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# Development of Powtoon Animation Videos for STEM-Integrated Physics Learning and Its Impact on Student Learning Outcomes

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**Abstract**

This study aimed to develop Powtoon animated videos for STEM-integrated physics learning and assess their impact on student learning outcomes. The Research and Development (R&D) method, using the ADDIE model, was employed to systematically develop and evaluate the instructional media. The study involved five phases: analysis, design, development, implementation, and evaluation. During the analysis phase, needs were identified based on observations of students' difficulties in understanding abstract physics concepts and their disengagement from traditional teaching methods. The videos were developed to integrate scientific, technological, engineering, and mathematical (STEM) concepts, focusing on simple machines such as levers and pulleys. Expert validation was conducted to assess the quality of the videos, and revisions were made accordingly. The implementation phase involved a pretest-posttest control group design with eighth-grade students from SMP Negeri 2 Watumalang. The experimental group used the STEM-integrated Powtoon videos, while the control group received traditional instruction. Data were analyzed using a t-test and N-Gain to measure the improvement in student learning outcomes. Results showed a significant improvement in the experimental group's post-test scores, with an average N-Gain of 66.95%, categorized as moderately effective. The control group had a lower average N-Gain of 49.22%, categorized as less effective. The findings demonstrate that the Powtoon videos not only enhanced students' conceptual understanding but also increased their motivation and engagement in physics learning. These results suggest that integrating STEM principles into instructional media, such as animated videos, is an effective strategy for improving learning outcomes in physics. The study recommends expanding the use of such multimedia approaches across other STEM-related subjects to foster critical thinking and problem-solving skills in students.

**Keywords**: STEM-integrated learning; Powtoon animated videos; Physics education; Student learning outcomes; Educational technology.

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## INTRODUCTION

Physics is a subject that transcends the mere memorization of theoretical concepts and mathematical equations, requiring instead a deep understanding and the application of concepts to make learning meaningful. Effective physics education relates complex concepts to real-world phenomena, thus requiring educators to facilitate the development of students' critical thinking, logical reasoning, and abstract thinking skills (Syawaludin, 2019). A well-executed physics lesson has the potential to enhance students' motivation and academic performance, provided that the teaching methods and materials are engaging and well-structured. Learning media, which guides educators in achieving learning objectives through systematic material delivery, can be instrumental in presenting engaging and high-quality instruction that positively impacts learning outcomes.

Despite these potential benefits, the reality of physics education in schools often reflects a different picture. Students frequently find physics difficult and uninteresting due to the perception that it involves a plethora of formulas and theories that require fundamental understanding. This challenge arises because physics not only involves concept comprehension but also demands students to think constructively to grasp the full essence of physics, which includes its nature as a product, process, and attitude (Murdani, 2020). Unfortunately, students' conceptual understanding remains weak, often due to learning strategies that focus primarily on rote memorization rather than true comprehension. As a result, students tend to forget the material they have learned quickly (Primayana et al., 2019). In many cases, students can only solve routine problems and perform simple computations but lack the ability to integrate information, draw conclusions, or generalize their knowledge to new situations (Roebianto, 2020).

The monotony of traditional physics instruction, often characterized by the use of textbooks or static modules with little variation, further exacerbates students' lack of interest in the subject (Yoshua, 2022). The limited use of instructional media during physics lessons can lead to boredom and a lack of engagement, ultimately affecting students' academic performance (Wafiq, 2021). Many schools have not yet adopted or developed learning media that can foster problem-solving skills, which are essential for students to thrive in the 21st century (Setiani, 2021).

To address these challenges, innovative instructional media can be introduced to improve the teaching and learning of physics. Such media should be tailored to the needs and characteristics of students, with the potential to stimulate their thoughts, emotions, interests, and attention, thus fostering effective and efficient learning experiences (Fitriyani, 2019). Learning media can help translate abstract concepts into more concrete forms, enhancing students' ability to think critically and analyze learning materials in a fun and engaging environment. The selection of media should be aligned with the teaching strategies and learning objectives, ensuring that the chosen tools enhance the learning experience.

