The effectiveness of local instruction theory for solid geometry topic using a realistic mathematics education approach

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Abstract. One of the efforts carried out to improve problem-solving in solid geometry is by using a realistic mathematics education approach. The Curriculum 2013 mandates the solid geometry learning in Year 5 of elementary school involving solving problems related to their traditions or local culture. This research aimed to examine the relevance of the LIT of solid geometry material between the Curriculum 2013 (revised 2016) and the Curriculum 2013 (revised 2014) and to review the effectiveness of LIT. This research employed a qualitative approach using the design research method consisting of three phases, namely: preparing, Hypothetical Learning Trajectory (HLT) test, and retrospective analysis. The pilot project was carried out in the Year 5 of three elementary schools located in Pidie District. The instruments involved student worksheet, student activity observation sheet, student conformity sheet comparing the observed and expected activity, problem-solving skill test, student questionnaire, and teacher questionnaire. The results indicated that: 1) The LIT of geometry topic of the Curriculum 2013 (revised 2016) was relevant to Curriculum 2013 (revised 2014), 2) The LIT developed satisfied six effectiveness indicators. Thus, the LIT developed can be disseminated to be used by elementary school teachers at schools.

1. Introduction

One of the mathematics branches is geometry. Geometry is the science learning the relationship of points, lines, angles, plane, and shapes. In general, geometry consists of two-dimensional geometry and three-dimensional geometry. The objects of two-dimensional geometry learned in elementary school level are square, rectangular, triangle, parallelogram, trapezium, rhombus, kite, and circle. Objects of the three-dimensional geometry studied in elementary school level are a cube, cuboid, prism, pyramid, cone, cylinder, and many others [1].

Mathematics as an abstract object is difficult to be comprehended by elementary school students, who have not been able to think formally [2]. The elementary school students' thinking phase has not yet exceeded the abstract phase. This is in line with Piaget's opinion mentioning that students at the elementary school age, ranging from 6 or 7 years to 12 or 13 years, are still in a concrete operational phase. The capability in this phase is the ability related to the thinking process to operate the logic rules, although they are still attached by concrete objects [3].
In the Curriculum 2013 (revised 2014), solid geometry material studied in Year 5 of elementary school is the ecosystems theme and the relationship between living creatures and ecosystems subtheme. The solid geometry learned are cube and cuboid. Cube and cuboid materials are presented, and then the students are allowed to find the formulas of cube and cuboid volume by themselves. On the contrary to the cylinder, the volume is provided from the general solid geometry formula. The volume is as the area of the solid geometry base multiplied by the height [4].

One of the efforts conducted to improve problem-solving in geometry is using a realistic mathematics education approach. The contextual problem proposed can encourage the students to develop their model from based on the situation and then they can create the model to solve the problem. Finally, they can achieve more formal mathematics knowledge [5]. The Curriculum 2013 mandates the geometry learning in Year 5 of elementary school involving solving problems related to their traditions or local culture. However, the learning trajectory, as mandated by the curriculum 2013, has not yet been available. Ariani [6] has developed a Local Instruction Theory (LIT) related to traditions or local culture [6]. In the second semester of the curriculum 2013 (revised 2016), mathematics in the higher grade of elementary school thematic approach is no longer used. It means that mathematics for Year 5 will be taught separately and without a thematic approach [7].

The LIT developed can still be used; however, several parts of the lesson plan components need to be analyzed and revised due to the Permendikbud No. 22 of 2016. Local Instruction Theory (LIT) developed involved only the validity and practicality phases. Thus it has not been used by the teachers yet. Therefore, the researcher wanted to continue the research by measuring the effectiveness of the LIT. The results of this study are expected to improve the previous research and support the teachers by providing valid, practical and effective learning instruments. It will also assist the students in developing their problem-solving skill in solid geometry. Besides, this research results will be disseminated, so elementary school teachers at schools can use it.

Based on the above description, the research questions of this study are: 1) how is the relevance of the LIT of geometry material between the Curriculum 2013 (revised 2016) and Curriculum 2013 (revised 2014)?; and 2) How is the effectiveness of the LIT of geometry material using a realistic mathematics education approach in developing elementary students’ problem solving skill?

2. Method
The research aimed to find out the relevance of Geometry material LIT between Curriculum 2013 revised 2016 and Curriculum 2013 revised 2014 and to review the effectiveness of Geometry material LIT using a realistic mathematics education approach in developing elementary students’ problem-solving skills. The test was administered to Year 5 students in three schools in Pidie district. The selection of the test subjects was based on the Year 5 teachers involved in the validity test and practicality phases of the previous research.

The instruments used in the test consisted of six instruments including student worksheet, student activity observation sheet, student conformity sheet comparing the observed and expected activity, problem-solving skill test, student questionnaire, and teacher questionnaire.

