Design of Massive Online Simulation in The Learning Physics of Thermodynamics Process

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Abstract. The thermodynamic process is an important material in learning physics. The needs analysis stated that 96.8% of students still experienced difficulties in understanding the thermodynamic process material. One of the media that can be used to help students understand the thermodynamic processes is simulation. This study aims to design a physics learning media in the form of a Massive Online Simulation (MOS) that can be accessed via an internet connection. The development model used in this study is ADDIE (analysis, design, develop, implement, evaluate), but in this study it was only carried out until the design stage. Analysis stage is obtained through literature study and student and teacher needs analysis. At the design stage, it focuses on making Massive Online Simulation (MOS) media designs on thermodynamic processes. This research is expected to produce a physics learning media design in the form of a Massive Online Simulation (MOS) on thermodynamic processes which can be an alternative to online-based interactive learning media that can be accessed anywhere and anytime.

1. Introduction
Thermodynamics is one of the materials in the learning of physics. In the material of thermodynamics there is a sub-material that discusses the processes of thermodynamics. Based on the results of needs analysis has been done by using the google form, the majority of students expressed are still having difficulty in understanding the thermodynamic process with percentage of 96.8%. Research conducted stated that the difficulties experienced by students in the process of thermodynamics, the first difficulty that is not consistent in the use of the concept of law ideal gas so that the difficulties in explaining a phenomenon, the second difficulty that students could not understand the phenomenon of macroscopic relationship between the pressure, temperature and volume [1]. Another study conducted stated that there are still many students who do not understand about the ideal gas and the first law of thermodynamics, as well as experiencing difficulties that are not able to connect the magnitude of the macroscopic such as pressure, temperature and volume in an ideal gas [2]. Another difficulty experienced by students in learning that still have the misconception in understanding the material process thermodynamics, among others, as follows: (1) a wrong connection between the pressure with temperature, (2) the work done by the system, and (3) students have difficulties in applying the first law of thermodynamics and define the diagram of the PV [3].

Physics consists of concepts that are macroscopic and microscopic [4]. To be able to understand the thermodynamics so required an understanding of the magnitudes of the macroscopic and the microscopic process of thermodynamics [1]. If the phenomenon of microscopically can be understood, so the phenomenon of macroscopic is also being easy to understand [4]. Simulation of laboratory can
be used as learning media for students [5]. With the use of laboratory simulation can visualize the properties of molecules and the physical properties of the gas [6]. As well as a media of simulation can help visualize physical phenomena microscopically.

One of the online learning media that is currently a trend and widely used is the Massive Open Online Course (MOOC). MOOC is a new idea for online education [7]. Massive Online is an online learning media that can meet global learning needs with the main advantage of providing free education and virtual learning [8]. Massive Online has a bigger impact compared with the Learning Management System (LMS), where students prefer the use of Massive Online than LMS, because of the Massive Online offer uses as the technology is a new learning for students [9]. MOOC can increase the enthusiasm and efficiency of student learning with online learning [10]. With the advantages of Massive Online, so need to develop the design of media learning Massive Online Simulation (MOS) that can provide free simulation. Massive Online Simulation (MOS) is a simulation that can be done online on a large scale. Massive Online Simulation (MOS) is an online-based open learning media that can be followed by students anywhere and anytime using an internet connection. This Massive Online Simulation (MOS) media design was developed through a website that can be accessed via the internet. Massive Online Simulation (MOS) is also useful to clarify students in understanding learning. Simulation of the virtual laboratory can be a solution for distance learning via online [11]. Media-based learning simulation is effective to introduce the students to the concept of physics, and to provide the opportunity for students to engage in higher order thinking process [12]. The simulation has a positive impact in developing the conceptual ideas of the scientific students [13]. The use of simulation in physics can overcome the difficulties of students' conceptual and facilitate the conceptual understanding of students [14,15].

However, some of the simulation platform cannot display the chart of the relationship of pressure, temperature and volume as well as not displaying the thermodynamic process microscopically. Therefore, the need for the development of the design of learning media Massive Online Simulation (MOS) processes in thermodynamics is the process of isobaric, isochoric, isothermal and adiabatic displaying a simulation of the interactive, graphic displays the relationship of pressure, temperature and volume as well as the state of the particles are microscopic. This research aims to design physics learning media in the form of a web-based Massive Online Simulation (MOS) that can be used anytime, anywhere and can be accessed via an internet connection.

2. Method
This research method using Research and Development (R&D). The design model of learning media using the stages of the ADDIE model. The stages of the ADDIE model consist of several stages, namely: (1) analysis, (2) design, (3) development, (4) implementation, and (5) evaluation [16][17]. The following scheme of the stages of the ADDIE model in Figure 1.

![Figure 1. The stages of ADDIE model](image-url)
Based on Figure 1. The stages of the ADDIE model consist of five stages, but in this research it was only carried out at the design stage. At the stage of analysis, the analysis of the availability of a media platform that has been developed and conduct a needs analysis to determine the design of learning media of physics that will be developed. At the design stage is done making the design of learning media of physics that will be developed.

3. Results and Discussion

3.1. Main Display

At the start of the simulation will appear in the main display before entering into the main menu of the application of learning media Massive Online Simulation (MOS). In the main view, there is the sign in button and the button to sign up. For users who don't have an account to sign in to the app, the user can select the sign up button and fill in the data themselves, among others, an email, username and password. After registering, the user can enter the application by completing the username and password that was previously created. The main display as shown in Figure 2.

![Figure 2. Main Display](image)

3.2. Start Menu

The start menu is the menu to start and sound settings in the app. On this start menu there is a play button so that users can enter in media Massive Online Simulation (MOS) and the sound button to enable or disable the sound. The start menu as shown in Figure 3.