However, the choice of learning media for physics cannot be generalized in the same way it might be for other subjects. Each topic in physics has unique attributes that require specific media to best convey the material (Ridwan, 2021). Various approaches can be employed to assist students in analyzing key concepts from the real world and to stimulate the development of 21st-century skills (Muttaqin, 2023). Among the innovative approaches suitable for modern education is the STEM (Science, Technology, Engineering, and Mathematics) approach. STEM education integrates science, technology, engineering, and mathematics, emphasizing not only theoretical understanding but also the practical application of knowledge. STEM-based learning encourages students to engage with technology and to develop problem-solving and critical thinking skills, which are essential in today’s world. When integrated with instructional media, such as animated videos, STEM education can help students accumulate knowledge and improve critical thinking skills, which are essential for 21st-century learners.

Animated videos are an effective tool for capturing students' attention, helping them focus, and making it easier to understand the material presented by the teacher. Dynamic and interactive educational content, presented in various formats, can motivate students to engage more deeply with the learning process. The ability of animated videos to visualize complex concepts and make them more accessible to students is a key advantage of using this medium in education (Wardani et al., 2024). One particularly effective tool for creating animated instructional videos is Powtoon, an online animation software that allows users to create engaging and visually appealing content easily (Anam, 2019). Powtoon enables the creation of interactive learning media that is not only simple to produce but also highly effective and efficient in supporting the learning process. Its interface is similar to that of PowerPoint, but the end product is more vibrant and engaging, often incorporating Flash animations (Fitriyani, 2019).

Given the challenges outlined above, there is a clear need for the development of engaging instructional media to create a more enjoyable learning environment. The current research focuses on developing Powtoon-based animated videos for STEM-integrated physics learning. The videos will cover the topic of simple machines, a subject that lends itself well to a STEM approach. By integrating physics, technology, engineering, and mathematics, the videos aim to help students better understand the subject matter. Through this integration, students will be able to explore the physics concepts behind simple machines, understand their technological applications, and solve related problems using mathematical reasoning. The researcher anticipates that the use of these STEM-integrated Powtoon videos will optimize student learning outcomes by making the subject matter more accessible and engaging.

Previous research has demonstrated the positive impact of Powtoon videos on students' learning outcomes across various disciplines. Numerous studies have consistently shown that Powtoon animated videos enhance students' conceptual understanding and academic performance (Firdaus, 2023; Nurmalah Hidayah, 2021; Gracia Efra Scolistika, 2022; Edi Mulyana, 2023). These studies highlight not only the academic benefits of using Powtoon videos but also their ability to increase students' motivation and engagement in the learning process, making the lessons more appealing and effective. Powtoon videos can serve as an alternative learning tool that allows students to learn either collaboratively or individually, without the constraints of time or place.

In the context of STEM-integrated physics education, Powtoon videos can help bridge the gap between theoretical knowledge and real-world applications. By providing a visual and interactive platform for exploring scientific concepts, these videos offer students an opportunity to engage with the material more deeply. The integration of STEM into the videos encourages students to approach physics not only as a set of theories and formulas but as a field that intersects with technology and engineering, offering practical solutions to real-world challenges. By fostering critical thinking and problem-solving skills, Powtoon videos support the development of competencies that are crucial for success in the 21st century.

The development of Powtoon animation videos for STEM-integrated physics learning represents a promising approach to improving student learning outcomes. By making complex concepts more accessible and engaging, these videos have the potential to transform the way physics is taught and learned. The interactive nature of Powtoon videos, combined with the STEM approach, allows students to explore and apply scientific concepts in a way that is both meaningful and enjoyable. As educators continue to seek innovative solutions to enhance learning, the use of Powtoon videos in physics education may offer a valuable tool for helping students achieve their academic goals.