The data was analyzed based on the design research method. The design research was carried out in three phases, namely: preparing for the experiment, the teaching experiment, and retrospective analysis [8]. The preparation phase was done by analyzing the Hypothetical Learning Trajectory (HLT), lesson plan, student worksheet, and mathematics test. Then, the learning instruments and mathematics test items were validated. The pilot study was conducted by socializing the valid and practical LIT to three teachers. Next, it was tested to the Year 5 students in three elementary schools in Pidie district. The retrospective analysis phase is an analysis of all data obtained during the pilot study in the classroom.

3. Result and discussion
The data analysis results based on the effectiveness indicators showed that the minimum average of activities in student worksheet was 90%; the minimum average of active students’ activity was 40%, and the minimum of student activity conformity between the observed and expected activity was 80%.
There was an improvement of problem-solving skills test scores, in which more than 50% of the students provided positive responses to LIT, and the teachers also gave positive responses to LIT [9].

3.1 The results of student worksheet

The student worksheets that were developed and revised consisted of student worksheet 01, student worksheet 02, student worksheet 03, and student worksheet 04. The analysis of student worksheet is presented in Table 1.

| The school name | The average of student worksheet | Total average |
|-----------------|---------------------------------|--------------|
|                 | 01  | 02  | 03  | 04  |            |
| School X        | 91.67| 89.58| 87.50| 91.75| 90.13      |
| School Y        | 90.63| 93.75| 87.50| 93.75| 91.41      |
| School Z        | 95   | 90   | 91.70| 93.40| 92.53      |

The results of the student worksheet analysis of School X showed that each group reached more than 80% while the total average was 90.13%. Student worksheet analysis results of School Y explained that each group achieved more than 80% while the total average was 91.41%. In addition, student worksheet analysis results of School Z indicated that each group reached more than 80% while the total average was 92.53%. It was concluded that the students were capable of applying and working on the student worksheet developed.

3.2 The results of the students' activity observation sheet

The students’ activity observation was done to examine the learning implementation by applying the learning instruments developed. The observation was conducted by three observers, assessing the students’ activity during the learning process. The observers’ assessment data were analyzed using the descriptive analysis (percentage). The results of students’ observation data analysis are illustrated in Table 2.

| The school name | The average of assessment percentage | Total average |
|-----------------|-------------------------------------|--------------|
|                 | 1st Lesson | 2nd Lesson | 3rd Lesson | 4th Lesson |          |
| School X        | 82.22      | 77.78      | 82.22      | 86.67      | 82.22     |
| School Y        | 84.45      | 82.22      | 88.89      | 91.11      | 86.67     |
| School Z        | 80         | 77.78      | 88.89      | 88.89      | 83.89     |

The minimum average of the expected active students’ activity was 40%. The total averages of students’ activity for all lessons in School X, Y, Z was 82.22%, 86.67%, and 83.89% respectively. The observation analysis of students’ activity in all elementary schools involved showed that the students’ activities to the LIT developed had run well.

3.3 The conformity between the observed and expected students’ activities

The expected students’ activity is the activity designed based on the characteristic of realistic mathematics education approach. Those activities were adopted from Zubainur [10], including 1) Paying attention to teacher/student's explanation, 2) Understanding contextual problem, 3) Giving response to contextual problem, 4) Expressing the ideas in solving the problem, 5) Discussing the solution in group,
6) Completing the tasks in group, 7) Expressing the solution and perception in the classroom discussion, 8) Summarizing the concept and procedure, and 9) Completing the personal tasks [10].

The conformity analysis between the observed and the expected students’ activity in School X, School Y, and School Z are presented in Table 3.

Table 3. The conformity analysis between the observed and the expected students’ activity.

| The school name | The average of assessment percentage | Total average |
|-----------------|-------------------------------------|--------------|
|                 | 1st Lesson | 2nd Lesson | 3rd Lesson | 4th Lesson |             |
| School X        | 77.78      | 77.78      | 88.89      | 88.89      | 83.34       |
| School Y        | 77.78      | 88.89      | 88.89      | 88.89      | 86.11       |
| School Z        | 88.89      | 88.89      | 88.89      | 88.89      | 88.89       |

The minimum average of the conformity analysis between observed and expected students’ activity was 80%. The total averages of the conformity analysis between observed and expected students’ activity for all lessons in School X, Y, and Z were 8.34%, 86.11%, and 88.89%. The conformity analysis between the observed and expected students’ activity showed that the conformity was more than 80 %, meaning that the students’ activity to LIT developed has run well.

3.4 Test score of problem solving skill

The test of problem-solving skill consisted of a description question. The test was administered to the students at the end of the lesson. The test aimed to evaluate the students’ understanding of the material learned. The analysis of problem-solving skill test can be explained in Table 4.

