Interactive Multimedia-based Teaching Material for Trigonometry

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Abstract. Trigonometry was one of difficult subject matter to be understood by senior high school students in Indonesia. Developing teaching material was one of alternatives to solve that problem. This study aims to develop the interactive multimedia-based teaching material for supporting students of senior high school in comprehend of trigonometry subject matter, namely Math Learn. This was an android-based application which developed through the stages of define, design, develop, and disseminate. The first step of developing was identify the problem and define the product will be developed. The next stage was design the storyboard as the guidance to develop the application. This application consists texts, picture, music, and animation. Two teaching and multimedia experts had validated the application. After revised based on experts’ advice, the application developed was judged valid. It had been disseminated to mathematics teachers and students in senior high school. Teachers stated that this application was very useful to delivered concept of trigonometry in senior high school while the students expressed that it helps them in understanding the concepts of trigonometry.

1. Introduction

One of the skills which a student must have in the 21st century is information, media and technological skills. Students must have good literacy skills in information, communication, and technology. This is because the most of instructional process delivered using digital technology. Teachers taught using computer, notebook, LCD, and internet. Nowadays, teaching materials are not only provided by printed but also in electronic. There are a lot of learning resources around the students. School is not the only one place for student to study. Thus, the use of technology and information-based devices will have an important role in student learning activities.

One of the technology and information devices that are familiar with students is smartphone. In 2017, 65,000,000 Indonesians use smartphones [1]. This means 25% of Indonesians are using smartphones. Of the smartphone users, 16.68% of them are students of junior to senior school age [2]. Senior high school students use smartphones for three main activities: social media, chatting, and playing games [3]. The use of smartphones to support learning activities has not been done.
Given the intensity of smartphone use for students is very high, it is necessary to develop ways to utilize smartphones to improve the quality of learning. One way is to utilize the smartphone as a mobile learning tool. Mobile learning is the next generation of e-learning that is based on mobile devices [4]. Mobile Learning or M-Learning is a type of e-learning that delivers educational contents and learning support materials through wireless communication devices [5]. Likewise, mobile learning as a personalized, connected, and interactive use of handheld computers in classrooms, in collaborative learning during fieldwork, and in counseling and guidance [6]. Mobile learning that can be developed for learning is to load applications in the form of teaching materials with android-based. Android is a mobile operating system based on Google [7]. In Indonesia, 94% of smartphone users use smartphones with android operating system.

In Indonesia, mathematics is a subject studied by students at various levels of education. The results of the national examination in 2016 show that at the high school level, there are 4 competencies tested. There were algebra, calculus, geometry and trigonometry, and statistics and probability [8]. Trigonometry was the most difficult to master by students. The average score of senior high school students in Indonesia on trigonometric material was only 40.90. Further, presented in table 1.

| Number | Competency                          | Score  |
|--------|-------------------------------------|--------|
| 1      | Algebra                             | 49.85  |
| 2      | Calculus                            | 50.55  |
| 3      | Geometry and Trigonometry           | 40.90  |
| 4      | Statistic and probability           | 46.30  |

The low percentage in mastering of trigonometry could be affected by some factors. Instructional material is one of them. It has main rule to make instructional efficient and improve students’ performance [9]. The most frequent errors made by student in solving problems in trigonometry include comprehension error, transformation error and process skill error [10]. It assists the teacher and allows students’ interaction and make students to achieve better and higher in lesson [11]. Instructional material used by the teacher was one of learning facilities kind which affect the students learning activity.

Visual teaching material is the most popular instructional material used by teachers in Indonesia. They usually use handout, book, module, and student’s worksheet in their lesson. The characteristic of these instructional materials are only present the seeing media like pictures, texts, or graphics. They are unable to provide sounds, animations, video, and interactive activity needed in trigonometry.

Trigonometry student’s comprehension could be improved if students have an innovative and flexible learning resource so students can learn whenever and wherever. Lately, android mobile learning applications for trigonometry has been developed by teaching material developers. Unfortunately, in presenting trigonometry material they only provide a texts, pictures, and sounds. There were not a video. Moreover, students access them only by their self. They do not provide an interactivity among some students. Therefore, it need to develop an innovative mobile learning application for trigonometry subject matter in senior high school using android. It provides a video and competition features. These menu motivate student to learn seriously. After learned the material, students can evaluate their comprehension by joining a competition. Students who most often win the competition will be the winner.

