Developing an Android application as a learning media oriented to problem-solving skill and mathematical communication skill for flipped classroom

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**Abstract**. This study aimed to: 1) develop an Android application as a learning media oriented to problem-solving and mathematical communication skills, 2) describe the characteristics of product developed based on validity, practicality, and effectivity. This study employed an ADDIE model (Analysis, Design, Development, Implementation, and Evaluation). The instrument of this study consists of an Android application validation sheet, a test to measure problem-solving skill and mathematical communication skills, and student response questionnaire sheet to evaluate the practicality. The product implemented to fourteen students second graders science program at State Senior High School 1 Ngemplak. The result of this study is an Android application as mathematics learning media named *AntureAdventure* for flipped classroom. *AnturAdventure* developed to train problem-solving skills and mathematical communication skills in the topic of anti-derivative. *AnturAdventure* meet the criteria of validity, practicality, and effectivity oriented to problem-solving and mathematical communication skills for flipped classroom.

1. Introduction

Technology cannot be separated in life. Ngafifi [1] states that a country is said to be a developed country if it has a high level of mastery technology, while countries that cannot adapt to technological advances are often called failed countries. Therefore, the use and mastery technology are very important in every aspect of life, including education.

In education, the use of technology in learning continues to grow, one of which is mobile learning. Mobile learning is the use of portable technology devices equipped with wireless network or cellphone networks to facilitate, support, enhance, and expand learning process and learning outcomes [2]. According to Taleb, Ahmadi, and Musavi [3], mobile learning offers enormous potential as a learning tool, because it can be used geographically separately, it can be used to present collaborative learning, to attract students’ attention to material, as an alternative learning resource, and can be used to convey information anywhere and anytime. In addition, according to Mahamad, Ibrahim, and Taib [4], mobile learning can be the best platform for everyone at all ages to always learn. This means that with the availability of mobile devices and internet networks, mobile learning has the potential to increase the efficiency and effectiveness of learning.

The Ministry of Communication and Information Republic Indonesia (*Kominfo*) has conducted a survey to find out an overview of the use of information and communication technology in Indonesia. The survey results released by *Kominfo* in 2017 show that smartphones are the most widely owned ICT devices in Indonesians, with a percentage of 66.31%. In addition, as many as 45% of Indonesians already use the internet [5]. This means that the internet has become part of the daily lifestyle of the Indonesian people. Seeing the fact of the high level of smartphone ownership and internet network access by the Indonesian people, mobile learning is very potential to be applied in Indonesia, one of which is through the Android application.

Integrating Android application is expected to improve the quality of learning, including learning mathematics. In learning mathematics, several competencies must be achieved by students, including problem-solving and mathematical communication. Problem-solving is defined as the process of finding a solution to a task whose solution method is not known quickly [6]. Problem-solving refers to a person’s effort to achieve a goal, for which they do not have an automatic solution to the problem [7]. NCTM [6] states that problem solving is an inseparable part of mathematics. Problem-solving is the main goal of all mathematics learning and is an integral part of all mathematical activities [8]. Thus, problem-solving is a very important competency in learning mathematics and helps determine student achievement in the field of mathematics.

Unfortunately, the achievement of high school student in Indonesia, in the field of mathematics has not been optimal. This can be seen from the average results of the National Examination for mathematics in three years, namely 2016, 2017, and 2018. Mastery of mathematics material for high school students, especially the science program in the last three years, is low and even tends to decline. In more detail, the percentage of material mastery by high school science program students nationally for each topic tested can be seen in Table 1.

