle
G: Try to draw a triangle based on the roof of the house.
The figures drawn by the students are presented as follows.

![Figure 4: The answer to the triangle](image)

At this stage, it can be seen that students were able to see already the real problems provided in mathematical symbols. The students have been able to do mathematical abstraction by drawing the triangle. In term of their communication, they have been able to provide reasoning from their answer.

One of the objectives of developing this learning model is to improve students’ mathematical communication. At this stage, the teacher presented each group works classically in front of the class. Besides, the teacher also provides other groups opportunities to respond to or ask questions to the presenter. The role of the teacher is responding to different opinions among students was to provide scaffolding by presenting guiding questions, illumination or other simple problems related to the problems arise so that the classical discussion between students remain as the appropriate problem-solving process and mistakes can be avoided. As for the students who have come to an agreement in solving the problem proposed, the teacher guided them to formulate and conclude the concepts and mathematical principles that students were expected to achieve. After that, the teacher gave the following problem in the student worksheet to be discussed by students in the group. This is question for student.

“If Tengku tries to lift both his hands and his friend’s hand forming an angle of 145°67 ′, what is the size of the angle in degrees (°)?”

Students created the following sub-problems to solve the problem.

“1. What is the degree of one minute? And
2. What is the degree of one second?”

This stage indicates that students must divide the problem given into parts to be solved first before solving the problem. In this case, the teacher encouraged students to see a big problem as small problems that will certainly help them in solving big problems.

Next, the teacher asked students to select the strategy to solve the problem. Next, students read the culture-based books provided to them and find the appropriate strategy to solve the problems. The strategy can be seen in the student book (page 4).
Students are expected to be able to use the strategies they have already known to solve problems. However, they made two calculation errors in solving the problem. Even though they knew the formula, they could not use it.

**Error 1.**

G: Why did you multiply 1,456'67" x 60?

S: Because one minute equals 60 seconds, so, we change 1456'67" to second.

G: Why it is divided by 3,600 after you change it to seconds?

S: Because 1 degree is 3,600 seconds, so 8,740.02 is divided by 3,600. The result is 24.3 degrees.

Based on the interview, it can be seen that the students understand the rules to be used. However, they were unable to apply the formulas. The calculation error occurred because they multiplied 1,456'67" by 60, they should calculate 1,456 x 60 + 67 instead. Students know the formula required, but they cannot manipulate the formula to solve the problem.

Also, there was an error committed by students in solving the problem related to the size of the angles. The students' error is presented as follows.

**Figure 6. Student’s Answer Related to the Magnitude of the Degree**

**Figure 7. Students’ Snswer Related to the Magnitude of the Angles**
G: Why did you divide 1,456 by 60?
S: Because one degree equals 60 minutes, so we changed 1,456 to a degree.
G: And then why did you divided 67 by 60?
S: Because one degree is 60 minutes, so we also changed it to degrees
G: Can you distinguish symbols of minutes and seconds
S: There are no answers from students
G: Why did you multiply 24.266° by 3,600?
S: Because one degree equals to 3,600 seconds, then I divide 24,266 by 3,600, and the result is 24.3

Students made mistakes in dividing 67: 60 because 67 is in second and should not be divided by 60. Only 1,456’ should be divided by 60.

In line with error 1, error 2 also indicates that the error occurred because they could not manipulate the formula to solve the problem correctly. Based on the two errors, it can be concluded that students find it challenging to manipulate the formula given. This is one aspect of abstraction that is difficult for students to understand in learning mathematics.

Figure 8 presents the students' answer using the appropriate strategies.

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Figure 8. Students’ answer related to the magnitude of the angles

G: What did you multiply 1,456 by 60?
S: Because I want to change it into seconds.
G: Then why did you add 67 to the multiplication result?
S: Because 67 is in seconds
G: Why did you divide 87,427 by 3,600?
S: Because One second, so 87,427 is divided by 3,600 resulting 24.28°

The teacher classically motivated each student to be confident to use the mathematical concepts and principles they have found. To review the problems solved by each group, the teacher provided group representatives the opportunity to explain the discussion results in front of the class. Discussions in the math classroom allow students to formulate logical arguments and students benefit from classroom discussions that compare different interpretations of the same text and that challenge their preconceived notions [16].

Figure 9 shows the students comparing which answers were in line with the concepts and which were not; in other words, they reviewed the problems they solved, whether it was correct or not.

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Figure 9. Students presenting the discussion results
4. Conclusion
Based on all activities conducted by teachers and students in mathematics learning using MEA model based on the local cultural wisdom, it indicated that the model was viable to improve students’ communication skills, but it was more study required for mathematical abstraction. Most of the students were not able to connect how to use their knowledge was. It was recommended to the next researchers to integrate other learning models with cultural contexts.

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