Table 4. The analysis of problem-solving skill test.

| The school name | Average score |         |         |         |
|-----------------|--------------|---------|---------|---------|
|                 | Test 01 | Test 02 | Test 03 | Test 04 |
| School X        | 75.98    | 74.42   | 79.32   | 80.93   |
| School Y        | 80.52    | 73.33   | 80.30   | 81.72   |
| School Z        | 84.29    | 80.57   | 85.43   | 85.65   |

The analysis of problem-solving test conducted in three elementary schools indicated that there was an improvement in every lesson. Even though the average score decreased in the second lesson, but there was an improvement in the third and fourth lessons. In the first lesson, the students were asked to describe the characteristic of the cylinder. It was an easy test, and there was no mathematical procedure required in solving the problem. In the second lesson, the decrease of the score occurred since the students were asked to determine the volume of a cylinder requiring the skill related to problem-solving steps and algebra understanding. The scores were improved in the third and fourth lessons. In the next lesson, the test covered on all material learned. The test analysis is shown in Table 5.
Based on the above table, it was obtained that the average score of students’ learning output in School X was 75.99, in School Y was 77.55 and in School Z was 81.96.

### 3.5 Students’ response
The students’ response was indicated by the questionnaire distributed to the students after learning. The questionnaire consisted of several questions related to the student worksheet developed. The student questionnaires of School X, Y and Z involved 43, 22 and 35 students respectively. The results of the student questionnaire are displayed in Table 6.

**Table 6. The results of students’ questionnaire related to student worksheet.**

| Respondent        | Percentage |
|-------------------|------------|
|                   | Not good   | Low  | Adequate | Good  | Excellent |
| School X students | 1.52       | 6.44 | 16.55    | 44.81 | 30.68     |
| School Y students | 2.97       | 7.78 | 14.51    | 48.95 | 25.79     |
| School Z students | 0.50       | 5.33 | 14.62    | 46.92 | 32.64     |

Based on Table 6, 75.49%, 74.74%, and 79.56% of students provided positive responses (good and excellent) in School X, Y, and Z, respectively. It indicated that more than 50% of students respond positively to student worksheet used. Student questionnaire related to the mathematics test developed was also administered. The results of the student questionnaire related to the mathematics test are illustrated in Table 7.

**Table 7. The results of the student questionnaire related to the mathematics test.**

| Respondent        | Percentage |
|-------------------|------------|
|                   | Not good   | Low  | Adequate | Good  | Excellent |
| School X students | 1.83       | 7.97 | 15.95    | 58.31 | 15.95     |
| School Y students | 2.60       | 3.25 | 9.74     | 61.36 | 23.05     |
| School Z students | 1.43       | 4.49 | 12.04    | 61.22 | 20.82     |

Based on Table 6, 75.49%, 74.74%, and 79.56% of students provided positive responses (good and excellent) in School X, Y, and Z, respectively. It indicated that more than 50% of students respond positively to the mathematics test used.

It can be concluded that the students’ responses to the student worksheet and mathematics test related to solid geometry using the RME approach to develop the problem-solving skill were very positive.

### 3.6 Teachers’ response
Teachers’ responses were indicated from the questionnaires distributed to the teachers after the learning process. This questionnaire consisted of several questions related to the lesson plan and student worksheet developed. Three Year 7 teachers from the three schools involved participated in the survey. The results of the teacher questionnaire are illustrated in Table 8.
The uncompleted activity perception in the class discussion. There uncompleted activities, including expressing the idea in absence of a response from the students during uncompleted activity summarizing the learning material. There are seven completed activities and two uncompleted activities in the second lesson. The uncompleted activities happened because the students were doubtful in expressing ideas and feedback to other groups even though the average score of school X, Y and Z were 4.47, 4.57, and 4.26, respectively. Then, teacher questionnaire related to mathematics test was also administered, and the results are presented in Table 9.

| Respondent            | Average score on the lesson | Total average |
|-----------------------|----------------------------|---------------|
| School X teacher      | 4.42 4.42 4.42 4.63 | 4.47          |
| School Y teacher      | 4.42 4.58 4.63 4.63 | 4.57          |
| School Z teacher      | 4.42 4.21 4.29 4.13 | 4.26          |

The analysis of teachers’ responses related to Lesson plan and student worksheet indicated that the average score of school X, Y and Z were 4.47, 4.57, and 4.26, respectively. Then, teacher questionnaire related to mathematics test was also administered, and the results are presented in Table 9.

| Respondent       | Average score |
|------------------|---------------|
| School X teacher | 4.29          |
| School Y teacher | 4.43          |
| School Z teacher | 4.21          |

The analysis of teachers’ responses related to Lesson plan and student worksheet indicated that the average score of school X, Y and Z were 4.29, 4.43, and 4.21. It can be concluded that the teachers’ responses concerning the lesson plan, student worksheet and mathematics test of the geometry material using the RME approach to develop the problem-solving skills were very positive.

