The Developing Mathematics-Teaching Learning Devices Based on CORE to Increase Students’ Ability to Communicate Mathematics

Putu Winda Marhayani Wijaya¹, I Wayan Puja Astawa², I Gusti Putu Suharta³

¹SMA Negeri 7 Denpasar, Jl.Kamboja No.9 Denpasar, Bali, Indonesia
²³Ganesha University of Education, Jl.Udayana No.11 Singajara, Bali, Indonesia

Email: windamarhayani11@gmail.com

Abstract. This study was aimed to obtained mathematics-teaching learning devices (lesson plan, student’s book, and teacher’s guidance book) in focus on the subject of functions in X Grade that was made based on CORE. This study was a design research by Plomp (preliminary research, prototyping phase, and assessment phase). Data were collected by using validation sheets (validity assessment), learning process observation sheet, student’s response questionnaire, teacher’s response questionnaire (practicality assessment), and mathematical communication test (effectiveness assessment). The collected data were analyzed descriptively.

The result of this research showed that developing mathematics-teaching learning devices are categorized: (1) valid, with average scores equal to 3.48; (2) practice, with average scores equal to 2.87, (3) effective, with average scores equal to 76.05.

The student’s book contained: (1) student’s activity based on CORE; (2) real problem in daily life; (3) open ended questions and tasks to cultivate mathematical communication; (4) motivation text in every topic to support the students.

The teacher’s guidance book contained: (1) substance of lesson plan, student’s book and its alternative solutions, (2) instruction in CORE learning.

Based on these results, the developing mathematics-teaching learning devices is expected to increase students’ ability to communicate mathematics

1. Introduction

There has been numerous innovation conducted in mathematics learning, such as cooperative learning [1], problem-solving-oriented learning [2], and technology-based learning [3]. Such learning innovations are done in order to reach the mathematics learning objectives i.e. in order for the students to possess the ability to comprehend mathematical concepts, to utilize reasoning, to solve problems, to communicate ideas, as well as to have respectful attitude towards mathematic activities in life [4]. Five basic mathematical skills included into the process standard namely problem solving, reasoning and proof, communication, connection, and representation [5]. Based on said matter, communication has strong connection to other mathematical processes, in which mathematical communication is the foundation in building mathematical comprehension [6]. Lomibao, Luna & Namoco (2016) mention that mathematical communication ability is the ability to express ideas, to describe, and to discuss mathematical concepts coherently [7]. In other words, mathematical communication skill as students’ ability to explain and to interpret mathematical ideas in speech and in writing, both in the form of illustration, table, diagram, formula or other demonstration [8].

But apparently the communication skills of mathematics receive less attention in the learning process [9]. Students are rarely asked to argue in learning mathematics, consequently it is very strange
for them to speak mathematics [10]. Students are also more required to listen to the teacher's explanation and work on problems based on the example given by the teacher or a particular algorithm, but students are rarely asked to communicate their ideas, either by asking questions or answering teacher questions [11]. The results of the publication of Lim and Pugalee (2004) stated that the mathematics communication skills of 9th grade students were evaluated, only 13% of students reached level 3 with level 4 as the highest level [12].

One sort of improvement that can be done is developing learning device. Posamentier (2007) states, “..., it is universally accepted a well-designed lesson plan is the main ingredient of a successful lesson.” The said statement supports that learning device development is important to be done by the teacher because with a good learning device it is expected that classroom learning to be good as well [13]. In fact, at SMA Negeri 7 Denpasar, the used learning device in mathematics lessons was student textbook with 2013 curriculum, but such book still required improvement due to syllabus and content alteration that led to the discrepancy of basic competence that was expected to be reached. Besides that, the selection of a learning model also has an important influence to adapt the students in self-constructing their knowledge and can direct the students to develop mathematical communication skill, one of which is CORE learning model. Calfee et al state, “The CORE model intercorporates four essential constructivist elements; it connects to student knowledge, organizes new content for the student, provide opportunity for students to reflect strategically, and gives students occasions to extend learning” [14]. CORE (Connecting, Organizing, Reflecting and Extending) learning model is a model which combines four important constructivist elements, namely connection to students’ knowledge, students’ new knowledge management, giving opportunities to students to reflect gained ideas, and giving opportunities to students to utilize or to develop their knowledge [15].

