

The Development of Learning Media for the Kinetic Theory of Gases Using the ADDIE Model with Augmented Reality

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Abstract. For senior high school students, learning concepts in physics is increasingly more difficult when the topic is abstract and cannot be seen with the unaided eye. The research here utilized augmented reality technology and instructional design following the ADDIE model (analysis, design, development, implementation and evaluation) to develop learning media for physics, specifically the kinetic theory of gases. Preliminary analysis was conducted in a senior high school to evaluate the challenges students face when learning physics. The design of the media was based on addressing problems that the students were having. Augmented reality technology was then utilized and the implementation aimed to incorporate the physics concepts into the product. The media was evaluated by six experts. Finally, the learning media presented real-time 3D animation of gas kinetic theory with three basic competencies relevant to the topic. In the final validation, the results indicated that the developed learning media had a validity value of 3.55 out of four-point scale and good quality outcomes. As such, the developed media regarding the kinetic theory of gases is valid and effective for the process of learning and teaching. It is ready to be tested and used in actual learning environments.

Keywords: *Augmented reality, Kinetic theory of gases, Media, Validation.*

1 Introduction

Education is a key factor in the development of a country. It is a conscious and deliberate effort to create an atmosphere for the learning process so that learners actively develop their potential along with maturity in spiritual aspects of religion, self-control, personality, intelligence, character, and skills, and contribution to the community (Indonesia's education regulation No. 20. 2003). In Indonesia, physics is one of the covered science subjects and compulsory for a student in the natural science major in senior high school. The physics curriculum includes natural phenomena, and using a process consisting of observation, measurement, analysis, and conclusion. The conclusion must be based on a scientific approach that is based on facts, honest research, with effort that is patient, persistent, tenacious and careful

in reaching conclusions. In practice, physics is very much correlated with a mathematical approach, and although physics is not merely understood in terms of math, it is vital to be able to understand the concepts contained therein, and to describe the phenomena into appropriate parameters or symbols. Additionally, it is important to understand the roots of the problem so that it can be solved mathematically.

In the syllabus of Indonesia's Senior High School 2013 Curriculum, students are required to understand the materials of gas kinetic theory and describe the characteristics of the gas in the enclosed space (Kemendikbud, 2013). This indicates that high school students are required to be able to observe, question, explore, associate and communicate everything about the kinetic theory of gases. In order to study the kinetic theory of gases, there are many concepts that are invisible in the discussion, including the behaviour of gas particles which are correlating with microscopic and macroscopic quantities. The invisible characteristics of the material will be easier to understand if they are associated with everyday experience and visualized in the learning. Therefore, the need a media that enables the presence of kinetic theory of gases simulation on the microscopic phenomena is a must so that students will be easy to understand.

2. Methodology

The development of the media in this research was conducted at the Laboratory of Physics Education Program, Department of Mathematic and Natural Science Education, University of Riau (Universitas Riau). It was started from the design using instructional ADDIE (Analysis, Design, Development, Implementation, Evaluation) model (Morrison, 2010) with the augmented reality technology to the media validation by the experts. One of the advantages of this model is allowing feedback based on continuous assessment throughout generating media.

The first phase of the ADDIE model called analysis phase, was to do the analysis on the seeking of main problem in the physics learning process. Hence, the learning outcome, learning material and learning assessment should be based on Indonesia's Curriculum 2013 for the Senior High School. The analysis was done referring to the result of the direct discussion with some senior physics teachers from a representative school. One of the problems found, the student was very hard to understand the physics concept for the kinetic theory of gases due to the topic is abstract and cannot be seen with the unaided eye.

The design phase was subjected to the result from the analysis stage. The design here was to make sure the product of learning media can be used to

solve the problem obtained in the first stage. The feedback was collected from six experts to ensure the validity of the design.

