Interactive Book Augmented Reality (IBAR) for Lesson Physics on STEM

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Abstract. The scientific development process can be carried out with STEM (Science Technology Engineering Mathematics) education where this interdisciplinary approach trains students to learn where the concept of science is combined with the context in applying science, technology, engineering, and mathematics. The purpose of the study is the development of Interactive Book Augmented Reality (IBAR) for Lesson Physics on STEM. The research method is the ADDIE Model which consists of the stages of Analysis, Design, Development, Implementation, and Evaluation. The sample for the implementation of IBAR used in the study amounted to 90 students aged 19-22 years from a province in Indonesia. The results showed that IBAR contributed to students’ concepts in physics. In the questionnaire given to students, information was obtained that the IBAR application was more useful, realistic, and interesting for their learning; help them understand and analyze problems and STEM scenarios. It has been suggested that IBAR technology could be a potent and effective tool to enable Lesson Physics students in the STEM process. In addition, the implications of using IBAR for physics education and recommendations for further studies are also discussed in this study.

1. Introduction
Physics is a science that examines the interaction between energy and matter, is the basis of natural science obtained from the results of experiments and theory development [1]. Physics is one of the branches of science education held to develop the ability to think analytically to solve problems related to the surrounding environment both qualitatively and quantitatively [2]. In short, physics is a branch of natural science that can explain all phenomena that occur in life in this universe, including one in the marine field [3]. The process of inquiry, which is a special feature of physics, has three main integrated components, namely aspects of the process, products, and scientific attitudes. The scientific development process can be carried out with STEM (Science Technology Engineering Mathematics) education where this interdisciplinary approach trains students to learn where the concept of science is combined with the context in applying science, technology, engineering, and mathematics [4]. In line with technological advances, currently emerging technology that can combine real objects and virtual objects with a real outside environment in real-time, which is currently known as Augmented Reality (AR) [5]. AR is a technology that combines two-dimensional and or three-dimensional virtual objects into a real three-dimensional environment and then projects these virtual objects in real time [6]. AR is currently experiencing rapid development and has touched various lives, one of which is in the world of education. The world of education is currently required to innovate and be creative with the aim of
increasing effectiveness in learning and the quality of education, namely by using Augmented Reality [7]. AR applications in the education of these studies have positive results related to increased collaboration, deeper understanding, and student motivation when using Augmented Reality-based learning media [8] [9].

The implementation of 21st Century education in this context creates a link between school, community, and work, which allows the development of STEM literacy with the aim of enabling the ability to compete in the economy [10] [11]. STEM is a step taken by scientists to carry out investigations to find explanations for natural phenomena. These steps include formulating problems, formulating hypotheses, designing experiments, collecting, and analyzing and finally concluding. Therefore, the process of discovering concepts has been done in a cookbook, not through contextualism and constructivism. In addition, based on the results of preliminary research, information was obtained that student really like playing with learning, so this is an opportunity to try to transform STEM for learning [12]. Through STEM learning activities, students can learn the principles and concepts of science, according to an understanding model to develop higher-order thinking skills, one of which is 21st-Century Skills.

Meanwhile, Interactive Book Augmented Reality has indeed been developed, but not many have been able to demonstrate or practice both microscopic and microscopic physics concepts. So, referring to the findings and results of the study above, the purpose of research is development of Interactive Book Augmented Reality (IBAR) for Lesson Physics on STEM. In addition, IBAR with the developed STEM Model must be able to provide solutions to the limitations of virtual learning equipment and be able to implement independent learning according to the demands of the government.

2. Method
The research method is the ADDIE Model which consists of the stages of Analysis, Design, Development, Implementation, and Evaluation [13]. The sample for the implementation of IBAR used in the study amounted to 90 students aged 19-22 years from a province in Indonesia. The comparison of the number of Boy and Girl student’s implementation of IBAR is shown in Figure 1.