The first indicator of LIT effectiveness is the average activity on student worksheet (a minimum of 90%). Based on the analysis of those three schools, it is indicated that the average activity was more than 90%, meaning that the students are capable of applying and working on the student worksheet developed.

The second indicator is the average of active students’ activity (a minimum of 40%). The analysis found that the average activity was more than 40%, meaning that the students’ activity concerning the LIT of geometry material using a realistic mathematics education approach to develop the students’ problem-solving skills has been conducted well. This finding agrees with Taufiq [11] arguing that the learning media can develop positive students activity such as listening to the teacher explanation, understanding the learning material, completing student worksheet, actively discussing/asking the question to other students/teacher, presenting the work and summarizing [11].

The third indicator is the conformity between observed and expected students’ activity (a minimum of 80%). There were nine activities expected to be completed in the learning process. For the first lesson, there were seven completed activities in School X. While there were two uncompleted activities including expressing the idea in problem-solving; and expressing the answer and perception in the class discussion. This case occurred because students were not familiar with the problem-solving activity. There were seven completed activities and two uncompleted activities in the second lesson. The uncompleted activities were expressing the answer and perception in the class discussion and summarizing the concept and the procedure. Since no group could conclude the material learned so the teacher should direct the students to summarize the learning material. There were eight completed activities in the third and fourth lessons. The uncompleted activity was expressing answer and perception during class discussion, indicated by the absence of a response from the students during a group presentation.

There were seven completed activities on the first lesson in School Y, while there were two uncompleted activities, including expressing the idea in problem-solving; and expressing the answer and perception in the class discussion. There were eight completed activities in the second and fourth lessons. The uncompleted activity was expressing the idea in problem-solving and expressing the answer. This happened because the students were doubtful in expressing ideas and feedback to other groups even though...
they were confident in presenting their tasks. There was eight completed activity in the third lesson. The uncompleted activity was expressing the idea in problem-solving; this indicated that the students were not familiar with the problem-solving activity.

There were seven completed activities on the first to the third lessons in School Z. The uncompleted activity was expressing the idea in problem-solving. It was indicated that the students were not familiar with the problem-solving activity, so the teacher needed to support the student in understanding the problems presented. The other activities were well completed in School Z, including group discussion; presentation of the group task in front of the class; and expressing the ideas and giving the input to other groups. They had not been familiar yet in completing the problem-solving activity. All activities were expected to complete in the fourth lesson.

Based on the analysis of all students’ activities observed in those three schools, it was concluded that the conformity between observed and expected students’ activity was more than 80%. It means that the conformity between observed and expected students’ activity developed meets the requirement.

The fourth indicator was the improvement of test scores in problem-solving skill. The results showed that there was an improvement in the test score in each lesson in the three schools, even though there was a decrease score in the second lesson. The scores were improved in the third and fourth lessons. The decreasing score was because the students were only asked to describe the characteristics of the cylinder in the first lesson, but they were asked to determine the volume of a cylinder in the second lesson, requiring problem-solving skill related to cylinder volume. The finding is in line with Bonotto [12] who explained that geometry learning in the classroom requires emphasizing on the interrelationship among geometry concepts and connecting them to contextual situations in daily activities; so the students can describe geometry concepts and apply them in the problem-solving activity [12]. Cemalettin [13] also concluded that in mathematics learning, students need to understand the basic concept before understanding the new ones [13]. The mistakes and difficulties in learning the previous concepts can affect the difficulties in learning the next concept.

The fifth indicator was the students' response. More than 50% of students provided positive responses to the LIT. It means that the students had a positive response to the LIT developed. The sixth indicator was the positive responses of the teachers to LIT. The overall average score was above 4. It means that the teachers also had a positive response to the LIT developed.

It is concluded that LIT developed to meet the indicators, meaning that the LIT developed meets valid, practical, and effective criteria.

4. Conclusion
Based on the analysis dan discussion presented in the previous section, it is summarized that Local Instruction Theory (LIT) of Solid Geometry material on the Curriculum 2013 (revised 2014) developed by Ariani [6] is still relevant to Curriculum 2013 (revised 2016). Several revisions are required in the lesson plan component, adhering to the Permendikbud No. 22 of 2016 and the Curriculum 2013 (revised 2016). The outputs of the pilot test were the revisions of LIT, lesson plan, student worksheet, and mathematics test adhering to the Curriculum 2013 (revised 2016). The LIT of Geometry material using a realistic mathematics education approach in developing elementary students’ problem-solving skill has met the six effectiveness indicators determined. It is concluded that LIT developed satisfied six effectiveness indicators.

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