Once the problem and design phase were completed, the media was ready to develop. The Adobe Photoshop CC 2015 was used to design the marker, and the 3D object was created using Blender 2.77. Augmented reality can be defined as a human-machine interaction tool that presents information generated by computer on the real world using a camera. The use of camera can increase the understanding and motivation of the student. The camera can aid the teacher in development of a multitude of classroom based multimedia resources (McHugh, 2015). Furthermore, visualization in combination with predict-observe-explain experiments offers students and teachers a pedagogically powerful means for unveiling abstract yet fundamental physics concepts (Jesper et al., 2015; Loo, 2012; Joshua, 2013; Noa et al., 2016). Augmented reality technology has the potential to draw student's attention to visualize a layer of information on real objects using handheld devices such as tablets and smartphones (Nazatul et al., 2015; Nils, 2015; Fengfei et al., 2015). The augmented Reality stage was realised using Unity 5.24 and the finally Vuforia SDK was used to provide the camera for this purpose. Finally, the real time three dimensions media can be seen visually using mobile android camera or using computer camera.

The last stage was to do evaluation which the result of the evaluation will imply either the media is valid or not valid. The validation of the media has been done by some experts. The validation process was to assess the media in term of the design, pedagogic, content and usability. All the aspects have been covered by the thirty eight questions with four in scale. The lowest value was 1 which means very not agree, 2 means not agree, 3 means agree and 4 means very agree.

3. Results and Discussion

3.1. Designing of the learning media

The design of learning physics media using Augmented Reality technology is to provide alternative solutions in teaching of the kinetic theory of gases. The material design is based on the Indonesia's Curriculum of 2013. The development of this media is made for three meetings consisting of several sub-materials and equipped with exercises. Each meeting is preceded by appreciation (figure 1).

3.2. Developing of the Learning Media

This physics learning media using augmented reality technology was developed with the Unity 5.2.4 application, which is useful for integrating three-dimensional objects and markers, as shown in figure 2. Development

of augmented reality was also assisted by the Vuforia Unity 5:59 packages, which is offered by a provider of cameras and augmented reality tools, which transforms markers into the target image by uploading markers to a website without the need for coding.