## Study objectives, novelty and hypothesis

The primary objective of this study is to develop Powtoon animated videos specifically designed for STEM-integrated physics learning and to evaluate their impact on student learning outcomes. This objective is rooted in the growing need for innovative educational tools that not only engage students but also enhance their understanding of complex scientific concepts. Physics, as a subject, often presents significant challenges to students due to its abstract nature, which requires a high level of cognitive processing. Traditional teaching methods, which frequently rely on textbooks and theoretical lectures, have been shown to contribute to students' disinterest and difficulty in mastering the subject (Syawaludin, 2019; Yoshua, 2022). Therefore, the introduction of animated videos as a learning medium aims to address these challenges by offering a dynamic and interactive approach to physics education.

The novelty of this study lies in the integration of STEM (Science, Technology, Engineering, and Mathematics) principles within the Powtoon video content. STEM education emphasizes the interconnection between these fields, encouraging students not only to understand scientific theories but also to apply them in real-world contexts (Muttaqin, 2023). By developing videos that incorporate STEM concepts into physics lessons, this study seeks to bridge the gap between theoretical knowledge and practical application, providing students with a more comprehensive learning experience. The videos, which focus on the topic of simple machines, are designed to facilitate students' understanding of physics principles by relating them to technological and engineering applications. This approach aligns with the goal of fostering 21st-century skills such as critical thinking, problem-solving, and innovation (Fitriyani, 2019).

Moreover, the study aims to assess the effectiveness of these STEM-integrated Powtoon videos in improving student learning outcomes. Previous research has demonstrated the positive effects of using animated videos in education, particularly in enhancing students' motivation and engagement (Firdaus, 2023; Gracia Efra Scolistika, 2022). However, this study seeks to go beyond motivational factors, focusing specifically on how these videos impact students' conceptual understanding and retention of physics knowledge. The evaluation of learning outcomes will be based on both qualitative and quantitative data, allowing for a comprehensive assessment of the video's effectiveness.

The hypothesis underpinning this study is that the use of Powtoon animated videos for STEM-integrated physics learning will lead to significant improvements in student learning outcomes. This hypothesis is supported by existing literature, which highlights the benefits of using multimedia tools in education. Studies have shown that multimedia, such as animated videos, can help simplify complex subjects by presenting information in a visually appealing and interactive manner (Wardani et al., 2024). In the context of physics, where students often struggle with abstract concepts, the use of animated videos can provide concrete visualizations that make learning more accessible and enjoyable. This study builds on that foundation, hypothesizing that the integration of STEM principles into these videos will further enhance their educational impact.

In conclusion, the development and evaluation of Powtoon animated videos for STEM-integrated physics learning is expected to contribute significantly to the field of educational technology. By offering an innovative approach to teaching physics, this study aims to provide educators with a valuable tool for enhancing student engagement, motivation, and learning outcomes. The focus on STEM integration further distinguishes this study, as it seeks to prepare students not only to excel academically but also to develop the skills necessary for success in the 21st century. Through this research, the effectiveness of Powtoon videos in improving student learning outcomes in physics will be rigorously assessed, potentially paving the way for broader applications of multimedia tools in science education.

## METHODS

This study employs the Research and Development (R&D) methodology, a research approach designed to create new solutions or develop new products while evaluating the effectiveness of these products (Sugiyono, 2017). The R&D method is particularly suited for this study as it focuses on the development and assessment of a product—in this case, Powtoon animated videos for STEM-integrated physics learning. To structure the research process systematically, the ADDIE model is utilized, a model specifically designed for the development of educational products to address learning problems by adapting to the needs and characteristics of learners. The ADDIE model consists of five stages: analysis, design, development, implementation, and evaluation (Rayanto, 2020). Each of these stages plays a crucial role in ensuring the research process is methodical and produces a viable and effective product.

