Design of Virtual Physics Laboratory (VPL) on Collision Topic

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Abstract. Collision phenomena are very difficult for teachers to visualize in distance learning. Facts in the field show that there are still many students who have difficulty understanding the concept of Collision. This is what causes the Collision concept to be one of the physics materials that are difficult for students to reach. This study aims to produce an interactive multimedia design in the form of a Virtual Physics Laboratory (VPL) in the Collision sub-material. The research method used is Research and Development (R&D) using the ADDIE development model (Analyze, Design, Develop, Implement, and Evaluate). However, this research was only carried out until the design stage. The results of the analysis of the distribution of the questionnaire data analysis of the needs of teachers and students stated that students needed to meet the needs of new learning media used to assist them in visualizing the Collision phenomenon in Distance Learning. The media used to visualize the collision is the Virtual Physics Laboratory (VPL) media. With the Virtual Physics Laboratory (VPL) design, it is hoped that it will produce interactive multimedia that is effective in helping students understand Collision material.

1. Introduction
Currently the world has entered the era of the industrial revolution generation 4.0 which is marked by increased connectivity, interaction and development of digital systems, artificial and virtual intelligence. With the increasingly convergent boundaries between humans, machines and other resources, information and communication technology certainly have an impact on various sectors of life. One of them is the impact on the education system in Indonesia [1]. The rapid development of Information and Communication Technology (ICT) gave birth to a trend of using computer-based multimedia as a medium of learning in schools. The skills that become the focus of learning competencies in the 21st Century are skills in mastering Information and Communication Technology (ICT) media. The 21st century learning paradigm emphasizes the ability of students to find out from various sources, formulate problems, think analytically and collaborate and collaborate in solving problems [2]

Physics is a part of science that studies natural phenomena and phenomena empirically, logically, systematically and rationally which involves scientific processes and attitudes [3]. Physics is one of the basic sciences that plays an important role in the development of science and technology [4]. Physics learning emphasizes on providing direct experience to develop student competencies. Part of teaching that aims to give students the opportunity to test and implement in real situations what is obtained in theory is to carry out practical activities.
One of the physics materials that still contains abstract concepts, namely momentum and impulse. For example, the law of conservation of kinetic energy does not necessarily apply to collisions. The difference between the types of collisions and their characteristics [5]. Collisions are one of the sub-materials of physics course whose application is widely encountered in everyday life. Every human day is not far from the collision. For example, when playing billiards, when a ball that is styled by a stick moves towards another ball and hits it, besides playing soccer, softball, tennis and many others. In physics, material is taught about collisions, so these events can be analyzed in two ways, namely first by theoretical calculations and assisted by the second way, namely using practicum which functions as direct observation activities carried out by students on physical events that occur.

The world is currently shocked by the outbreak of a virus, the spread of this virus almost throughout the world very quickly. The World Health Organization (WHO) has declared this outbreak a global pandemic. Indonesia is one of the countries affected by the Covid-19 virus, which has had a major impact on people's lives. With the stipulation of the covid-19 outbreak as a pandemic, the Indonesian government began to be fast and responsive to encourage its people to establish social distancing [6]. Online learning is a learning process mechanism that is far from the center of education and is independent. Technological developments allow online learning to be carried out well. The emergence of the COVID-19 pandemic has pushed the demands of the use of digital technology so that learning will be easier for students [7]. The current learning situation, teachers are required to present contextual, creative, efficient and fun learning, so teachers must try to update their abilities according to the demands of the times [8].

The implementation of online learning is considered close to face to face, namely using video conferencing applications, including the Zoom webinar. Webinar Zoom is a face-to-face conference platform where educators and students can interact directly like meeting face-to-face [9]. Research on the use of webinars in the learning process compared to face-to-face meetings, it was found that student participation was much higher in Zoom webinars when the teacher encouraged students to speak [10]. Physics learning and laboratories are inseparable parts. The application of the practicum process with an online learning system is one of the new things that must be done by educators.

