Interactive multimedia-based teaching material for 3-dimensional geometry

A Prabowo, R P Anggoro, D Astuti and S Fahmi
Universitas Ahmad Dahlan, Jalan Prof. Dr. Soepomo SH, Warungboto, Umbulharjo, Yogyakarta 55164, Indonesia

E-mail: anggit.prabowo@pmat.uad.ac.id

Abstract. This study aims to develop the interactive multimedia-based teaching material for 3-dimensional geometry in junior high school. The product was produced through the stages of define, design, develop, and disseminate. Two media experts and two teaching experts had validated it. They judged that the product developed was valid. It had been revised based on their advice. It has been disseminated to 15 mathematics teachers and tried to 30 students of junior high school. Teachers stated that this product gives a new form of teaching material in 3-dimensional geometry. According to the student, the product is interesting. It can motivate them to study mathematics, help them to master the material and increase their interest in mathematics.

1. Introduction
Mathematics is a subject learned by students from elementary school level to higher education level. It is always related to human activities as it helps human life to be easier. Mathematics plays a main role in many branches of science such as physics, engineering, and statistics [1]. Thus, it has a main role in developing of science and technology [2]. Considering the importance of mathematics in the human life, students have to be skilled in the mathematics subject. However, the real condition of students in Indonesia does not meet the expectation. The Indonesian national examination in 2016 showed the low score of the students in mathematics. Compared to the other subjects (Bahasa Indonesia, English, and Science), the students’ score in mathematics was the lowest (50.24) [3] as shown in Figure 1.

![Figure 1. Score of the Indonesian national examination in 2016](image-url)
This problem needs a notice from teacher, parents, government, and all part related why mathematics being the hardest matter for students. Students’ competence in mathematics which measured at national examination consist 5 competencies. The percentage of competence achievement is shown in Table 1.

**Table 1. Percentage of competence achievement in mathematics at national examination**

| Number | Competence Assessed                                                                 | Percentage |
|--------|-------------------------------------------------------------------------------------|------------|
| 1      | Using arithmetic concept and number property, comparison, exponential number, root number, social arithmetic, sequence number, and the use in problem solving | 60.64      |
| 2      | Understand the algebra arithmetic, linear equation and inequality concept, line equation, set, relation, function, Linear equation system, and their use in problem solving | 57.28      |
| 3      | Understand the congruent concept, property of flat shape, and concept of relation of angles and/or line, and use them in problem solving | 52.44      |
| 4      | Understand the property of 3-dimensional, and use it in problem solving.              | 51.37      |
| 5      | Understand the property of statistics and use them in problem solving                | 62.28      |
| 6      | Understand the concept of probability of event and use it in problem solving          | 56.25      |

Based on Table 1, the lowest percentage of achievement is understanding the property of 3-dimensional shapes, and use it in problem solving. The 3-dimensional is a geometrical object with length and width (base area) and height such as cone, pyramid, sphere, cylinder, prism, cube, and cuboid [4].

Mastering competency is affected by students activity in learning. The low percentage of mastering in understanding the principle and element of 3-dimensional geometry could because of some factors. One of them is the instructional material. Instructional materials have the main role in teaching and learning of school subjects to promote teachers’ efficiency and improve students’ performance [5]. Instructional resource assists the teacher and allows students’ interaction and make students achieve better and higher in lesson [6]. Instructional material used by the teacher was one of learning facilities which affect the students learning activity.

The most popular instructional material used by teachers is visual teaching material like handout, book, module, and students worksheet. These kinds of instructional material only present the seeing media like pictures, texts, or graphics. They are unable to give the sounds, 3-dimensional animations, video effect and interactive activity that needed in study geometry. Instructional material needs them because competency of understanding the principle and element of 3-dimensional geometry, and using it in problem solving needs good spatial ability. Students’ difficulty in geometry was caused by non-availability of instructional materials and teachers’ method of instruction [7]. Students generally encountered difficulties in geometry and performed poorly in senior secondary school mathematics lesson [8].

The spatial ability could be improved when a teacher teaches using the multimedia-based instructional material. It can provide media effects like audio, video, simulation, animation, and video related to 3-dimensional geometry. Therefore, it needs to develop the interactive multimedia-based for 3-dimensional geometry subject matter in senior high school.
2. Method
This was a research and development (R&D) using 4D (Define, Design, Development, and Dissemination) procedure [9] shown in Figure 2.

