# Exploration of various visual media (real and virtual) in physics learning

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**Abstract**
This study aims to explore the role of visual media in physics learning especially in static electricity and capacitors, and to identify the obstacles faced by teachers in using these visual media. This study uses a qualitative descriptive approach with a literature review and analysis of data obtained through a questionnaire distributed to high school physics teachers in Bandung City. The data collected includes the use of various types of visual media, the purpose of their use, students' responses to visual media, and the obstacles faced in their implementation. The findings show that visual media such as PowerPoint, digital simulation (PhET), and animated videos are very effective in physics learning to help students understand abstract concepts, especially in capacitor material. Digital simulation, with an effectiveness rate of 82.4%, proved to be the most effective in explaining the concept of capacitors. The use of this visual media also has a positive impact on student motivation in learning. However, the main obstacles faced are the limitations of time, facilities, and technical skills of teachers in developing visual media. In conclusion, although the use of visual media is very beneficial, further support in the form of training, provision of facilities, and better time management is needed to optimize the application of visual media in physics learning.

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## 1. Introduction

Physics learning often requires an approach that is able to integrate three levels of concept representation: macroscopic, microscopic, and symbolic (Chandrasegaran et al., 2008). When studying concepts like electrical circuits, various of visual media can illustrate phenomena across multiple representation levels. Videos or live demonstrations are effective for showcasing macroscopic events, while symbolic representations often rely on graphs or visual analogies. To explain microscopic processes, dynamic computer-based modeling helps students visualize interactions that are not visible to the naked eye, such as electron movement within an electrical circuit.

Physics learning requires an understanding of three levels of representation, namely macroscopic, microscopic, and symbolic, each of which plays an important role in building understanding of physics concepts (Chandrasegaran et al., 2008; Davidowitz et al., 2010; Juriševič et al., 2008). Macroscopic representations are physical phenomena that can be directly observed by students, such as electric current, temperature, or pressure, which can often be felt and measured in the real world. For example, physics learning begins with these macroscopic phenomena, such as in physics labs conducted in the laboratory, to provide students with a concrete picture before moving on to more abstract representations (Cheng, 2009).

At the microscopic level, learning leads to an understanding of phenomena that occur on an atomic or subatomic scale. These phenomena cannot be directly observed by human senses and require conceptual models or computer-based animations to present a visual depiction of the processes that occur at the microscopic level (Tregidgo & Rateliffe, 2000; Wibowo et al., 2017). For example, to understand the flow of electricity in a conductor, students need to study the movement of electrons in matter, which can be simulated through dynamic microscopic models. These microscopic models are important in facilitating understanding of physics concepts that are difficult

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to observe directly, as well as improving students' mental models of the phenomena they are studying.

Meanwhile, at the symbolic representation level, physics concepts are expressed in the form of formulas, mathematical equations, graphs, or other physics symbols. This symbolic representation is needed to describe microscopic phenomena more abstractly and allow for further analysis through mathematical manipulation (Harrison & Coll, 2008). Analogies, both in static and dynamic forms, are important tools in visualizing microscopic phenomena that are difficult to understand. Dynamic analogies, such as animations or computer simulations, are more effective in describing dynamic physics events because they can provide a clearer and more easily understood picture compared to static analogies that only display fixed images (Harrison & Coll, 2008).

The combination of the use of macroscopic, microscopic, and symbolic representations in physics learning can help students connect abstract concepts with more concrete and easily understood phenomena. Therefore, it is important for teachers to select and integrate these various representations effectively in physics teaching to improve understanding and facilitate deeper learning.

The use of various visual media, both real and virtual, has been the focus of various studies to improve the effectiveness of physics learning. Real and virtual visual media have their own advantages, but the combination of the two provides a more comprehensive approach.

A variety of visual media, both real and virtual, play an important role in learning, especially in helping students understand the material more interactively and interestingly. Real visual media is media based on real objects, such as physical props and experimental demonstrations. For example, the use of a capacitor model to explain the concept of electricity or a mechanical device to illustrate Newton's laws of motion (Chandrasegaran, et al., 2008). This media allows students to interact directly with real phenomena, so that the learning experience becomes more concrete. However, limitations of tools, costs, and time are often challenges in its use.