A virtual laboratory is a system that can be used to support a conventional practicum system. This virtual laboratory is commonly referred to as a Virtual Laboratory or V-Lab. Virtual laboratories as supporting factors of real laboratories enrich students' learning experiences and offer students to conduct experiments, control materials and equipment, collect data, conduct experiments interactively, and prepare experimental reports and develop experimenting skills [11]. The laboratory approach is based on the idea that experiments to prove basic information about science should be carried out in the laboratory by students. Individual differences will be eliminated in laboratory studies in some way. This is because all the equipment and methods used in conducting experiments in the study laboratory are also elements of individual training [12]. In addition, the use of laboratories as a teaching method develops reasoning, critical thinking, scientific perspectives and problem solving abilities of students [13]. With this skill, students are encouraged to think, learn and conduct experiments like a scientist [14]. Laboratory activities can make students able to solve problems according to the physics theory learned in class [15].

There are a number of studies that were previously developed in generating and utilizing virtual labs in Physics subjects. Among them is this research aims to produce interactive virtual laboratory learning media that is effective and practical for Optical Physics subjects [16]. Other studies [17] This study aims to provide students with access via the internet to various experiments in control techniques, which are located in control laboratories in several universities. Other research [18] The research study referred to here is to produce an application virtual physics laboratory called ViPhyLab using an Android-based smartphone. This research can also determine the suitability and quality of the virtual physics laboratory application that has been developed and to describe the improvement of learning. Other research [19] This study aims to describe the feasibility of Algodoo VPL-based physics practicum software on Newton's Law of Gravity. Other studies [20]. This study aims to examine the application of
discovery learning models assisted by virtual laboratory media to influence the mastery of concepts in students.

Based on the results of the analysis of student needs, as many as 77.7% of students stated that the teacher had never presented virtual practicum activities needed during distance learning. As many as 71.2% of students have difficulty in distinguishing the criteria for collision in working on the description test questions. As many as 83.5% of students are interested in learning Physics using the Virtual Physics Laboratory. As many as 94.2% of students agree that learning media in the form of Virtual Physics Laboratory (VPL) is developed for Collision topic.

Based on the description above, this can provide an opportunity to conduct research by designing a Virtual Physics Laboratory on the Collision topic. This study will discuss the design of the Virtual Physics Laboratory (VPL) media which contains an overview of the comparison between collisions.

2. Method
The method used in this research is the Research & Development method. Media design development is carried out by referring to the ADDIE development model. ADDIE stands for Analyze, Design, Develop, Implement, and Evaluate [21]

![Core Elements of the ADDIE Model](source)

*Source: (Branch, 2010)*

**Figure 2.1** Core elements of ADDIE

However, the ADDIE development model used is only up to the design stage. The analysis stage is the stage to determine the needs of physics learning media in schools. The analysis carried out includes literature studies in the form of journal analysis and the availability of simulation media, analysis of student needs, and analysis of teacher needs. While the design stage is the stage that determines how a learning program is designed according to the needs and objectives that have been determined. The design carried out includes a design (storyboard) from the Virtual Physics Laboratory (VPL).

3. Results and Discussions
3.1. Literature Study
The literature study was carried out by analyzing and synthesizing various international and national journals available from various sources of database providers. The stages carried out in the literature study are reviewing abstracts from each study, collecting library data, and comparing other literature to be processed and produce conclusions. From these stages, an overview of the problems in physics learning can be obtained so that they can be solved in research. The articles analyzed contain the results of studies on the development and use of computer simulations in learning physics. The scientific articles used were obtained from Computers and Education, Asia-Pacific Forum on Science Learning and Teaching, Science Education, IOP Conf. Series, Journal of Physics, Procedia Technology, Physical
Review Physics Education Research, Science Direct, American Scientific Publishers, Instructional Science, Research in Higher Educational Journal, American Journal of Physics, American Physical Society and several other sources. The search process is limited to journal articles published in the range of 2000 to 2020. In addition to journal analysis, an analysis of the availability of simulation media is also carried out on several platforms. The availability of the collision simulation platform can be seen in Table 3.1.