Step 1 was define. The product developed was an interactive multimedia-based instructional material for 3-dimensional geometry. Step 2 was design. The instructional material was designed by constructing the storyboard and preparing the tools and material. It was developed using Macromedia Flash Professional program. Step 3 was development. The product developed has been reviewed by four experts (2 multimedia experts and 2 teaching experts) and tried to 30 junior high school students. It also was disseminated to 15 junior high school mathematics teachers.

3. Results and discussion
The steps of this research started from defining the product developed. The product is an interactive multimedia-based for 3-dimensional geometry. It contains all aspects of media i.e. text, graphic, audio, video, and animation. The product is interactive. Users or students have an access to operate it and get a response base on what they want. It was developed using Macromedia Flash Professional program.

This product was designed by constructing the storyboard first. Storyboard is a visualization of the idea of the application to be built, so that gives an overview of the application to be generated [10]. The storyboard shows the stages of a story or an order of events [11]. Storyboards also defined as “...a visual reference depicting particular scene or action, usually taken from a screenplay or some other form of the written storyline.” [12]. It provides visual script as an outline of the project which will be used to be guided to develop the product. It is shown in Figure 3.

The main display contains 7 menus (SK-KD, MATERI, LATIHAN, EVALUASI, VIDEO, PROFIL, and PETUNJUK). When the SK-KD menu is clicked, the page will show the competence standard and basic competence of teaching material. MATERI menu shows users the types flat sided spaces (cubes, beams, prisms, pyramids) and curved side spaces (cones, tubes, balls). LATIHAN menu shows users 10 items exercise followed by discussion. EVALUASI menu gives users an 10 item test to evaluate their
comprehension of the 3-dimensional material. *VIDEO* menu contains videos related to a 3-dimensional geometry. *PROFIL* menu will display the profile of the instructional material and the developer. *PETUNJUK* menu shows the instructions to operate the product. After the storyboard was prepared, it needs to specify the tools and materials used to develop the product as shown in Table 2.

### Table 2. Tools required

| Tools                  | Function                                                      |
|------------------------|---------------------------------------------------------------|
| Personal Computer      | Used to develop interactive multimedia-based teaching materials |
| Printer                | Used to print storyboard                                      |
| Scanner                | Used to scan images to be used in teaching materials          |
| CD                     | Used to save data                                            |
| Flash drive            | Used to save data                                            |
| Speaker                | Used to check the functionality of audio media on instructional materials |

After the tools required were prepared, the designing instructional materials were complete and ready for product development as shown in Table 3.

### Table 3. Materials required

| Material                     | Function                                                        |
|------------------------------|-----------------------------------------------------------------|
| Macromedia Flash Professional| Used to create programs                                        |
| 3-dimensional material       | Used as the content of developed teaching materials             |
| 3-dimensional shape          | Used as the content of developed teaching materials             |
| Video                        | Used as the content of developed teaching materials             |

The product development was done by implementing the plan that has been designed at the early stage. Based on the storyboard that has been compiled, the product is successfully developed as shown in Figure 4 and Figure 5.

**Figure 4.** The storyboard of the main display of the multimedia

**Figure 5.** The product of the main display of the multimedia
The main menu of the product consist some 3-dimensional shape in daily life like ball, bottle, wardrobe, cone hat, tent, Rubik, and roof of the house. It also contains 7 menus (SK/KD, Materi, Latihan, Evaluasi, Video, Profil, and Petunjuk). When each menu is clicked, they will go to the page related.

After the product developed, it was assessed by 2 media learning experts and 2 mathematics material experts. The result of media learning expert assessment is shown in Table 4.

**Table 4. Assessment of media experts**

| No | Assessment |
|----|------------|
| 1  | The arrangement of days and dates overlaps, especially between months and years |
| 2  | The instructions for using are clear, so it is easy to operate the products. |
| 3  | The language used is simple so it is easy to understand |
| 4  | The cover of the developed product CD already represents the contents |
| 5  | The font type used is correct so it is easy to read |
| 6  | The letters size are proportional |
| 7  | Alloy colors are presented in harmony |
| 8  | The quality of audio, video, image is good |
| 9  | The presentation of the menus is presented consistently |

The result of teaching expert assessment is shown in Table 5.

