Education-based _augmented reality_ applications for heat learning media content lesson in physics

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**Abstract.** This study aims to create applications that can be used as a medium of physics learning with sub-material heat. Application-shaped learning media created using Augmented Reality-based technology Android. The application created is named Mecalor. Mecalor application process using the Waterfall method. This Waterfall method provides a sequential approach to software lifecycle. Testing the feasibility of the application is done through four characteristics of the ISO 25010 standard which *Suitability Functional*, *Performance Efficiency*, *Portability*, and *Usability*. The test was conducted in Garut - Indonesia Vocational High School with a total of 30 students and two software experts. Data analysis techniques use a Likert scale and Guttman scale. The test results on the characteristics of *Functional Suitability applications*, *Performance Efficiency*, and *Portability* is valid with a percentage of 100% so it can be said that the application is good to use. Likewise, characteristics *Usability* test results also suggested a value of 3.9 so that applications can Mecalor declared fit for use.

1. **Introduction**

Each student's learning style different from each other. This learning style can help a person to optimize his ability in learning. There are three types of learning styles based on the modalities of visual, auditorial, and kinesthetic [1]. Among the three types of learning styles, the visual learning style has a stronger influence on learning. This is evidenced by the results of research [2] states that visual learning styles, auditorial learning styles, and kinesthetics learning styles are related to each other with visual learning style coefficient of 0.080; auditorial learning style of 0.043; and 0.079 kinesthetics learning style.

A person who has a visual learning style tends to have strong visual-spatial intelligence. This is reinforced by the results of research that prove that visual-spatial intelligence has a percentage of 67.86% higher than formal thinking skills tests and for ability tests describing molecular shapes [3].

The subject of physics is an example of a subject that requires visual intelligence is a subject of physics. This is because the eyes of physics learners explain something abstract and visible. Heat is one of the subject matter of physics that explains something visible. The heat of movement cannot be seen directly unless practiced. In physics book [4] to know simulation does the heat movement but only conventional written simulation, so it will be difficult to know the movement of heat with the visible. Then we need a tool that is used to visualize the concept.

Currently, the technology is growing rapidly, one example of a technology that is popular and growing is Augmented Reality [5]. Before Augmented Reality appears Virtual reality is already known,
according to RD Robert Joan [6], the difference between Augmented Reality and Virtual Reality is in its function. Augmented Reality can be used in various fields such as Medicine, engine, robot, entertainment, and military [7]. Also, this technology can also be used for the education field as has been done by Septi Elvira [8] who utilize Augmented Reality as a means of prayer study guide. Mobile devices have a high potential to be used as an Augmented Reality media app [9]. With this potential then by using a smartphone, the spread of Augmented Reality will be wider.

The final goal of this research is to create an interactive learning media using Augmented Reality technology with the Mobile device. However, the developed Augmented Reality application will contain only caloric material. With this application is expected to serve as an alternative learning media interesting in the process of improving the quality of education, especially on the subject of physics.

2. Methods
Software development using the Waterfall method. This method is often referred to as a linear sequential model or a classical lifestyle. This waterfall model provides a sequential or sequential approach to software lifecycle starting from analysis, design, coding, and testing. Here is a picture of the waterfall model:

![Waterfall Model](image)

**Figure 1** Flow Waterfall [10]

While the software modelling using UML (Unified Modelling Language) which is a standardized modelling language using object-oriented programming techniques. UML is used to specify, describe, build, and document software systems. UML design that will be used is the Use Case diagrams, Activity diagrams, and sequence diagrams. Use case or use case diagram is to perform system modelling information to be made. A use case describes an interaction between one or more actors with the information system will be created. Activity diagram or activity diagram describes the results of the workflow (workflow) or activity of a system or business process or menu on the software. Sequence diagrams illustrate the behavior of objects in use case by describing the life time of the object and the message that is sent and received between objects. Software that will be used to create applications is Blender and Unity and Vuforia plugin. Blender is an open source application design and 3D animation package for free that can be used by Windows, Linux, and MacOS [11]. Unity 3D is a game maker and a suitable application for game developers, game enthusiasts, and can be used to create programs, designing, developing video games, focusing on the things that become a necessity game [12]. Vuforia is a software platform that use to create Augmented Reality applications.

3. Result and Discussion
Mecalor is software designed as a medium of physics learning with sub-material calor for high school/vocational students. Applications Mecalor an Android-based application using Augmented Reality technology. In the development process, this application has been through several stages including, the stage of analysis, the design phase, the coding phase and the testing phase. The analysis phase is the stage before the application is developed technically. At this stage of the analysis is done
by doing literature study on the syllabus of physics class X high school along with the physics package book. From the results of the analysis that has been done, starting with reading the book, understand the material, then analyze and describe it then give a conclusion. The next stage is the design stage, at this stage scheduled application development to have a scheduled time. Also at this stage done modelling the application design both the User Experience Design and User Interface Design. Results from the design stage and then conducted the implementation at the encoding stage created using Blender and Unity.

Periodically applications repaired and tested by ISO 25010. There are four criteria used include Suitability Functional, Performance Efficiency, Portability, and Usability. Functional Suitability Testing is done to 2 experts with using the instrument test cases that have been adapted to a functional application. The results of this test were 100% with the classification "Valid" so that it can be concluded that the applications meet the standards Functional Suitability.

Efficiency Performance Tests carried out by the software on the site cloudy. Results of the test are the average time it takes to run the application is about 20-30 seconds, the device activity using CPU resources while running an average application is 66.3MB, and device activity using Memory resources while running the application the mean average is 14.4%. It can be concluded that the Mecalor application is identified as a sufficient application using resources. However, although a lot using the resources of the test results did not cause any warning or error, it may be said that the application Mecalor classified applications regarding both Performance Efficiency.

Portability Testing is done by software on the site cloudy. The results of this testing Mecalor states that applications can be installed, uninstall and di- di- updates on a wide range of devices and OS versions, and can customize the appearance of applications in different screen sizes.

Usability testing is done by the method of trying out a direct application to the user. This test is done to students in SMK YPPT class XI Multimedia with some students as many as 30 people. The test is performed using questionnaires Usability of USE Questionnaire. The questionnaire includes indicator Usefulness, Ease of Use, Ease of Learning and Satisfaction. The test results indicator-indicator is at 3.9 with the classification of "Eligible." So, the application can be said to be good regarding Usability.

Some problems were found in this study is on when the camera is directed at the marker 3D objects sometimes does not appear, it is they are due on the lighting marker. If the marker is used in the room glow then the faster the 3D objects will appear and vice versa. Moreover, in some application device running a bit slow due to the application of this Mecalor consume quite a lot of CPU resources and memory. But the application has not been doing a Mecalor force close to the device for developers to provide special features to exit the application.

4. Conclusion
Based on the results of research and discussion then the researchers can take the following conclusions:
 a) Based on the results of testing the characteristics of Functional Suitability, Portability, and Performance Efficiency shows that the application meets the standard characteristics well, b) Application Mecalor Able help Inpart big Students understand Material heat. This supported with results Usability testing to users at 3, 9 with classification "Eligible."

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