![Figure 1. Comparison of Boy and Girl student’s implementation of IBAR (%)](image-url)
Figure 2 shows the method of research in this study, the development of IBAR uses the ADDIE development model which consists of 5 stages, namely the analysis stage (Analyze), the planning stage (Design), the development stage (Development), the implementation stage (Implement), and the evaluation stage (Evaluate). This analysis was carried out through interviews and observations of prospective IBAR users. The purpose of holding interviews and observations is to find out the difference between real conditions and ideal conditions. The second stage is Design in the form of design planning, this activity aims to determine the design of the Augmented Reality application interface. The third stage, Design Development, this stage performs objective analysis, capability analysis, and design planning, then the IBAR book design is developed in the form of storyboards. The next stage is implementation, namely with validation tests, product validation is carried out by experienced experts to assess, identify weaknesses and strengths, and propose improvements to the IBAR. The result is in the form of inputs that can be used as a basis for revising the developed product and as a basis for product testing on students. The next implementation, with Trial to Users by conducting IBAR trials on users who are students, by providing links to users who contain IBAR with the application. The evaluation stage is always carried out at every stage of ADDIE.

3. Result

3.1. Characteristic IBAR

The implementation of IBAR in the experimental group was carried out at two weeks (8 hours). IBAR was taught to the experimental group through an interactive book based on AR, while the control group used traditional methods using physics textbooks on the structure of the atomic nucleus. In the experimental group, the concept was taught by the teacher with AR-based IBAR, where students actively participate in the class and each student can use the IBAR in every activity. During classroom learning, the virtual objects of the AR-based IBAR use the students’ own smartphones, thus creating a learning environment that facilitates the construction of the atomic nucleus structure concept [14]. The procedures applied during the implementation phase and visuals for the implementation of IBAR are shown in Figure 3 and Figure 4.
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In the first week of the meeting, students were given lessons about introduction to the concept of atomic nucleus structure using IBAR on the concept of Atom Dalton and Atom Thompson. Students obtain information about learning materials prepared with IBAR technology.

![Images of atoms](image1)

Figure 3. Results of moving images of Dalton and Thompson's Atoms

The second week, Characteristics of the Rutherford Atom, and the Bohr Atom, teaches students how the Rutherford Atom and the Bohr Atom work and how their nuclei move. The results showed that IBAR contributed to students’ concepts in physics. In the questionnaire given to students, information was obtained that the IBAR application was more useful, realistic, and interesting for their learning; help them understand and analyze problems and STEM scenarios [15]. It has been suggested that IBAR technology could be a potent and effective tool to enable Lesson Physics students in the STEM process. In addition, the implications of using IBAR for physics education and recommendations for further studies are also discussed in this study.
3.2. IBAR Questionary to Students’

The results showed that IBAR contributed to students’ concepts in physics with total sample 90 students. In the questionnaire given to students, information was obtained that the IBAR application was more useful, realistic, and interesting for their learning [16] and them understand and analyze problems and STEM scenarios. It has been suggested that IBAR technology could be a potent and effective tool to enable Lesson Physics students in the STEM process. The full results are shown in Figure 5.

![Figure 5. Result of IBAR Questionary to Students’](image-url)

Based on Figure 5, information is obtained that The IBAR for STEM learning is carried out according to the needs of the Student's in the Class of 2.90 with a very good category from a scale of 1-3. Meanwhile, IBAR media are easy to use and emphasizes microscopic aspects (unobservable) of 2.86 with a very good category on a scale of 1-3. And The implementation of IBAR to support learning STEM with 21st century skills is 2.90 with a very good category from a scale of 1-3. For The IBAR material presented facilitated to study during the COVID-19 (Corona Virus) pandemic of 2.93 with very good category on a scale of 1-3. Students feel that the benefits from implementing IBAR Media are 2.94 with a very good category from a scale of 1-3.

### 4. Conclusion

The conclusion of the study is Interactive Book Augmented Reality (IBAR) for Lesson Physics on STEM. The results showed that IBAR contributed to students’ concepts in physics. In the questionnaire given to students, information was obtained that the IBAR application was more useful, realistic, and interesting for their learning; help them understand and analyze problems and STEM scenarios. It has been suggested that IBAR technology could be a potent and effective tool to enable Lesson Physics students in the STEM process. In addition, the implications of using IBAR for physics education and recommendations for further studies are also discussed in this study.

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