Multimedia animation for mathematical application in engineering

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Abstract. The concept of mathematical applications in engineering is still difficult for students to understand because besides they have to understand the technical concepts; they also be able to associate it with the mathematical concepts. One aspect that needs more understanding of this concept is how to visualize the technical concepts so that mathematical rules can be modelled. Therefore, the purpose of this research is to develop multimedia animation for the concept of mathematical applications in the field of engineering. The method used in this study is analysing the development needs of multimedia, both in software and hardware, the material of mathematical application that used in engineering, design, development, and testing. The results of the study show that multimedia animation in the application concept of mathematical in engineering is able to explain abstract concepts from mathematical concepts in engineering. The results of testing from media and material experts show that this animation multimedia is considered feasible to use.

1. Introduction
Multimedia is a technology product that is widely used in various fields, including learning processes in schools or colleges. Several studies using multimedia have been conducted, such as in the field of art [1], learning courseware in English [2], graphic [3], and architecture [4]. Multimedia has advantages such as being able to simulate, sound, move, video, etc., can be used as a learning aid.

Multimedia technology has become increasingly mature. This growth further promotes the development of multimedia technology and brings challenges for teaching strategy and method. Multimedia teaching system can effectively achieve resource sharing [5]. Without space and time limit, students can rationally arrange the time to study according to their needs, learning plan and knowledge structure. Multimedia teaching systems can improve students' abilities and interests as a form of using advanced technology to obtain information that is immediate, real-time, and fast.

The use of multimedia in universities is still very limited at this time. In fact, multimedia with its advantages is considered suitable to be used in college learning. There are still many students who have difficulty in understanding the concepts taught, especially in abstract concepts [6]. Even though students at their age are considered to have abstract thinking ability, but in reality, there are still many students who are difficult to understand abstract concepts, so that certain facility is needed to increase their abstract thinking process. Efforts that can be made to encourage them to have the ability to understand abstract concepts are by using media/tools that can display and clarify abstract concepts to become more real.
Multimedia is one of the alternative media that can be used to anticipate this problem because multimedia able to display animation and simulation, so abstract concepts can be illuminated by the support of simulation and animation [7]. With the help of multimedia, the instructors can explain abstract concepts easily; thus, the learning process can proceed in accordance with the expectation.

Multimedia provides various kinds of conveniences and advantages, such as the existence of interactive properties which means it can be opened anywhere and anytime when it is needed. This benefit causes multimedia very suitable for use in individual student learning. In addition, multimedia provides various facilities such as text, graphics, images, sound, video, and animation [8], so multimedia is very suitable to be used as a medium or a tool in learning because of the availability of all components that support learning [9]. The use of media in learning process is still very limited because the lack of teacher's ability to develop and use multimedia. When in fact, using multimedia in learning process need to be considered to stimulate students' interest in learning through animation and simulation [1]. Similar to other educational media, multimedia still performs as a tool, method, and approach used to establish communication between teachers and students during the teaching and learning process.

The use of media in learning process is not mandatory. A teacher who teaches without media cannot say that he failed to teach. However, the media plays an essential role in directing the learning process so that the expected results are achieved. The advantages of teaching supported by media or multimedia are: 1) providing more understanding of the discussed learning material because it can explain difficult or complicated concepts to be easier or simpler; 2) explaining abstract learning material or objects (unreal, cannot be seen directly) to be concrete (real, can be seen, felt, or touched); 3) helping teachers present learning materials more easily and quickly so that students can be certainly understand the materials, memorize the materials for a long term, and easily recall them; 4) attracting students' attention, interest, motivation, activity, and creativity and also entertaining them; 5) evoking students' participation in the learning process and giving a deep impression in students’ minds; 6) learning material that has been learned can be replayed (playback), for instance, by using video recordings, compact disks (solid discs), tape recorders, or televisions; 7) forming the same opinion and correct perception of an object, because the material is not only conveyed verbally but also in a concrete form by using learning media; 8) creating a conducive learning environment, so that students can communicate and interact with their surroundings, thus providing a real and direct experience; 9) establishing students' attitudes (affective aspects), improve their skills (psychomotor); 10) students learn according to their characteristics, needs, interests, and talents, both learning individually, in groups, or in classical conditioning; 11) saving time, energy and costs [7].