In addition, the use of various visual media provides flexibility in designing learning that is not monotonous. The combination of animation, interactive simulations, and other multimedia elements allows students to see, hear, and interact with learning materials. This approach helps explain physics concepts from the most concrete to the most abstract levels, thus supporting a complete understanding.

Based on these needs, the development of various visual media for physics learning, especially on the concept of charging and discharging capacitors, is very relevant. This media is expected to be able to integrate the three levels of concept representation while improving student conceptions, thus supporting the achievement of more effective learning objectives.

To further explore this issue, this study aims to answer the following research questions: How effective is the use of various visual media to improve physics learning. By addressing these questions, this study seeks to provide insights into the benefits and obstacles of using visual media in physics education, offering recommendations for more effective teaching strategies.

## 2. Method

This research is included in qualitative descriptive research using literature review research using various relevant sources to then be used for study and problem solving. The research flow is as follows (Figure 1):

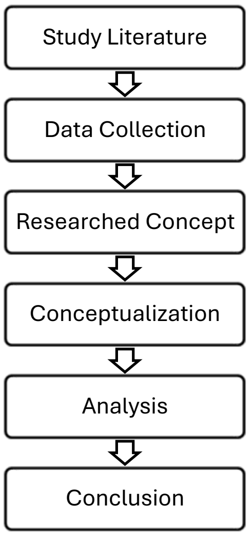


**Figure 1. Research Flow of preliminary study**

A literature review is a type of research conducted by examining various relevant library sources to answer certain problems. Through this process, solutions to problems can be found. The library sources used include books and journal articles both nationally and internationally. Boote & Beile (2005) also said that literature review includes theoretical literature, scientific literature, and other references related to culture and norms that emerge in the social environment being studied. The steps in literature study research according to Kuhlthau (2004) include; 1) Choosing a Research Topic 2) Exploring Related Information, 3) Determining Research Topics, 4) Collecting Various Data Sources, 5) Preparing for Data Presentation, 6) Compiling Research Results. In this study, research data collection uses sources from articles in national and international journals.

This study utilized a questionnaire to analyse media usage and needs, which was distributed to 20 high school Physics teachers in Bandung through Google Form. The respondents were selected based on specific criteria, including their teaching experience, access to technological resources, and their active involvement in delivering Physics instruction. This purposive sampling approach was chosen to ensure that the participants could provide relevant insights regarding media utilization in educational settings.

## 3. Results and Discussion

The findings of this study include data from the analysis of the use of visual media that have been used in the development of physics learning media in their schools. Based on the data obtained from the questionnaire results, several important findings can be identified regarding the types of visual media used, the purpose of using visual media, student responses to the media used, and obstacles in using visual media in the learning process.

### 3.1. Typed of Visual Media Used

Based on the data shown in Figure 2, as many as 94.1% of teachers use visual media in the form of PowerPoint, 82.4% of teachers have utilized digital simulation media, and 58.8% of teachers use animated videos and sketch in physics learning, especially in the material Static electricity and capacitors. This shows that teachers have actively applied various types of visual media to support the physics learning process. Meanwhile, based on the data in Figure 3, the visual media considered the most effective for explaining the concept of capacitors is digital simulation, with a percentage reaching 82.4%. This high number indicates that digital simulation is able to represent abstract concepts in capacitor material that are difficult for students to understand.