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| **Table 1.** The average results of the national examination for mathematics in three years. |
| Topic | Year |
| 2016 | 2017 | 2018 |
| Calculus | 46.68 | 37.26 | 39.14 |
| Geometry and Trigonometry  | 48.78 | 37.45 | 39.30 |
| Statistics  | 50.78 | 46.57 | 38.78 |
| Algebra  | 59.54 | 43.75 | 39.55 |

Mathematical communication is also an important competency for students. Communication is a way to share ideas and clarify understanding [6]. Mathematical communication is the ability to convey mathematical ideas, both verbally and in writing, as well as the ability to understand and accept other people’s mathematical ideas carefully, analytically, critically, and evaluatively to sharpen understanding [9]. Mathematics communication skills are the ability to communicate which includes activities using writing, listening, studying, interpreting, and evaluating ideas, symbols, terms, and mathematical information that is observed through the process of listening, presenting, and discussion [10]. So mathematical communication becomes an important part of mathematics. Mathematical communication is not only about how to communicate an idea but also describes the level of student’s understanding and mastery of mathematical material.

Several experts have conducted research to determine the level of mathematical communication skills of student in Indonesia. The results of case study by Merdian and Sari [11] show that many students have difficulty working on problems with mathematical communication skills, especially in understanding the questions and interpreting them. Similar results were also conveyed by Chotimah [12] and Zetriuslita [13] that students’ mathematical communication skills were still low. In addition, based on the results of need analysis sheet filled in by mathematics teacher at State Senior High School 1 Ngemplak, Sleman, Yogyakarta, it was also stated that only about 40% of students had good mathematical communication skills.

The low ability of problem-solving and mathematical communication skills of student should be a concern of the teacher. The teacher as a facilitator has a role to help students build knowledge in each lesson, including helping students improve their problem-solving skills and mathematical communication skills. One way that teachers can do is by choosing the right learning model. One learning model that can be used by teachers is a flipped classroom.

The flipped classroom is a learning model in which learning materials or learning instructions are given at home through videos that have been compiled by the teacher, while what is usually used as homework in traditional learning models is done in the classroom during learning [14]. Flipped classroom involves online learning through a series of instructional videos supported by a face-to-face learning through discussion and individual activities [15]. With the high ownership of technological devices, especially smartphones accompanied by high internet usage, flipped classroom assisted with Android application has potential to be applied. As far as research information related to Android and flipped classroom, until now there has not been found an Android application that is used as mathematics learning media for a flipped classroom that is oriented to problem-solving and mathematical communication skills.

Therefore, it is important to do research on developing android application as mathematics learning media that is oriented to problem-solving and mathematical communication skills for flipped classroom. The learning media developed were learning media for calculus material, especially anti-derivative material for second-grade high school students referring to the 2013 Curriculum.

1. Research Methods

## Types of Research

The type of research is a Research and Development follows the ADDIE model which is intended to develop Android application as mathematics learning media for a flipped classroom. ADDIE model consists of five stages, that are analysis, design, development, implementation, and evaluation.

* 1. *Time and Place of Research*

This research was conducted in April-May 2020 at State Senior High School 1 Ngemplak, Sleman, Yogyakarta.

* 1. *Research Subjects*

The product trial subjects of Android application users were 14 second graders science program at State Senior High School 1 Ngemplak, Sleman, Yogyakarta.

* 1. *Instruments and Data Analysis Technique*

The instruments are 1) an Android application validation sheet to measure the validity of the android application, 2) a test to measure problem-solving skills and mathematical communication skills, 3) student response questionnaire sheet to evaluate the practicality.

To know the validity of the Android application developed, carried out by looking at the result of an Android application validation sheet. There are two types of Android application validation sheets, an Android application validation sheet from the material side and an Android application validation sheet from the media side. The result of an Android application validation sheet is classified into five classes. The categorization is calculated using the following formula in Table 2, where M=(maximum score+minimum score)/2, and S=maximum score-minimum score)/6 [16]. The criteria used are presented in Table 2. The Android application developed is said to be valid if at least it reaches a good category.