Nowadays, simulations and animations can be operated by using multimedia. Animation and simulation provide easy feedback (feedback) to what is demonstrated [10]. Animation and simulation are widely used in explaining the concepts of mathematics, language or other applied subjects. Animation and simulation are basically one of the learning strategies that intend to provide a more concrete learning experience through examining the imitation of experience that resembles the real form and take place in a risk-free environment. Animation and simulation are divided into 4 categories which are physical, situation, procedure, and process. All these four categories explain the steps taken in the animation and simulation process. Therefore, in this study, multimedia animation will be developed that later can be used to facilitate students in understanding abstract engineering concepts that require mathematical concepts.

2. Methods
The method employed in this study is in accordance with the method of software development [11]. The chart of multimedia animation development is as follows:
The explanation of the stages of the employed research method in figure 1, are as follows: 1) The development of animation multimedia starts with the needs analysis phase, including the analysis of software, hardware, users, interfaces, and material. This stage is very important so that multimedia can be in line with other elements such as hardware, databases, etc. Then, software requirements analysis is conducted i.e. examining required software that will be used in the development of animated multimedia. 2) Designing, which is the process of changing the above mentioned needs into representations in the form of "blueprint" software before coding begins. The design must be able to implement the requirements mentioned in the previous stage. Similar to the previous two activities, this process must also be documented as a configuration of the software. 3) Developing is the process of creating multimedia. This stage is the implementation of the designing stage which is technically done by multimedia creators. 4) Testing is the process which involves a test toward the created multimedia animations so that all menu functions, error-free buttons, and the results suit the needs that have been previously set. It includes the test to multimedia users, to seek their responses whether the menus in multimedia are easy to use and the operation of multimedia is fast without any errors. If there are still errors then repairs must be made. In this step, experts, both media experts and material experts, also conduct a test on the multimedia. 5) Implementation, which means applying multimedia animation in learning processes to students.

3. Findings and discussion

3.1. Findings

In accordance with the method employed in this study, the research process begins with the initial steps of multimedia development i.e. the stage of needs analysis. Needs analysis of multimedia animation development includes software, hardware, material, user, display requirements, and display sequences analysis in multimedia animation.

The development of this multimedia animation uses flash software by considering that this software is quite compatible with other software. Hence, the developed multimedia can be run by other operating systems such as Microsoft Windows.

The results of hardware analysis demonstrate that the hardware for the multimedia must have the specifications of a Core 3 processor with 1 GB memory, a monitor with 102400 resolution, and 1 GB hard disk capacity minimum in order to run properly. Minimum hardware specifications are required for the development and implementation of multimedia animations as shown in Table 1.

The results of the material analysis which is going to be displayed in the multimedia are mathematical material consists of differential, derivative, and integral equations. Meanwhile, the technical material which is going to be displayed is braking, energy conversion, and tensile testing. These materials are part of the technical material which its multimedia animation will be created. These materials use a lot of mathematical concepts and most of them are abstract, so the animation is needed to help students
understand the materials more clearly. Some animations are self-developed by researchers, while other animations are downloaded from https://phet.colorado.edu/. The results of the display analysis and display sequence analysis reveal that the appearance and sequence do not attract much concern because the multimedia animation users are adolescent students. They have been able to read the instructions well and use the computer frequently, so they are familiar with the menu of an application.

Table 1. Minimum requirement of hardware.

| H/W            | Specification |
|----------------|---------------|
| Processor      | Core 3        |
| RAM            | 1 GB          |
| Hard disk      | 1 GB          |
| Display Resolution | 102400   |

The next step in developing this multimedia animation is designing. In this step, the storyboard, multimedia animation flowchart, and animated multimedia display are designed. Multimedia animation flowcharts are shown in Figure 2. The flowchart contains a sequence of multimedia animation from the start menu, and then information about the multimedia includes usage instructions, learning objectives, about multimedia animation, choices of lecture materials, test, animation, and closing.

![Flowchart of multimedia animation](image)

**Figure 2.** Flowchart of multimedia animation.

An example of this multimedia animation storyboard is presented in Figure 3 which consists of the initial display, start menu, and animation page. In the flowchart, three courses are planned to be selected by students. After learning the three courses, the user must take a test on multimedia before completing it.

From Figure 3, we can see part of the multimedia animations storyboard starting from the opening page to the animation page. On the animation page, there is an image of a car that shows how the braking function works on a vehicle.
After the process of designing a flowchart and storyboard, the next step is development. At the development stage, multimedia animation is made according to the design that has been decided. Figure 4 is an example of a display of multimedia animation that has been developed. In Figure 4, the animation for the brake system in a vehicle is shown. The animation is about the process of shrinking the thickness of the vehicle brake canvas. The animation shows the initial thickness, final thickness, and duration of use for several months. In the picture on the right, the graph of the depletion rate of the brake disks on the vehicle according to the mathematical function produced by the modelling process of brake thickness shrinkage is displayed. From the results of the animation, it can be seen whether the brake discs need to be replaced or not. In addition, predictions of mathematical functions can be calculated that is used to calculate brake time. Based on this animation, later in the lecture the relation between modelling and the mathematical concepts used are required to be discussed.