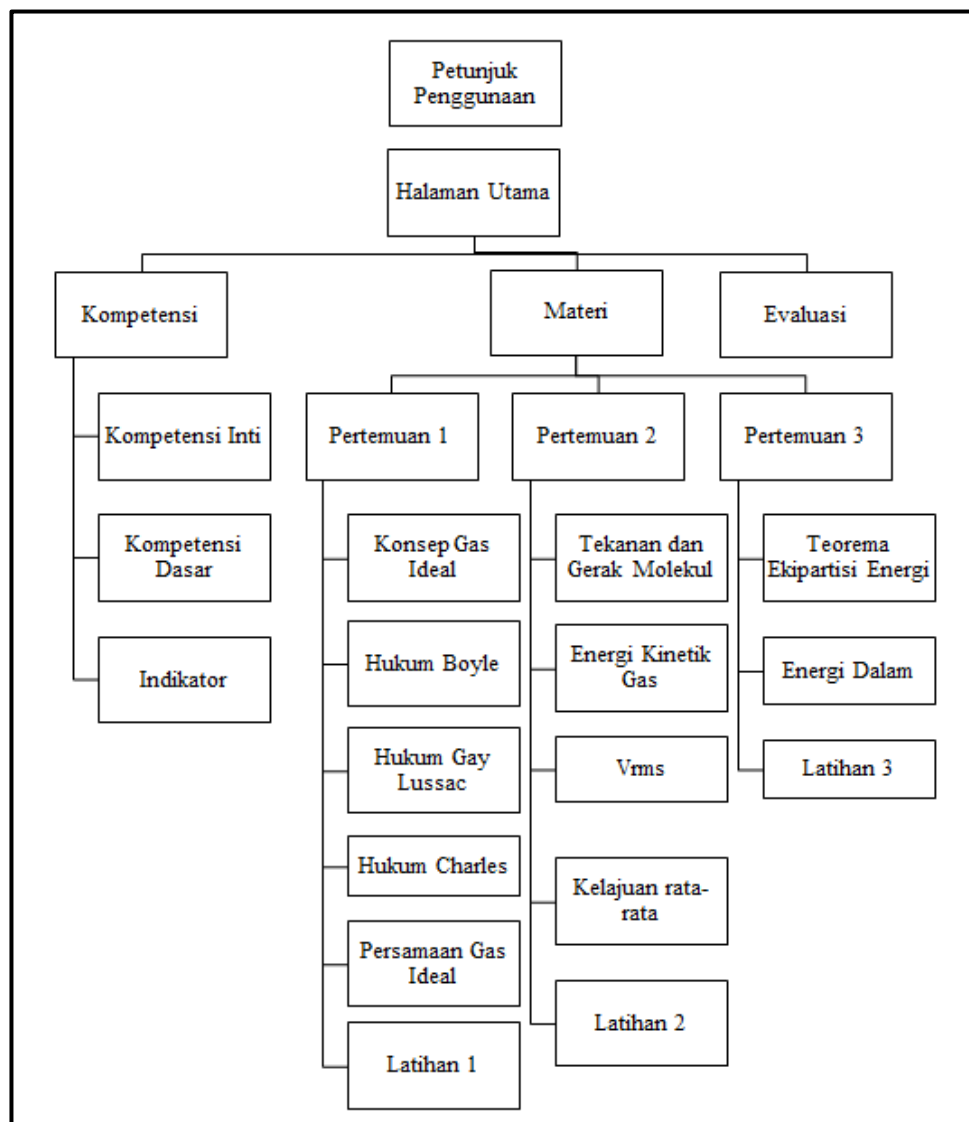


Figure 1. The design of the media based on the Indonesian Curriculum 2013 for Senior High School

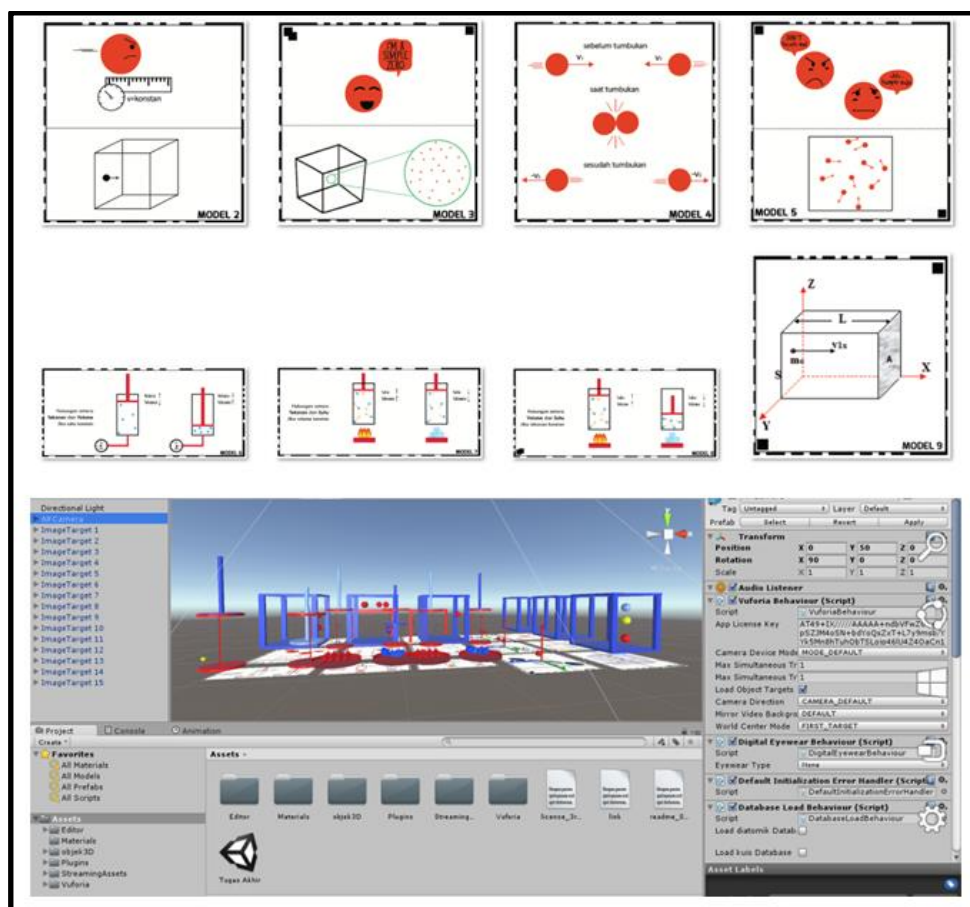


Figure 2. The process of marking and integrating into the three-dimensional object