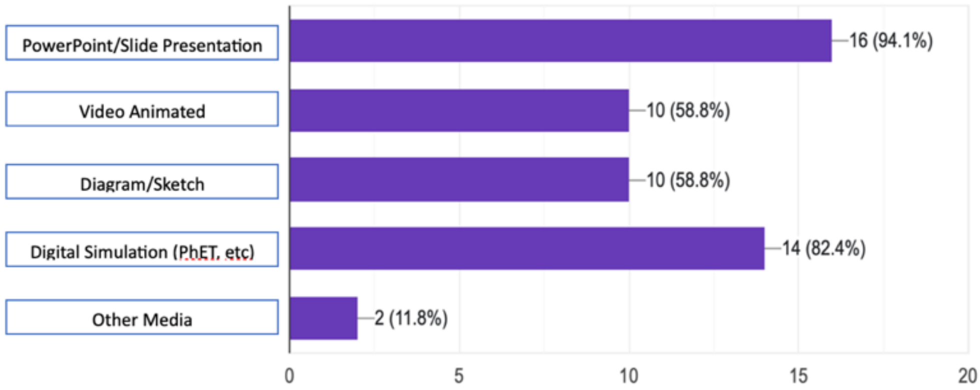


**Figure 2. Diagram of physics teacher responses regarding the types of visual media used**

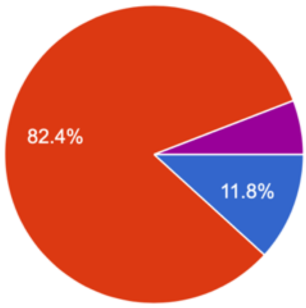


**Figure 3. Diagram of physics teachers' responses to types of effective visual media**

Based on the data shown in Figure 4, it is known that 52.9% of high school physics teachers in Bandung have used digital simulations, such as PhET and similar media, in the physics learning process, especially in Static Electricity and Capacitors. The main reason for using this digital simulation is to help students understand the abstract concepts of Static Electricity and Capacitors. These abstract concepts are often difficult to understand through simple verbal or visual explanations, so digital simulations are a very effective tool. By utilizing simulation technology, teachers can present physics phenomena interactively and dynamically, allowing students to observe and explore various variables directly. In addition, the use of this simulation also helps overcome limitations in laboratory experiments that sometimes require special equipment or certain conditions that are difficult to replicate in the classroom.

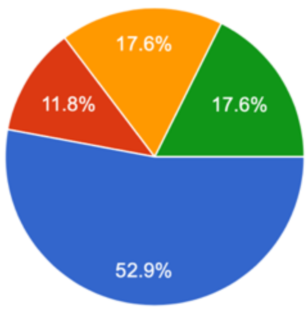


**Figure 4. Diagram of Physics teachers' responses regarding the purpose of using visual media**

## 3.2. Student Responses to the Use of Visual Media

The use of various types of visual media, both real and virtual, by teachers in the physics learning process has a very positive impact on learning. Based on the data displayed in Figure 5, it can be seen that the application of this media can increase student motivation in learning physics. Real visual media, such as physics teaching aids, allow students to interact directly with learning objects, thereby strengthening their understanding of basic concepts. Meanwhile, virtual visual media, such as digital simulations and animated videos, offer flexibility in depicting complex or difficult-to-replicate physics phenomena in the real world.