After doing the multimedia development, it is continued with the testing phase. This testing phase uses the black box analysis method. The results obtained presents that multimedia animation is seen to be feasible to be used. The next step is expert judgment. In this process, there are two experts involved i.e. media and material experts. This validation involves experts in the field of study relating to multimedia
learning. The aspects assessed in media validation are aspects of design presentation, aspects of ease of interaction, accessibility, reusability and compliance standards as shown in Table 2 below:

Table 2. Validation of learning multimedia by media experts.

| Aspects               | Number of items | Ideal score | Ideal score | %   |
|-----------------------|-----------------|-------------|-------------|-----|
| Design                | 2               | 10          | 9           | 90% |
| Ease of Interaction   | 3               | 15          | 13          | 87% |
| Accessibility         | 2               | 10          | 10          | 100%|
| Reusable              | 1               | 5           | 4           | 80% |
| Compliance Standards  | 1               | 5           | 4           | 80% |
| **Average**           |                 |             |             | 87.3% |

From Table 2, the results show that overall the supporting aspects of the multimedia obtain good results with 87.3% for the average. This value indicates that multimedia has been developed according to user needs and is feasible to use. Material validation was carried out by technical experts and mathematicians. The aspects assessed in this validation are content quality aspect, learning aspect, feedback and adaptation aspect, and motivational aspect as shown on the table below:

Table 3. Learning multimedia validation by material experts.

| Aspects                  | Number of items | Ideal score | Ideal score | %   |
|--------------------------|-----------------|-------------|-------------|-----|
| Quality of content/material | 4               | 20          | 17          | 85% |
| Learning                 | 4               | 20          | 19          | 95% |
| Feedback and adaptation  | 1               | 5           | 4           | 80% |
| Motivation               | 1               | 5           | 5           | 100%|
| **Average**              |                 |             |             | 90% |

Based on Table 3, it can be seen the results of multimedia validation by material experts obtain the average percentage of feasibility 90% included in the category of "very good". This means that the material presented in multimedia is in accordance with the learning needs of applied mathematics in the field of engineering. Suggestions from material experts to improve these media are adding certain materials that are considered more difficult for students to understand so that students can learn them well.

3.2. Discussion

Based on the findings of this study, it can be explained that the development of multimedia animation is conducted in accordance with the steps of software development. The consideration is because multimedia is categorized as a type of application or system, so in developing multimedia, some steps is required like when developing software. Multimedia must be able to meet user needs, it is necessary to do the steps of needs, design, development, testing, and implementation analysis according to user needs [3,12].

All development processes have been carried out. Therefore, it is hoped that this multimedia animation can be used as an alternative in applied mathematics lectures. Multimedia with its advantages is expected to support the increase of the success of student earning processes [13]. The animation exemplified in multimedia is adjusted to the needs of research i.e. to improve the ability of students to understand the abstract concepts [14-16]. With animation, students can see the brake disc thinning process in a simulation, with no need to directly look at the real running vehicle. This learning process is expected to increase students' mathematical connection skills gradually because students not only see
the animation but also can associate it with mathematical concepts that are used along the animation process.

The results of expert testing of this multimedia animation as shown in Table 2, reveal that multimedia animations are very feasible in terms of the design presentation aspects. It means that the design is good and does not confuse the user. From the convenience aspect also shows that multimedia animations are easy to use by users. The functions of menus, icons, or commands provided in multimedia animation are easily understood, so users can use this multimedia without problems. Likewise, aspects of accessibility, usability, and application compliance standards all show decent results. It means that based on the opinion of media experts, in general, this media is very suitable to be used in the learning process.

The results of the examination of material experts who examines aspects of the quality of material content, learning, feedback and adaptation, and motivation displays very decent results as well. All aspects are scored above 80%. It means that based on the aspect of material feasibility it shows that this multimedia animation is feasible to use. The material presented in multimedia meets minimum standards to be used in the learning process.

4. Conclusion
Animation multimedia was developed in accordance with the steps of the appropriate multimedia development, by considering aspects of students’ needs and the taught materials. After testing by material experts and the media, on multimedia animation, they see that multimedia is feasible for use in applied mathematics in engineering

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