3.3. The Learning Media

The product of this study is an application media that is formatted in .apk, which is able to operate on any mobile phone with Android base. Instructional media provides information about the material of the kinetic theory of gases through the modules in augmented reality and virtual animation. The augmented reality module is divided into two parts, the introduction and the content, respectively. In the introduction part consists of a cover (figure 3), media instructions and the instructions for students. Whilst in the content section consists of competence of the learning, the title of the subject, the concept of matter, motivation, marker drawing, sample questions, exercises, and evaluations. The augmented reality module is consisted of 32 pages on A4 printed paper. The pages contains the marker that will bring the animated visualization of material kinetic theory of gases through the camera mobile phone by pointing the camera at the marker images on augmented reality module (figure 4). The Kinetic theory of gases applications can be run on a mobile phone devices (minimal memory storage of 24,2Mb) with a minimum resolution of 480x800px without the internet connection, or using the PC's camera.



Figure 3. The cover of the module

3.4. Validation of the Media

Evaluation of the media is done through the series of validation test. Validation Test of the media is conducted on four aspects: design, pedagogic, content and usability. Three lecturers of Physics Education Study Program with Ph.D level, Faculty of Teacher Training and Educational Sciences, Universitas Riau, and three senior teachers (with the Master level) of top Senior High School as the user are selected to evaluate the media. Evaluation was conducted in two times, wherein the first validation was for improvement the design and the second validation was for the final assessment.

During the assessment, the validators were required to provide the free comment in term of these four aspects. Table 1 shows the advices given by validators when the first validation phase.

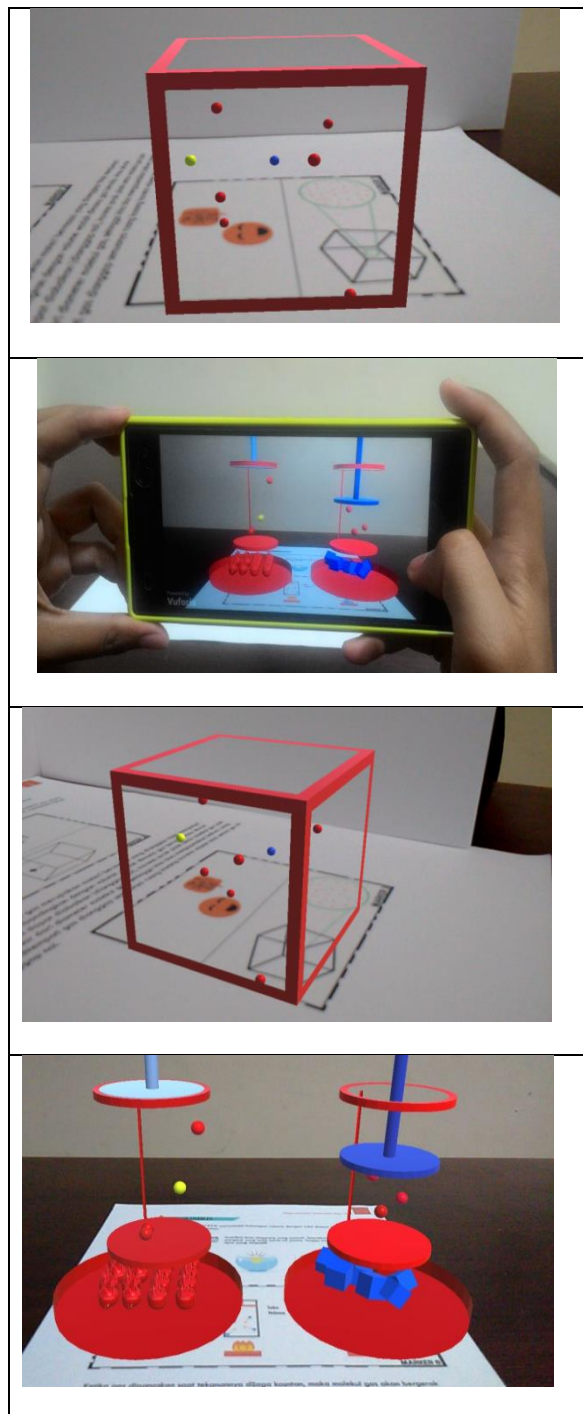


Figure 4. The 3D real time visualization of the media for the kinetic theory of gases.