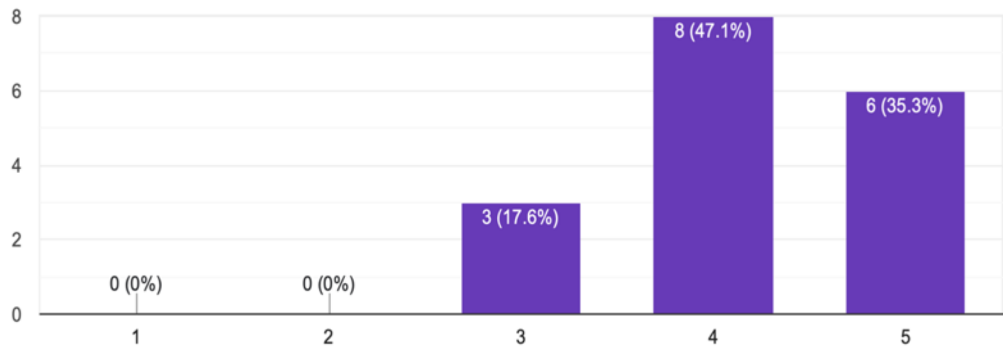


**Figure 5. Teacher response diagram related to student responses to the use of visual media**

## 3.3. Obstacles to the Use of Visual Media

Although the application of various visual media in physics learning has had a positive impact, there are several obstacles faced by high school physics teachers in Bandung City. Based on the data (Figure 6), as many as 58.8% of teachers stated that time constraints are the main obstacle in preparing learning media. This shows that busyness and high administrative demands often make it difficult for teachers to design and prepare optimal visual media. In addition, 23.5% of teachers stated that limited facilities or technology in schools are also inhibiting factors. The lack of supporting tools, such as adequate computer devices or access to simulation software, limits teachers' creativity in creating innovative visual media variations. Not only that, some teachers also face technical obstacles, such as lack of ability or training in creating and using visual media effectively. These obstacles indicate the need for greater support, both in terms of time, training, and facilities, to ensure that the application of visual media in physics learning can run more optimally and provide maximum results for students. Based on the results of the questionnaire above, it can be concluded that the use of various visual media, both real and virtual, has proven effective in improving students' understanding of complex physics concepts, especially Static Electricity and Capacitors. Digital simulations, such as PhET, are the most effective media because they are able to represent abstract concepts interactively, allowing students to explore various variables that are difficult to explain through simple verbal or visual explanations. In addition, visual media such as animated videos and real props provide an interesting learning experience and motivate students to be more enthusiastic in understanding physics material. However, obstacles such as time constraints, minimal technological facilities, and lack of technical training for teachers are still challenges in implementing this media. Therefore, support in the form of training, provision of facilities, and effective time management are needed to maximize the benefits of visual media in physics learning. Various visual media, such as real and virtual models, play an important role in physics learning, which often involves complex concepts that are difficult for students to understand. Video as an audio-visual medium allows students to see the physics process in motion and hear direct explanations, making complex concepts easier to understand. Videos can depict physical phenomena dynamically, such as demonstrations of experiments or presentations of scientific processes that cannot be directly observed in the real world, thus providing a more engaging and interactive learning experience (Pritsker, 2016).

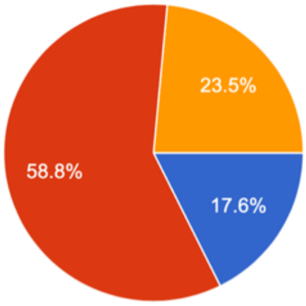


**Figure 6. Diagram of teacher responses to obstacles in using visual media**

On the other hand, virtual models, which utilize technologies such as computer graphics, augmented reality (AR), and virtual reality (VR), offer digital representations of physical objects or processes that cannot be seen with the naked eye. Virtual models allow students to explore phenomena at the microscopic or microscopic level, such as the movement of electrons in an electrical circuit or the interaction of particles in a system, that are difficult to explain through macroscopic or symbolic representations alone (Laudon & Laudon, 2020). The use of virtual models in physics learning provides a more immersive learning experience and allows students to interact directly with physics concepts, enriching their understanding of the material being taught. These two types of visual media, with their respective advantages, complement each other in helping students understand physics concepts from various levels of representation, thus supporting more comprehensive and effective mastery of the material (Flath, C. M., et al., 2019).

Digital simulations, such as PhET, are particularly effective compared to PowerPoint presentations or animated videos due to their interactive nature. Simulations allow students to manipulate variables in real-time, observe cause-and-effect relationships directly, and experiment with conditions that are challenging to replicate in real-life settings. This active engagement fosters deeper conceptual understanding and critical thinking skills (Zacharia, 2007; Wieman & Perkins, 2005). Moreover, digital simulations are highly adaptive, enabling students to proceed at their own pace, revisit concepts, and explore multiple scenarios, which supports differentiated learning (de Jong et al., 2013; Rutten et al., 2012). These characteristics make digital simulations superior for mastering complex physics concepts like static electricity and capacitors, where dynamic interactions between electric charges and fields can be visualized clearly and interactively.

In terms of static electricity and capacitors, digital simulations excel in illustrating abstract concepts that are otherwise difficult to demonstrate with traditional media. For example, students can visualize electric field lines, charge distribution on capacitor plates, and the effect of dielectric materials in real-time, reinforcing theoretical concepts through visual demonstration. The ability to manipulate conditions such as voltage, capacitance, and distance between plates helps students grasp the underlying principles more effectively (Smetana & Bell, 2012; Finkelstein et al., 2005).

Real visual media involves physical props and direct experiments that allow students to interact with real objects. For example, the use of simple electrical circuit models can help students understand the basic principles of electricity and magnetism (Chandrasegaran et al., 2008). Live demonstrations in a physics laboratory facilitate students' understanding of concepts such as Newton's laws of motion or Archimedes' principle (Davidowitz et al., 2010). Research by Marshall and Young (2006) highlights that hands-on experiments significantly improve students' ability to connect theoretical concepts with practical applications. Similarly, Abrahams and Millar (2008) emphasized that students engaged in practical laboratory activities tend to retain scientific concepts longer and develop stronger inquiry skills. Additionally, a study by Hofstein and Lunetta (2004) demonstrated that combining real visual media with interactive discussions enhances students' conceptual understanding and boosts their engagement in science learning.