![Figure 3. Start Menu](image)
3.3. Home
The home menu is the main view from media Massive Online Simulation (MOS). Inside the home there is a menu: basic competencies, objectives, materials & simulation, as well as a quiz. As shown in Figure 4.

![Figure 4. Home Menu](image)

Based on Figure 4. There are basic competencies that have been adjusted and the goals to be achieved in learning activities.

3.4. Material and Simulation

![Figure 5. Material & Simulation Menu](image)

Based on Figure 5. On the menu material & simulation there is some selection of material, among others, isobaric, isochoric, isothermal and adiabatic. If the user selects one of the materials so there is a material explanation of the process thermodynamics therein, after the user read the material, there is a button simulation in the corner top right which serves to display the page of the simulation. And there is an exit button that functions to return to the home menu.
3.5. Isobaric Simulation

Based on Figure 6. On the simulation page there are macroscopic quantities, namely pressure, volume and temperature. In addition, there are down and up buttons that function to adjust the increase in pressure, volume and temperature. Also, there are pressures, volume and temperature drop buttons. When the user adjusts the pressure, volume, and temperature, the gas particles in the piston will move and automatically the PV graph will display the relationship between the thermodynamic processes that occur. In Figure 6 is a simulation design for the isobaric process. In the isobaric process, the pressure button is not activated because the process changes the state of the gas at constant pressure. After the simulation is done, there is an exit button that functions to return to the material & simulation menu, then the user can try several other thermodynamic process simulations.

3.6. Quiz

Figure 7. Start Quiz Page

Figure 7. Is the display to start the quiz, there is a start button that serves to continue to work on the quiz and an exit button that functions to return to the start menu. If you click the start button on the Figure 7. So the display will appear in Figure 8.
Figure 8. Question

Figure 8 is a quiz page display, on this page there are several multiple choice questions in it. The user can choose one of the options the correct answer from the four options provided. After the user selects an answer, it would appear the answer key directly. The correct answer is shown on the green color, while the red color is the wrong answer. To continue to the next questions, users can click the next button colored blue in the bottom corner. After all the questions have been completed, then the last question will appear a finish button which functions to finish the quiz.

Figure 9. Quiz Score

After the quiz is completed, it will automatically display the score of the correct answer. The score page is as shown in Figure 9. The score page displays the score obtained from the correct answer choices. On the score page there is a start button that serves to repeat the work on the question and an exit button that functions to exit the simulation. If the user does not want to repeat the task, the user can click the exit button on this page which will redirect the user back to the start menu.

4. Conclusions

This research resulted in the media design of web-based a Massive Online Simulation (MOS), where this simulation can be accessed anytime and anywhere via an internet connection. The design of this Massive Online Simulation (MOS) media presents four thermodynamic processes, namely isobaric, isochoric, isothermal, and adiabatic processes. This media design also displays a graph of the PV relationship and displays the phenomenon of microscopic gas particles. In addition, the Massive Online Simulation (MOS) media design presents quizzes in it. The design of Massive Online Simulation (MOS) media that has been developed can be an alternative to online-based interactive media that can be accessed anywhere and anytime with an internet connection. This research is
expected to be continued in further research so that the designs that have been made can be developed to the final stage.

References

[1] Loverude M E, Kautz C H, and Heron P R L 2002 Journal of Physics 70(2) 137–148
[2] Kautz C H, Heron P R L, Loverude M E, and McDermott L C 2005 Journal of Physics 73(11) 1055–1063
[3] Wattanakasiwich P, Taleab P, Sharma M D, and Johnston I D 2013 Journal of Innovation in Science and Mathematics Education 21(1) 29–53
[4] Astra I M, Wibowo F C, Susanti D, and Darman D R 2021 Journal of Physics: Conference Series 1869(1)
[5] Astra I Made, Nasbey H, and Nugraha A 2015 Journal of Mathematics Science and Technology Education 11(5) 1081–1088
[6] Chao J, Chiu J L, DeJaegher C J, and Pan E A 2016 Journal of Science Education and Technology 25(1) 16–33
[7] Zhang Y, Chen J, Miao D, and Zhang C 2018 Journal of Emerging Technologies in Learning 13(7) 111–123
[8] Sneddon J, Barlow G, Bradley S, Brink A, Chandy S J, and Nathwani D 2018 Journal of Antimicrobial Chemotherapy 73(4) 1091–1097
[9] Tarmuji N H, Nassir A A, Ahmad S, Abdullah N M, and Idris A S 2018 Students’ acceptance of e-learning in mathematics: Comparison between LMS and MOOC using SEM PLS approach AIP Conference Proceedings 1974
[10] Ji Z 2016 Journal of Emerging Technologies in Learning 11(5) 62–67
[11] Khoroshko L L, Ukhov P A, and Keyno P P 2019 Journal of Engineering Pedagogy 9(4) 4–15
[12] Falloon G 2019 Using simulations to teach young students science concepts: An Experiential Learning theoretical analysis Computers and Education 135 138–159
[13] Park M 2019 Journal of Mathematics Science and Technology Education 15(7)
[14] Stephens A L and Clement J J 2015 Use of physics simulations in whole class and small group settings: Comparative case studies Computers and Education 86 137–156
[15] Meli K and Koliopoulos D 2019 Journal of Physics: Conference Series 1287(1)
[16] Henukh A, Reski A, Nikat R F, Waremra R S, and Bahri S 2020 Journal of Physics: Conference Series 1569(2)
[17] Serevina V, Raihanati, Sunaryo, and Andriana W 2019 Journal of Physics: Conference Series 1280(5).