Based on the aforementioned argument, it was considered important to develop mathematical learning which supports the development of students’ mathematical communication competence. The developed learning devices were lesson plan, student’s textbook, and teacher’s guidebook compiled based on the learning model of CORE. The quality of the developed learning devices in this research were based on the criteria presented by Nieveen (in Suharta, 2016) namely validity, practicality, and effectiveness [16]. Valid device means that such device is decent to be used, experts’ judgements are required. A developed device is said to be practical if it is easy and can be conducted. The effectiveness of the developed learning devices in this research were measured based on the achievement of the learning objectives by using the developed learning devices. Based on that, in this research it was important to investigate the characteristics and quality of the learning device based on CORE that could improve the students’ mathematical communication skill as well as provide consideration on innovative development of mathematics-learning devices.

2. Methods
This research was a design research that developed mathematics-learning devices for Grade X of Senior High School in focus on the subject of functions. The device development procedure was based on the procedure by Plomp that consists of 3 phases namely preliminary research, prototyping phase, and assessment [17]. This design research was only up to attaining final products in which the trial of the devices was conducted with the research subjects, namely the students of Grade X of SMA Negeri 7 Denpasar in the academic year of 2017/2018 and did not conduct any trial at several other schools.

The first phase is preliminary research, in this phase a collecting activity, need and context analysis, literature review, field study as well as development conceptual establishment were conducted. From the identification results on the said learning process and mathematics learning devices, an initial draft, which was called prototype, I was later designed. The second phase is prototyping phase, in this phase the quality of the arranged learning devices was viewed. The conducted activities included testing the validity of the learning devices, which were still in the form of prototype I by two experts (validators) from Ganesha University of Education. Based on the result of this validity test a revision was later conducted so that learning devices were then obtained in the form of prototype II that had valid quality to be field-trialed later. Field trial was conducted to investigate
the practicality and effectiveness of the developed learning devices. The first trial conducted was limited trial. In limited trial, the devices were trialed on 16 students of X MIPA 10 class and a teacher. The trial implementation of the CORE-based learning devices took four meetings conducted on 2 until 5 January 2018. The focus of this trial was to gain a description of the implementation of learning process with CORE-based learning devices. On the implementation phase, the teacher and students did learning process based on the schedule and referred to the developed learning devices. Observation was done during the learning activities to see the implementation of the learning devices use by involving a teacher and an expert. The revision result of prototype II was called prototype III. The arranged prototype III was later trialed. The later trial was called field trial I, which was conducted on 9 until 31 January 2018 by involving 36 students of X MIPA 9 and a teacher. The focus of this trial was to improve product quality or to gain the characteristics of CORE-based mathematic learning process. The students were also provided with mathematical communication ability test at the end of field trial I and the results were used as the material in revising prototype III. The result of prototype III revision was called prototype IV. The last phase is assessment phase, in this phase field trial II was conducted on 1 until 24 February 2018 by involving 36 students of X MIPA 8 and a teacher. The results of the assessment were used as revision material, thus practically and effectively qualified CORE-based mathematics learning characteristics (final product) were obtained. The collected data were then processed descriptively. The learning devices in this were at least had to achieve valid, practical and effective category. In order to obtain valid and practical category, the average score of validation sheets, students’ responses, and the teacher’s responses questionnaire should at least reach 2.50 ≤ Sr < 3.50. The learning devices could be called as effective if the average score of the students’ mathematical communication ability test reached at least the determined passing grade, which was 70.

3. Results and Discussion
Based on the learning device development procedure, it was found out that in the preliminary research phase, the mathematics learning devices at SMA Negeri 7 Denpasar had not been optimal to accommodate the application of 2013 Curriculum, had been less close to students’ daily activities, and had not reached the expected competence especially in developing students’ mathematical communication skills. Based on the said identification results, lesson plan, student’s textbook, teacher’s guidebook and research instruments were then design.