2. Method
This research was a research and development. Research procedure used in this research was four D procedure (Define, Design, Develop, and Disseminate) [12] showed at figure 1.
The first step was define. The aims of this research was to develop an application of teaching material for trigonometry using android system operation. The second step was product designing. Designing product was done by arranging the storyboard and setting up the tools and materials needed. Personal computer, trigonometry material, and Adobe Flash CS6 Professional software was used to develop the application. The third step was develop the application based on the design. Two multimedia experts and two mathematics content knowledge had reviewed application developed. It had been tried to 25 senior high school students. It also had been disseminated to mathematics teachers of senior high school in Yogyakarta Indonesia.

3. Result and Discussion
This development research was conducted by defining the product at the first step. The product that would be developed is application of teaching material for trigonometry using android operation system namely “Math Learn”. It could be applied in smartphone which using android system operation. This application contains various media namely text, audio, image, animation, and video. Interaction between user and the features will be the advantages of this product. Users can access the application to operate it and get feedback base on their instruction. Adobe Flash CS6 Professional was a software which used to develop the application.

This application was designed by mapping out the storyboard. It is an idea visualization to build the application that give a representation of the application developed [13]. Storyboard shows the story stages or a sequence of cases [14]. It also interpreted as visual representation describing certain scene [15]. It presents visual script as as project outline as a guide of product developer. Figure 2 show the storyboard of product developed. The icon of menus above are a button. So, user can hits them to explore the contain more.

![Figure 2](image-url)

Figure 2. The above view is the main display of application of mobile learning for trigonometry. It contains 6 menus (PETUNJUK/INSTRUCTION, PROFIL/PROFILE, MATERI/MATERIAL, EVALUASI/EVALUATION, KOMPETISI/COMPETITION, and VIDEO).

After the tools and materials were ready, the product was ready to be developed. Product was developed based on the design. Using personal computer and Adobe Flash CS6 Professional software, storyboard developed to be more complete dan interactive as shown at figure 3.
Product developed has main view consisting animations related trigonometry like angle, phi, sinus, and cosines. The title of the application is Math Learn Trigonometry. It contains 6 menus (PETUNJUK, PROFIL, MATERI, EVALUASI, KOMPETISI, and VIDEO). Each menu can be chosen by selecting the icon and hitting it. Each menu can be moved to the right and left. When the icon is clicked, it will display to the page related. By hitting PETUNJUK menu, the stage will display the instructions how to operate the application (figure 4). By hitting PROFIL menu, the stage will display the application developer profile (figure 5).

**Figure 3.** Products developed.

**Figure 4.** PETUNJUK menu content.

**Figure 5.** PROFIL menu content.

MATERI menu shows users about the competency will be reached, material of trigonometry (angle, quadrant, trigonometry identity, sine and cosine property, and the application of trigonometry) (figure 6). EVALUASI menu provides tests consisting multiple choices items tests to evaluate students’ comprehension about trigonometry (figure 7).
Figure 6. MATERI menu content.

Figure 7. EVALUASI menu contains 20 multiple choices items consisting 5 alternatives answer.

After finished doing the test, the stage will display the result of the test (figure 8). Student identity, score, how many items correct and false, and the assessment showed in the stage.

Figure 8. The result of the test.

KOMPETISI menu shows users items exercise to be competed among the classmates (figure 9). In this menu, two students of teams make a tournament or competition to assess their comprehension in trigonometry. Student or team who get the higher score will be the winner.
Figure 9. KOMPETISI menu contains 10 items test that must be competed by two students or groups.

Student or group must answer the items correct and faster than the rival. A student or team who answer one item correct and faster, he/she will get 100 score. The winner is student or group that collecting score higher. Figure 10 shows the final of the competition.

Figure 10. Final result of the competition.

VIDEO menu contains two videos of trigonometry material (figure 11). First video is about the sine, cosine, and tangent of special angels. The second one is about the application of trigonometry in daily life.

Figure 11. VIDEO menu content.