However, real media has limitations related to cost, availability of equipment, and time required for implementation. Nevertheless, the direct experience gained through this media is difficult to replace because it provides a concrete basis for building students' initial understanding.

Virtual visual media includes animation, computer simulations, and digital-based technologies such as Virtual Reality (VR). Verdian et al. (2020) showed that PhET simulations improve students' conceptual understanding through in-depth interaction with the material. In addition, research by Husnaini and Chen (2019) showed that guided inquiry-based virtual laboratories are more effective in improving students' understanding of complex concepts and scientific inquiry self-efficacy compared to physical laboratories. Likewise research by Cabural (2024) found that using VR simulations can enhance students' conceptual understanding in electricity and magnetism topics. Students who used VR simulations showed a 35% increase in post-test scores compared to a 15% increase in the control group that received traditional instruction. Virtual media allows students to learn abstract concepts, such as particle motion, electric fields, or microscopic processes, which are difficult to represent through real media (Mayer, 2017).

The advantage of virtual visual media lies in its flexibility, because it can be accessed anytime and anywhere if the device is adequate. However, challenges such as uneven technological infrastructure and the need for teacher training are still major obstacles to its use.

Research shows that a combination of real and virtual media provides more optimal results than using one type of media alone. Abdulrahaman et al. (2020) found that the combination of these two media significantly improved students' understanding of physics concepts. For example, in learning electrical circuits, real media can be used to demonstrate physical processes, while virtual simulations provide microscopic images, such as the movement of electrons in electrical circuits.

Based on the literature study, further research that can be developed is the development of a variety of real and virtual-based visual media to improve students' conceptual understanding and motivation in capacitor material. Capacitor material is often considered difficult to understand by students because it involves abstract concepts, such as electric fields, electric potential energy, and charge distribution in capacitors. Therefore, this study aims to develop learning media that are able to represent these concepts in a concrete and interesting way, so that they can help students understand the material more deeply while increasing their learning motivation.

This study will use the ADDIE (Analysis, Design, Development, Implementation, Evaluation) model development approach. At the analysis stage, identification of students' learning difficulties in capacitor material is carried out through interviews with physics teachers and analysis of student needs. The design stage will focus on the development of visual media that integrates physical demonstrations (real) and digital simulations (virtual). The development phase will include the creation of instructional videos, interactive animations, and VR-based simulations designed to demonstrate physics phenomena from the macroscopic to the microscopic level. Real media will be used to demonstrate how capacitors store and release charges in simple circuits, while virtual media will be used to visualize abstract processes such as charging and discharging capacitors at the particle level. Both media will be designed to complement each other, providing a holistic learning experience for students.

The implementation phase will be conducted on grade XII students in a high school to measure the effectiveness of visual media on conceptual understanding and learning motivation. Students' conceptual understanding will be measured using a conceptual test developed based on Bloom's taxonomy, while learning motivation will be measured through a questionnaire based on the ARCS (Attention, Relevance, Confidence, Satisfaction) learning motivation theory.

The results of this study are expected to show that the use of real and virtual visual media can significantly improve students' conceptual understanding of capacitor material. In addition, this study is also expected to reveal the impact of various visual media on students' learning motivation, thus providing new insights for physics teachers to integrate innovative learning media into their teaching. The combination of real and virtual media that is strategically designed is believed to be able to create learning that is more interactive, effective, and relevant to the needs of students in the modern technological era.

## 4. Conclusion

The use of various visual media, both real and virtual, has been proven to increase the effectiveness of physics learning. Real media provides concrete experiences, while virtual media allows for in-depth abstract visualization. The combination of these two media provides a holistic learning approach that supports students' conceptual understanding. For optimal implementation, appropriate learning design and teacher training are crucial. Further research can be directed at developing learning strategies using various visual media (real and virtual) that are more adaptive and innovative, in accordance with the needs of physics learning in the digital era.

## Author Contributions

All authors have equal contributions to the paper. All the authors have read and approved the final manuscript.

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The author declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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