**Table 5. Assessment of teaching experts**

| No | Assessment |
|----|------------|
| 1  | The use of square and square mathematical symbols is not displayed properly |
| 2  | The material presented is suitable with the competence to be achieved |
| 3  | The material is presented in a coherent manner |
| 4  | Training questions have been completed with the discussion so as to facilitate the students to know the truth of the answer |
| 5  | The discussion of exercise questions is presented appropriately |

The experts gave scores in 84 maximum scale for the product as presented in Table 6.

**Table 6. Score of product based on experts judgment**

| Validator      | Score | Category  |
|----------------|-------|-----------|
| Media expert 1 | 77    | Very good |
| Media expert 2 | 72    | Very good |
| Teaching expert 1 | 83    | Very good |
| Teaching expert 2 | 70    | Very good |

Based on the expert assessment above and after the revision based on expert judgment, it can be concluded that the developed teaching material is very good and can be said valid. The last step, valid product disseminated to 15 teachers of mathematics in junior high school. They implemented the product as a teaching material for 3-dimensional geometry. Figure 6 and 7 show it.
Nowadays, instructional was not only held in the classroom by talk and chalk. Traditionally, instructional methods have been described “presentation forms” such as lectures and discussion [13]. Traditional learning is an activity occurring in the classroom where teachers deliver learning the material to students [14]. Traditional instructional is started to be abandoned. Instructional using the more various method and instructional material had been implemented in the class. Instructional using technology is not strange. Along with these developments, there exists a prodigious increase in the amount of educational software provided for use in a class [15, 16]. Many applications are provided to develop teaching material. Every new technological development opens new opportunities for lesson planning for teachers and learning tools for student [17].

This research had produced an interactive multimedia-based instructional material of 3-dimensional geometry for junior high school. It is the kind of Computer Aided Learning (CAL). CAL means the application of computers integrated with learning system for learning and teaching process [18]. It was developed to help students in mastering 3-dimensional geometry. In the developing process of computer-based learning program, the concern is not on “what technological tools are to be used during the development process of e-learning program”, but it is on “how to design and plan an e-learning program that ensures the achievement of the learning objectives” [19].

The product developed can be used the mathematics teacher of the junior high school to teach 3-dimensional geometry. It can be implemented with various models of learning in the classroom available computer facilities. It confirms that the use of teaching material should be integrated with the teaching method such that it can be implemented optimally [20].

Based on the implementation of the product in class, it helps students to master 3-dimensional geometry material. The score of student achievement in 3-dimensional geometry was 85.67 from score maximum 100.00. The minimum criteria for mastery learning is 75.00. Students got more information (material, simulation, exercise, discussion, video tutorial, and evaluation) from the product. Students used it not only in the classroom but also in their house using computer or notebook. It gives a capability for students to study at home. An interactive multimedia instructional material, the information more meaningfully and repeatedly can be obtained by students [21]. Many kinds of media are provided by interactive multimedia more systematically using rich instructional strategies [22].

Beside affect in cognitive, the product developed also affect to affective aspect of students. There are 80.00% students that state that studying using interactive multimedia more motivate them to study mathematics. The interactive multimedia instructional material also made them more interest in mathematics (76.67%). Technology-backed learning environment motivates students to participate and to interact with others in the instructional process [23]. Their motivation made them confident in studying mathematics. Interactive multimedia helps the students to strengthen self-esteem in a learning community [24-27]. From this study, 86.67% students state it.
4. Conclusion
This research has produced a valid interactive multimedia-based teaching material of 3-dimensional geometry for Junior high school. It had been disseminated to mathematics teachers and implemented in the class of 3-dimensional geometry instructional. This product help students understand the concept of 3-dimensional geometry, motivate to study mathematics, and increase their interest and self-esteem in mathematics.