Table 1. Comment and suggestion from the validators

No	Suggestion
1	Apperception sentence should be able to provide more motivation.
2.	Improve the visualization aspect of the 3D object for momentum process.
3.	Repair the three-dimensional object that shows gas particles as point particles
4.	Distinguishing marker and another picture by adding the dotted line box
5.	Create the lattice of the test in order to reach the learning indicators
6.	Alter the example of practical for the Gay-Lussac's law
7.	Alter the marker word in the module to the 3D object
8.	Change the designed title and sub-title in order to distinguish them.

In this study, ten indicators of the learning objectives have been developed using the augmented reality technology. The media provides the real-time animation media of these indicators: Ideal Gases in a closed space, The characteristic of ideal gases, The momentum of ideal gases, The Boyle's law, The Gay-Lussac's law, The Charles's law, Influence of pressure to the gases movement, Influence of temperature to the kinetic energy of gases, RMS Speed and Vibration.

There are four aspects of the learning media that is assessed by the validators, the design, pedagogic, content, and usability aspect. The total of 38 questions should be given a score by validators that cover these aspects of the assessment. Table 2 shows the score given by validators.

Table 2. The average score (scale 4) for each assessment aspect obtained from the experts and user

No	Aspect	Experts		User	
		Score	Remark	Score	Remark
1	Design	3,48	Valid	3,52	Valid
2	Pedagogic	3,63	Valid	3,56	Valid
3	Content	3,52	Valid	3,63	Valid
4	Usability	3,52	Valid	3,52	Valid
	Average	3,54	Valid	3,56	Valid

Based on the table 2, the pedagogic aspect is the highest score given by the experts with the average of 3,63. Whilst the highest score form the user is at content part with the value of 3.63. The lowest score 3,52, is observed at the usability and content aspect that are given by the experts. Referring to the given score, it implies that the media is valid and ready to be used in the

school for alternative media in the teaching and learning for the topic of kinetic theory of gases.

4. Conclusion

Learning media for concepts in physics were developed using augmented reality technology for senior high school students. The design and development of the media was found to be of high quality and appropriate. This learning product is ready for use as physics learning media for students of a class XI Senior High School level. The results of this study can be used as an additional instructional media option for teaching about the kinetic theory of gases, which is a topic that can be abstract and invisible to a learner.

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References

- Jesper H, Fredrik J, David H and Konrad J.S 2015 Thermal cameras in school laboratory activities, *Physics Education*, 50, 424
- Joshua C and Stephen H 2013 Using a video camera to measure the radius of the Earth, *Phys. Educ.* 48 731
- Kemendikbud 2013 Permendikbud No 69 Tahun 2013: Kerangka Dasar dan Struktur Kurikulum Sekolah Menengah Atas/Madrasah Aliyah. BSNP. Jakarta
- Loo K. W 2012 One-dimensional collision carts computer model and its design ideas for productive experiential learning , *Phys. Educ.* 47 301
- McHugh M and McCauley V 2015 Designing physics video hooks for science students, *Physics Education*, 51, 015015
- Morrison G.R 2010 Designing Effective Instruction (6th Edition). John Wiley & Sons
- Nao N, Yamato K, Daisuke B and Tomohiro K 2016 3D velocity measurement by a single camera using Doppler phase-shifting holography , *Meas. Sci. Technol.* 27, 104004
- Nazatul A. A. M, Hazura M, Rossilawati S 2015 Students' Perception of Mobile Augmented Reality Applications in Learning Computer
-

Organization, *Procedia - Social and Behavioral Sciences*, 176, 111-116

Nils P, Didier S 2015 Cognitive Augmented Reality, *Computers & Graphics*, 53, 82-91

Pengfei H, Gang Z 2015 CAD-based 3D objects recognition in monocular images for mobile augmented reality, *Computers & Graphics*, 50, 36-46