Table 3.1 Availability of Collision simulation across multiple platforms

| No | Developed virtual lab | Source | Information |
|----|------------------------|--------|-------------|
| 1. | ![Collision Lab Image] | [https://phet.colorado.edu/sims/html/collision-lab/latest/collision-lab_en.html](https://phet.colorado.edu/sims/html/collision-lab/latest/collision-lab_en.html) | This simulation shows 2 balls colliding with a flat plane with a mass that can be varied, but the results of observations is not placed in the table directly. So students have to transfer the results of the observation data to a notebook. |
| 2. | ![Collision Carts Image] | [https://www.physicsclassroom.com/Physics-Interactives/Momentum-and-Collisions/Collision-Carts/Collision-Carts-Interactive](https://www.physicsclassroom.com/Physics-Interactives/Momentum-and-Collisions/Collision-Carts/Collision-Carts-Interactive) | This simulation displays 3 collision processes in the same experiment. Existing experiments include: 1. Perfectly Elastic Collision, 2. Collision is not elastic at all and 3. Explosion Process There have been no experiments on the partially elastic collision process. |
| 3. | ![Collision Simulation Image] | [https://vlab.amrita.edu/?sub=1&brch=68&sim=197&cnt=4](https://vlab.amrita.edu/?sub=1&brch=68&sim=197&cnt=4) | This simulation shows the process of 3 collisions, namely: perfectly elastic collisions, partially elastic collisions and completely elastic collisions. However, the user must make arrows on the ball so that the ball moves according to the direction of the arrow, and this is not in the instructions for use. |
Table 3.1 shows the simulations of Collision available on several platforms. Based on the table above, it can be synthesized that the available simulations only show Collision simulations for 2 Dimensions. The results of the collision process simulation shown have not directly shown the difference between the three collisions.

3.2 Student Needs Analysis and Teacher Needs Analysis

Analysis of student needs was carried out in several high schools in the city of Jakarta, as many as 132 students contributed in filling out the questionnaire. Analysis of teacher needs was carried out in several high schools, as many as 24 physics teachers contributed in filling out the questionnaire.

3.3. Virtual Physics Laboratory (VPL)

Virtual Physics Laboratory (VPL) is an interactive multimedia that provide facilities and infrastructure for virtual practicum activities with the help of computers. The virtual laboratory design is made to resemble a real laboratory. Users can prepare practical materials and simulate the media to obtain observational data. The design of the VPL in the Collision sub-material can be seen in Figure 1.

Figure 1 shows the main menu page on the VPL which contains a login page for students who will do a practicum. Figure 2 shows the main menu consisting of KI & KD, Learning Objectives, Theoretical Foundations, Practical Instructions, exercises and developer profiles. As for each sub-material, there is a virtual simulation and a description of the tools and materials that can be used by users during the practicum activity.
Figure 3. Perfectly Elastic Collisions, Partially Elastic Collisions and Totally Inelastic Collisions

Figure 3 shows an atmosphere that is made similar to a real laboratory, students can prepare the tools and materials that will be used during virtual practicum. The button used provides a description of the instructions for use so that it can reduce the confusion faced by students when carrying out practical activities. The available columns are also equipped with recommended instructions for filling in. The table of observations will be automatically filled if the user has made 3 experiments on each material.

4. Conclusion
Based on the literature study, the analysis of the needs of teachers and students can be concluded that the available learning media have not helped students to visualize, describe, and describe the Collision sub-material correctly. Therefore, it is necessary to develop interactive multimedia that can help students understand the Collision material correctly. The media used to visualize the collision is the Virtual Physics Laboratory (VPL). Virtual Physics Laboratory (VPL) is an interactive multimedia that provide facilities and infrastructure for virtual practicum activities with the help of computers. The virtual laboratory design is made to resemble a real laboratory. Users can prepare practical materials and simulate the media to obtain observational data. With the development of VPL, it is expected that learning will be more effective and help students to understand the sub-material Collisions in Distance Learning. This VPL design will be refined and further developed to meet the research stages of the ADDIE model.

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