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Development of Virtual Science Learning Media Assisted by Musschenbroek Tools on Length Expansion Material

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Abstract: This research was conducted in response to the lack of science learning media, particularly in physics materials, that can engage students' interest during the learning process. The purpose of this research is to develop virtual science learning media on the topic of linear expansion. The research method applied is research and development using the 4D model. In this study, a linear expansion tool was created. The research was conducted by developing a science e-module as learning media using the Flip Pdf application.

Keywords: Length expansion; Musschenbroek; Virtual science learning

Introduction

Along with technological advancements and the ongoing era of globalization, today's education must focus on efforts to shape students who are capable of facing these challenges. Students need to be equipped with skills and knowledge relevant to this era, including the ability to navigate 21st-century technological developments, especially the impact of science-based technology (Nurulhidayah et al., 2020).

One of the essential skills that needs to be developed in the millennial generation is 21st-century life skills, particularly in optimizing the use of educational media products by utilizing technology (Jayawardana et al., 2020). Technology-based learning media functions as both a physical and non-physical support tool to facilitate interaction between students and teachers, making it easier to understand the material being taught effectively and efficiently (Khotimah et al., 2019). Technological advances in education have made various new teaching methods possible (Alimuddin et al., 2023). Teachers, as educators, always strive to use media that are simple and efficient (Thahir et al., 2022). Learning media can be in the form of audio, visual, or a combination of both (Patresiyah et al., 2021). Appropriate learning media can enhance interaction between teachers and students, ensuring that students do not get bored during lessons (Wulandari et al., 2023). Learning media are technologies and/or sets of tools that carry content messages and can be used for learning purposes in the form of text, visual images, audio, video, virtual reality, interactive multimedia, including hardware and software technologies that support the learning process (Yuliawati et al., 2020).

Most teachers face obstacles in utilizing learning media during teaching (Ismawati et al., 2021). In practice, teachers often only use PowerPoint presentations as a means to display images to students.

As a result, students' enthusiasm and interest in physics subjects have decreased, and their understanding of the material is not yet optimal, especially on the topic of thermal expansion (Niyati, 2021). Software can be an alternative solution in physics education. Media allows for virtual object simulations

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and covers physics concepts that are expected to attract students' interest, creating a conducive teaching and learning environment (Fauziah et al., 2024).

This digital module will be developed into a digital module or e-module, which will be integrated with multimedia content known as a Multimedia Flipbook. The electronic module that will be created will feature a flipbook display containing information supported by audiovisual technology, with material accompanied by audio, animation, and educational videos. Flip PDF Professional is an application that helps convert the module into an electronic format (Putri et al., 2022).

Based on this, the development of comprehensive and curriculum-aligned learning media that are practical is highly needed in physics education, making the electronic module (e-module) suitable for use in the physics learning process.

Method

The method used in this research involves creating educational media in the form of instructional videos. The instructional video was created for the Science subject using teaching aids on the topic of linear expansion. The procedure for developing the learning media in this research uses the 4D model by Thiagarajan, which consists of Define, Design, Development, and Dissemination. The define stage involves activities to determine what product will be developed and its specifications. This activity is a needs analysis conducted through research and literature review. The design stage involves creating a plan for the product that was established during the define stage. The development stage involves turning the design into a product and testing the product's validity repeatedly until a product is produced according to the specified specifications. The dissemination stage involves spreading the tested product so that it can be utilized by others (Sugiyono, 2019).

Result and Discussion

Tools and Materials

The tools and materials used in the making of the Musschenbroek apparatus include a set consisting of an aluminum rod, an iron rod, a brass rod, a spirit container, a pointer needle, a length change scale, a pointer needle adjustment screw, and spiritus.

Musschenbroek

A measuring tool is an instrument used to measure an object or event (Yatnikasari et al., 2021). The expansion of an object can be measured using an expansion measuring tool. The expansion measuring tool used to investigate the linear expansion of an object is the Musschenbroek apparatus. Physics learning materials for measuring linear expansion are conducted by aligning the teaching method with experiments in science subjects on the topics of temperature, heat, and expansion.

The basis for designing the expansion test tool is the development of the Musschenbroek apparatus. The Musschenbroek apparatus typically operates on a simple principle of obtaining heat in the process of expanding the metal being tested (Santoso et al., 2023). The heat for the Musschenbroek tool is usually generated from a flame, such as a candle. This device is equipped with a scale pointer needle that can measure the increase in the size of a solid. The tool consists of three metal rods made of aluminum, copper, and iron (Fradyatama, 2024). Generally, the Musschenbroek apparatus is used to investigate the amount of linear expansion in solid objects shaped like rods, such as metals.

Figure 1. Musschenbroek

How to calculate length expansion results

$$\Delta L = \alpha L_0 \Delta T \text{ or } Lt = L_0 (1 + \alpha \Delta T) \quad (1)$$

Information:

L_t : the length of an object when heated (m)
L_0 : the initial length of the object (m)
α : long expansion coefficient (^{0}C)
ΔT : temperature changes (^{0}C)

Science E-Module

The use of learning media in the form of technology and/or a set of tools containing educational material can influence the learning process (Nurleni et al., 2022). An electronic module (e-module) is a set of non-print digital learning media that is systematically arranged and can be used independently by students to solve problems in their own way (Gufran et al., 2020). E-modules in learning are presented in electronic format. E-modules have advantages as practical media, are durable, and have lower production costs compared to conventional printed modules (Nurhasanah et al., 2023). The e-module created uses Flip PDF Professional. Flip PDF is an interactive medium that allows for the easy addition

of various types of animated media into the flipbook (Febrianti, 2021). Flip PDF can incorporate videos, hyperlinks, animated text, images, audio, and flash into the flipbook (Aftiani et al., 2021). In this study, there is a science e-module on the topic of linear expansion, as shown in Figure 2.

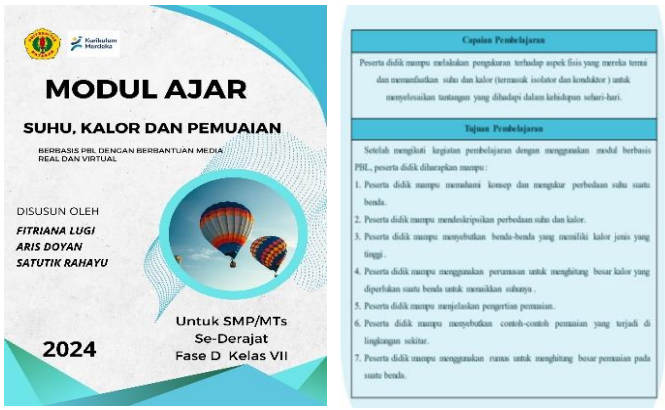

Figure 2. Science e-module

Conclusion

The use of learning media that utilizes technology is very helpful in increasing the effectiveness and efficiency in delivering learning materials. In using the musschenbroek tool, it can provide a realistic understanding of the actual concept to students. The material in the e-module makes it easier for students to use the length expansion tool that has been made.

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Conflicts of Interest
The authors declare no conflict of interest.

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