In the prototyping phase the quality of the arranged learning devices were viewed. The conducted activities were testing the validity of the learning devices that were still in the form of prototype I by two validators. Based on the results of the validity test on the learning devices, a revision was done to obtain learning devices in the form of prototype II and the criteria of the developed learning devices are provided on Table 1 as follow.

| Validator | Lesson Plan | Student’s Textbook | Teacher’s Guidebook |
|-----------|-------------|--------------------|---------------------|
| 1         | 3.81        | 3.46               | 3.40                |
| 2         | 3.54        | 3.40               | 3.30                |
| Average   | 3.67        | 3.43               | 3.35                |
| Criteria  | Highly Valid| Valid              | Valid               |

It can be seen based on Table 1 that (1) the Lesson Plan was valid, which means that the Lesson Plan had met the CORE learning model steps. This could help teacher in teaching the students on functions material and support the teacher to direct the students to actively involve in the learning process, so they could develop the students’ mathematical communication skill; (2) the student’s textbook was valid, which means that the student’s textbook had met the students’ activities based on CORE learning which combines the principles of cooperative learning and constructivism-based learning; (3) the Teacher’s Guidebook was valid, which means that the teacher’s guidebook had met the steps of CORE-learning and had been equipped with answers on the student’s textbook, the provided alternatives of students and teacher activities could support the teacher in conducting
learning to reach the expected learning objectives. The instruments used to measure practicality and effectiveness such as observation sheet of the implementation of the learning devices, students’ and teacher’s responses questionnaire, as well as the student’s mathematical communication ability test were also categorized valid.

After obtaining the learning devices in the form of prototype II, field trial was later conducted to investigate the implementation, practicality and effectiveness of the developed learning devices. The first trial conducted was limited trial. During the limited trial implementation, several flaws were found on the learning devices, which were suspected to contribute to the disturbance of the learning implementation on the next trial. The revision results conducted on this phase was later called as Prototype III. In field trial I, the devices were trialed on all students of X MIPA 9 class and a teacher. On field trial I, most of the students showed cooperative attitude and began to show that they were courageous to communicate ideas both orally and written well. There was also flaws on the devices which required revisions. The revision result of prototype III was called prototype IV. On the assessment phase, the learning devices in the form of Prototype IV, was later field-trialed II. On field trial II, the devices were trialed on all students of X MIPA 8 class and a teacher. The following is the summary of the practicality of the learning devices.

**Table 2. The Summary of the Practicality of the Learning Devices Based on the Implementation of the Learning Devices**

| Phase          | Sr  | Category |
|----------------|-----|----------|
| Limited Trial  | 2.78| Practical|
| Field Trial I  | 2.82| Practical|
| Field Trial II | 3.01| Practical|
| **Average**    | 2.87| Practical|

Based on the above table, on field trial II, the average score of implementations was 3.01 and was categorized as Practical, which means that there was improvement on the practicality score from the previous trial. This shows that the learning devices had gotten more convenient to be conducted during the classroom learning. The same thing occurred to students’ responses towards the student’s textbook as illustrated on the following Table 3.

**Table 3. The Summary of Practicality of the Learning Devices Based on Students’ Responses**

| Phase          | Sr  | Category |
|----------------|-----|----------|
| Limited Trial  | 2.70| Practical|
| Field Trial I  | 2.75| Practical|
| Field Trial II | 3.12| Practical|
| **Average**    | 2.85| Practical|

Based on Table 3 the average score of student’s questionnaires was categorized as Practical, which means that the CORE-based student’s textbook had gotten more convenient and more interesting to be used by the students during the learning process compared to the previous trials. Besides that, the summary of teacher’s responses towards the learning devices is provided on the following Table 4.