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| **Table 2.** Categorization formula and the criteria used. |
| Interval of Mean | Category |
| $$\overbar{x}>M+1.8S$$ | Very Good |
| $$M+0.6S<\overbar{x}\leq M+1.8S$$ | Good |
| $$M-0.6S<\overbar{x}\leq M+0.6S$$ | Enough |
| $$M-1.8S<\overbar{x}\leq M-0.6S$$ | Less |
| $$\overbar{x}\leq M-1.8S$$ | Very Less |

To know the effectivity of the Android application developed, carried out by looking at the result of the test. The Android application developed is said to be effective if the average of the test result is greater than or equal to 70. The data were analyzed descriptively and followed by hypothesis testing.

To know the practicality of the Android application developed, carried out by looking at the result of the student response questionnaire sheet. The result of the student response questionnaire sheet is classified into five classes. The categorization formula and the criteria used are shown in Table 2. The Android application developed is said to be practical if at least it reaches a good category.

1. Research Results and Discussion

The results of this study are divided into two parts, namely: 1) the results of the development of Android application, and 2) the results of the analysis of the quality of Android application from the aspects of validity, effectivity, and practicality. The Android application as mathematics learning media developed is named *AnturAdventure*. *AnturAdventure* is an abbreviation of *Anti turunan* Adventure or Anti-derivative Adventure. With the *AnturAdventure*, it is hoped that students can go on an adventure to learn anti-derivative material more easily and pleasantly.

*AnturAdventure* is divided into three parts, namely: the introduction, the main section, and the closing section. The introduction contains the login page, sign up page, and main menu page. The main section contains four levels of learning, each of which is a sub-topic of anti-derivative. The four levels are: 1) Level 1: Anti-derivative relationship with derivatives, 2) Level 2: Anti-derivative properties, 3) Level 3: Application of anti-derivatives, 4) Level 4: Application of anti-derivatives to solve differential equation problems. Each level in *AnturAdventure* contains a menu of *Bekal* (Supplies), *Latihan* (Exercise), *Tantangan* (Challenges), and *Bekal Tambahan* (Additional Supplies).

The Supplies menu contains the material needed by students to be able to solve question on the Exercise and Challenge menu. The exercise menu contains multiple-choice questions to train students in solving questions. The Challenge menu contains problems that are challenging for students to solve with anti-derivative concepts. In solving problems on the Challenge menu, students must follow the problem-solving steps, which includes write down what is known, write down what was asked, make a mathematical model, write down the steps required, complete each steps that has been arranged, and write down the conclusion of the answer obtained. After all the steps are filled in, a dialog box will automatically appear that says: “Are you sure of your answer?”. The appearance of this dialog box is intended for students to check the answers obtained. Looking back the answers that have been obtained are also part of problem-solving steps.

The Additional Supplies menu contains additional links to material that can be accessed by students to increase their knowledge. Through this additional menu, students can watch the learning videos that have been prepared. In the final adventure, there is an Examination menu that aims to evaluate students’ abilities after an adventure to study anti-derivative material. This Exam menu is divided into two parts, multiple-choice questions and essay questions.

The closing section contains the closing page. The closing page contains information that the adventure in the Android application has ended, thanks to students, motivation for students to continue learning, and a column for requests the suggestions from students.

Android application as mathematics learning media (*AnturAdventure*) was tested on 14 students’ second graders science program at State Senior High School 1 Ngemplak. Learning in school is carried out using the flipped classroom model so that there are students’ activities outside the classroom and inside the classroom. The android application is used as a learning media for student learning outside the classroom while learning activities that have been compiled in the lesson plan are applied during class hours. During the implementation phase, Indonesia was hit by the Covid-19 pandemic, so learning in schools was carried out by online learning, including at State Senior High School 1 Ngemplak. Therefore, the implementation phase in this study was also carried out through online learning with schoology.com.

In general, the implementation process using *AnturAdventure* and online learning through schoology.com went well. However, several obstacles still emerged, such as the implementation of group discussions through schoology.com which did not work optimally because students in one group did not access the discussion forum at the same time. This is in line with Green and Perkins [17] which states that several problems that arise in the implementation of flipped classroom include: difficulties in synchronizing group meeting schedules, difficulties in working collaboratively on project completion because some members are often not in the same focus concerning with understanding the material.