References
[1] Muijs D and Reynolds D 2005 Effective Teaching Evidence and Practice (New Jersey: Pearson-Merrill Prentice Hall)
[2] Fabi yi T R 2017 Geometry concepts in mathematics perceived difficult to learn by senior secondary school students in Ekiti State Nigeria IORS Journal of Research & Method in Education (IOS-JRME) 7 83
[3] BSNP 2016 Laporan Hasil Ujian Nasional Tahun Pelajaran 2015/2016 (Jakarta: Badan Standar Nasional Pendidikan)
[4] Salman M F 2009 Active learning techniques (ALT) in mathematics workshop: Nigerian primary school’s assessment International Electronic Journal of Mathematics Education 4 23
[5] Olayinka A R B 2016 Effect of instructional materials on secondary schools students’ academic achievement in social studies in Ekiti State, Nigeria Worlds Journal of Education 6 32
[6] Omebe C A and Akani O 2015 Effect of instructional resource on students’ achievement in physics and chemistry in secondary schools in Ebonyi state Nigeria European Journal of Training and Development Studies 2 56
[7] Adolphus T 2011 Problems of teaching and learning of geometry in secondary schools in River State Nigeria International Journal of Emerging Science 1 143
[8] Adegun I K and Adegun B O 2013 Students and teachers’ views of difficult areas in mathematics syllabus: basic requirement for science and engineering education Journal of Education and Practice 4 235
[9] Thiagarajan S, Semmel D S and Semmel M I 1974 Instructional Development for Training Teachers of Exceptional Children: A sourcebook (Minnesota: ERIC)
[10] Waryanto N H 2005 Storyboard dalam Media Pembelajaran Interaktif (Yogyakarta: Yogyakarta State University)
[11] Birchman J and Sadowski M 2006 Idea development and communication through storyboards American Society for Engineering Education 1723 11.711.1
[12] Fraioli J O 2000 Storyboarding 101: A crash course in professional storyboarding (California: Michael Wiese Productions)
[13] Heinich R, Molenda M, Russel J D and Smaldino S E 1996 Instructional media and technologies for learning (New Jersey: Prentice-Hall Inc.)
[14] Astra I M, Nasbey H and Nugraha A 2015 Development of an android application in the form of a simulation lab as learning media for senior high school students Eurasia Journal of Mathematics, Science & Technology Education 11 1081
[15] Bayram S and Nous A 2004 Evolution of educational software evaluation: instructional software assessment TOJET 3 21
[16] Le Q and Le T 2007 Evaluation of educational software: theory into practice Technology and Teaching ed J. Sigafoos and V Green (New York: Nova Science Publisher) chapter 11 pp 10-11
[17] Rosado D E N V, Argüero M E and Rojas R 2014 An adaptive interactive multimedia system for intelligent environments International Journal of Information and Education Technology 4 54
[18] Rahmawati E and Hartati S J 2013 The application of computer-aided learning to learn basic concepts of branching and looping on logic algorithm The International Journal of Multimedia & Its Applications (IJMA) 5 15
[19] Tuparov G, Tuparova D D and Peneva J 2004 Proceedings of the 5th International Conference on Computer Systems and Technologies (Ruse: University of Ruse) pp. IV.14.1-6
[20] Fadillah S and Jamillah 2016 Pengembangan bahan ajar struktur aljabar untuk meningkatkan kemampuan pembuktian matematis mahasiswa Jurnal Cakrawala Pendidikan 35 106
[21] Dembo M H and Seli H 2012 Motivation and Learning Strategies for College Success: A Focus on Self Regulated Learning (New York: Erlbaum)
[22] Qureshi E 2004 Instructional Design Models (Ontario: University of Windsor)
[23] Leow F T and Neo M 2014 Interactive multimedia learning: innovating classroom education in Malaysian university The Turkish Online Journal of Educational Technology 13 99
[24] Suh H 2011 Collaborative learning model and support teaching technologies in the future classroom International Journal for Educational Media and Technology 5 50
[25] Young J R 2017 Technology integration in mathematics education: Examining the quality of meta-analytic research International Journal on Emerging Mathematics Education 1 71
[26] Fathurrohman M, Porter A L and Worthy A L 2017 Teachers’ real and perceived of ICT supported-situation for mathematics teaching and learning International Journal on Emerging Mathematics Education 1 11
[27] Tanujaya B, Prahmana R C I, and Mumu J 2017 Mathematics instruction, problems, challenges, and opportunities: A case study in Manokwari regency, Indonesia World Transactions on Engineering and Technology Education 15 287