**Table 4. The Summary of the Practicality of the Learning Devices Based on Teacher’s Responses**

| Phase          | Sr  | Category |
|----------------|-----|----------|
| Limited Trial  | 3.04| Practical|
| Field Trial I  | 3.21| Practical|
| Field Trial II | 3.45| Practical|
| **Average**    | 3.23| Practical|

Based on Table 4, the average score of teacher’s responses towards the learning devices (Lesson Plan, Student’s Textbook and Teacher’s Guidebook) was categorized as Practical. This shows that the overall Lesson Plan could be implemented well. The teacher’s responses towards the developed
teacher’s guidebook was also good i.e. made it easier for the teacher in conducting the learning process by using CORE learning model. Besides the practicality, field trial II also measured the effectiveness of the learning devices by using student’s mathematical communication ability test. The results of the mathematical communication ability test is provided on the following Table 5.

| Phase            | Average | Category    |
|------------------|---------|-------------|
| Field Trial I    | 74.59   | >Passing Grade |
| Field Trial II   | 77.52   | >Passing Grade |
| Average          | 76.05   |             |

Based on Table 5, the average score of the learning outcome surpassed the passing grade, which was the effectiveness criteria for students’ mathematical communication ability test. On field trial II, most of the students showed cooperative attitude and were courageous and began to develop in communicating their ideas and opinions both orally and written. With the improvement of the average score of the mathematical communication ability which was equal to or more than the passing grade, thus the developed learning devices based on CORE can be said as effective.

Based on the trial activities and the review of supporting theories it can be concluded that CORE-based learning devices has distinctive features. The occurring learning characteristics during the use of CORE-based learning devices among others are: (1) Emphasizing on prerequisite material on the connecting stage by providing a problem that was close to students’ daily life and was related to the material. The function of this real-life problem was so important so that the students could see the merit of mathematics in real life, develop reasoning, improve their attitude, as well as have source of inspiration in constructing mathematical concepts [18]; (2) Providing freedom to speak and to discuss for students with CORE stages to grow students’ courage in expressing their opinions.Communicating ideas or thoughts by using notations, symbols, tables, graphs or other mathematics model to explain mathematics problems is one of the objectives of mathematics learning [4]. Through good mathematical communication ability, the students can present their ideas to solve a problem by using various alternative solutions. The students needed to get accustomed to provide answers or argumentations on every idea so that everything that had been learned would became more meaningful [19]; (3) Providing motivational sentences to improve students’ confidence and passion in learning. The teacher became facilitator and motivator for the students who experienced difficulties during the learning process.

The characteristics of the developed CORE-based learning device (student’s textbook) in this research among others were as follows: (1) Facilitating student to share and to communicate their ideas and thoughts orally through discussion on the organizing stage in order to arrange new knowledge and on the reflecting stage the students were provided with freedom to communicate their understanding by using their own words on the empty columns as provided; (2) Close-to-daily-life problems occurred during the connecting stage; (3) Facilitating students in honing mathematics ability and skills by providing exercises and open-ended tasks on the extending stage, the students were provided with freedom to communicate their answers; (4) Providing support to the students through motivational sentences in order to improve their confidence and persistence in learning mathematics. Besides that, the characteristics of the CORE-based teacher’s guidebook among others were: (1) Containing Lesson Plan components and student’s textbook as well as answers and solutions to the tasks in the student’s textbook, the teacher only needed to bring the teacher’s guidebook because it had been synchronized to the other devices; (2) Containing guidance and directions that could be done by the teacher during CORE learning. Through description regarding the activities that should be done by the teacher during the learning, the teacher would gained general description regarding students’ learning steps by using CORE learning model and the developed devices.
4. Conclusions
Based on the result of this research and the discussion, it could be concluded that CORE-based learning devices which met the criteria valid, practical, and effective to improve their mathematical communication ability. The learning characteristics of using CORE-based learning devices among others were: (1) Emphasizing on prerequisite material on the connecting stage; (2) Providing freedom to speak and to discuss for students with CORE stages; (3) Providing motivational sentences to improve students’ confidence and passion in expressing opinions. Besides that, the characteristics of CORE-based student’s textbook among others were: (1) students’ activities were presented by using CORE stages; (2) there were close-to-daily-life problems; (3) providing exercises and open-ended tasks; (4) there were motivational sentences. The characteristics of the CORE-based teacher’s guidebook among others were containing the substances of Lesson Plan and student’s textbook along with the alternative answers and also containing instructions and directions for the teacher in conducting CORE learning.

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