In developing process, this product was reviewed by two experts in multimedia and two experts in mathematics content knowledge. The result is showed at table 2 and 3.
Table 2. Review of multimedia experts.

| No | Review |
|----|--------|
| 1  | Main stage must be reflected the content |
| 2  | The color between background and the text must be contrast |
| 3  | The type font of the text is readable clearly |
| 4  | The size of texts are reasonable |
| 5  | It contains nice audio, video, image, and animation |
| 6  | The presentation of menus are consistent |
| 7  | Mathchingcolors |
| 8  | The menu icon must represent the content |

Table 3. Assessment of mathematics content knowledge experts.

| No | Assessment |
|----|-------------|
| 1  | The angle size should not only in degree but also in radian |
| 2  | To differ the positive angle and negative, need an illustration of drawing angle animation |
| 3  | The item test in evaluation menu should be in various difficulty |
| 4  | The content must be related with students daily activity |

After the product revised based on the expert review, they gave score shown at table 4 (scale 84).

Table 4. Score of product developed.

| Validator                        | Score | Category |
|----------------------------------|-------|----------|
| Multimedia experts               | 80.74 | Very good |
| Mathematics content knowledge    | 86.67 | Very good |

Table 4 shows that application developed is very good category. It means the application is valid as a teaching material of trigonometry. The last step, it disseminated to 10 mathematics teachers and tried to 29 students of senior high school.

These days, students do not study only in school using traditional learning but also in another place they can do that. Traditional learning is learning at the classroom where students receive learning material from the teachers [16]. Curriculum in Indonesia had changed this method to be constructivist method. Students are given the opportunity to build their knowledge by constructing the knowledge from any resources (internet, peers, parents, society, and nature). Information, technology, and communication are used in instructional. There is currently an increase in the number of devices used for classroom learning [17,18]. Many softwares were built to develop the instructional material. With the existence of technology-based teaching materials enriching the learning carried out[19].

This research had developed an application of learning material for trigonometry using android operation system namely Math Learn. It is one type of Computer Aided Learning (CAL). It is application of technology-based for teaching and learning [20]. Math Learn was developed to provide students a teaching material in order to help them mastering trigonometry material. This application can be installed in smartphone. Therefore, students have the opportunity to make use of this application to study trigonometry both at school and house. In teaching in school, mathematics teachers can use it as teaching material to deliver the material, especially trigonometry. They do not necessary to write on the board, display material on the liquid crystal display (LCD). To deliver teaching material they just ask students to access their smartphone and operate the application. Teachers facilitate them when they have any questions or something unclear during learning. Because smartphone is a mobile device, students can access it everywhere, even at there house. By this way, students have a self regulated learning both at school and house.
The development of this teaching material is oriented towards the achievement of learning objectives. Because basically the development of teaching materials is not solely oriented to the technology used but oriented towards learning objectives [21]. The application can be implemented by mathematics teacher to teach trigonometry. Various model of teaching can use it. This is corresponding with the study in 2016 that by integrating the teaching material and teaching method can be implemented optimally [22].

Base on the implementation in class, indicating that Math Learn helps students to comprehend the trigonometry material. The average score of student's achievement in trigonometry after using this application was 77.77. The minimum completeness criteria is 75.00. It means Math Learn is effective in helping student to comprehend trigonometry. From this application, students have a new and innovative learning resources. It is mobileable with more complete informations (material, simulation, exercise, video, evaluation, and competition). It is not like a book, module, or student's worksheet which only provide text and graphics. Students can use it to study not only at the classroom but also in everywhere and every time they want using interactive multimedia teaching material [23]. With mobile learning students can get clear information and repeat learning [24]. Mathematics teacher stated that it helps them in teaching trigonometry. They have more alternative instructional material to deliver mathematics material especially trigonometry. By utilizing technology-based learning and information can improve the quality of learning [25].

4. Conclusion
This research has developed a valid application of interactive multimedia-based, namely Math Learn, as instructional material for trigonometry using android operation system. Math Learn had been disseminated to mathematics teachers. It had also been implemented in class of trigonometry instructional in senior high school. Math Learn helps students to comprehend the concept of trigonometry and give the teacher an alternative teaching material of trigonometry.

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