After the implementation phase, the next step is to analyze the quality of the product developed. The analysis includes the analysis of validity, practicality, and effectivity. The results of the validity show that the product developed is valid based on the Android application validation sheet. The Android application validation sheet is carried out from the material side and the media side. The validation results from the material side are in a very good category. Meanwhile, the validation results from the media side are in a good category. From these results, it can be concluded that the *AnturAdventure* is valid.

Practicality was analyzed from the results of the student response questionnaires that were filled in by students after participating in learning activity. Filling in the student response questionnaire is done via a google form. Based on the results, the average results are in a good category. So, it can be concluded that the product developed is practical. The students’ comment written on the google form also show that students give good responses to the use of the *AnturAdventure* in learning mathematics.

The effectivity is analyzed from two aspects, namely: problem-solving skills and mathematical communication skills. The effectivity in terms of problem-solving skills and mathematical communication skills is analyzed based on student test scores. Descriptively, the average problem-solving skills test result was 79.84. It is higher than 70, thus meeting the effectiveness criteria. After the descriptive analysis, hypothesis testing was also carried out. The results of hypothesis testing also show that the android application is effectively used in terms of problem-solving skills. Meanwhile, the test results of mathematical communication skills show an average value of 77.38. This average is also higher than 70, so it meets the effectiveness criteria. After hypothesis testing, the results of the mathematics communication skills test also show that the android application developed is effective in term of mathematical communication skills.

The results show that the use of the *AnturAdventure* as mathematics learning media was effective to support learning using the flipped classroom model. Bhagat, et al. [18] states that with technological advances and the use of the flipped classroom, teaching and learning mathematics can be made more enjoyable and effective. The flipped classroom can improve skills, knowledge, and good attitude towards learning [19]. Flipped classroom is very motivating and more effective in achieving learning outcome [17].

*AnturAdventure* is effective for train problem-solving skills and mathematical communication skills. Features that serve to train problem-solving skills and mathematical communication skills are the Supplies menu and the Challenge menu. In the Supplies menu consist of anti-derivative concepts and examples of problem-solving problems along with the steps for solving it. The solution steps shown refer to the indicators of problem-solving skills and mathematical communication skills that synthesized from the experts, namely: write down what is known; write down what was asked; created mathematical models of problems using appropriate notations, symbols, mathematical terms, or visualizations; write down the steps needed to answer the questions; complete each step that has been compiled; and write down a conclusion [20] [21] [22] [23] [24] [8] [25].

After studying the material and examples of solving problem through the Supplies menu, students are given the challenge to solve problem-solving problems through the Challenge menu. In solving the problem, students must also follow these steps: write down what is known; write down what was asked; created mathematical models of problems; write down the steps needed to answer the questions; complete each step that has been compiled; and write down a conclusion. It aims to train students’ problem-solving skills and mathematical communication skills.

1. Conclusion

This research and development produce an Android application as mathematics learning media named *AnturAdventure* for flipped classroom. *AnturAdventure* stands for *Anti turunan* Adventure or Anti-derivative Adventure. *AnturAdventure* consist of three main parts, namely: introduction, main menu, and closing menu. The introduction section consists of a login page, a signup page, and the main menu page. The main section consists of four levels with each level containing a menu of Supplies, Exercises, Challenges, and Additional Supplies. The closing section contains the closing page. *AnturAdventure* was developed to train problem-solving skills and mathematical communication skills. The main part of *AnturAdventure* that support problem-solving skills and mathematical communication skills are the Supplies menu and Challenge menu because there are problem-solving problems that must be slved by students following the problem-solving steps presented. The *AnturAdventure* as mathematics learning media meet the criteria of validity, practicality, and effectivity oriented to problem-solving and mathematical communication skills for flipped classroom.

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