### Analysis Phase

The first stage in the ADDIE model is the analysis phase. In this phase, the researcher identifies the specific needs and problems in the current learning environment, particularly within the context of physics education. Through a thorough needs analysis, the researcher assesses the difficulties students face in understanding complex physics concepts and the limitations of traditional teaching methods. The analysis focuses on understanding the gap between the current state of physics learning, which is often perceived as difficult and unengaging (Syawaludin, 2019), and the desired state, where students find learning physics both accessible and engaging through the integration of STEM principles and innovative media such as Powtoon animated videos. Data is collected through observations, interviews with educators, and surveys distributed to students, which helps pinpoint specific areas where instructional media could enhance learning outcomes.

### Design Phase

Once the analysis is completed, the next step is the design phase, where the instructional media—Powtoon animated videos—is planned. In this phase, the researcher determines the learning objectives, content structure, and design of the animated videos. The videos are created to focus on the topic of simple machines, integrating STEM principles to ensure that students not only understand the physics behind simple machines but also explore technological and engineering applications related to the topic. The design phase includes planning the video structure, developing the scripts, and outlining the visual elements that will be used in the animations. Additionally, assessment tools, such as pre-tests and post-tests, are designed to measure the effectiveness of the videos in improving students' learning outcomes.

## Development Phase

The development phase is where the actual creation of the Powtoon videos takes place. Using the design from the previous stage, the videos are produced using the Powtoon software, which is chosen for its simplicity and effectiveness in creating engaging and interactive animations (Fitriyani, 2019). The content of the videos is carefully crafted to ensure alignment with the learning objectives set during the design phase, with particular emphasis on integrating STEM principles into the physics lessons. In addition to creating the videos, this phase also involves developing supplementary materials such as quizzes and interactive activities that reinforce the concepts taught in the videos. Once the materials are developed, expert validation is conducted to assess the quality and validity of the product.

Expert validation involves media experts, content experts, and practitioners who evaluate the videos based on several criteria, including clarity, accuracy, and effectiveness in delivering the material. The validation process follows a specific scoring formula, as shown in Equation (1).

$$P_k = \frac{S}{N} x100\% \text{ ......... } (1)$$

Where:
- $P_k$ is the score percentage indicating the validity of the media,
- S is the total score obtained, and
- N is the ideal total score (Sugiyono, 2015).

The results of this validation are categorized based on Table 1, which classifies the media's validity into different levels ranging from "very valid" to "not valid."

**Table 1.** Validity category

| Range | Criteria |
|---|---|
| 76%-100% | Very valid |
| 51%-75% | Valid |
| 26%-50% | Less valid |
| 0%-25% | Not valid |

## Implementation Phase

The implementation phase involves testing the developed Powtoon videos in real classroom settings. In this study, a pretest-posttest control group design is employed, as outlined in Table 2, to assess the impact of the videos on student learning outcomes.

**Table 2.** Research design

| Group | Pretest | Treatment | Posttest |
|---|---|---|---|
| Experimental group | $O_1$ | X | $O_2$ |
| Control Group | $O_3$ | - | $O_4$ |

Two groups of students are involved: an experimental group that uses the Powtoon videos and a control group that receives traditional instruction. The pretest is administered to both groups before the intervention (denoted as $O_1$ for the experimental group and $O_3$ for the control group), followed by the intervention, where only the experimental group receives instruction using the Powtoon videos (denoted as X). After the intervention, both groups take a posttest (denoted as $O_2$ for the experimental group and $O_4$ for the control group). This design allows for a direct comparison of learning outcomes between the group that used the STEM-integrated Powtoon videos and the group that did not, thus enabling the researcher to measure the effectiveness of the media.

### Evaluation Phase

The final phase is evaluation, which occurs throughout the development process as well as after the implementation phase. The evaluation focuses on two aspects: the quality of the Powtoon videos and their effectiveness in improving student learning outcomes. Data collected from the pretest and posttest results are analyzed using a t-test to determine the statistical significance of the difference between the experimental and control groups. In addition to the t-test, normalized gain scores are calculated using the N-Gain formula (Hake, 1999) as shown in Equation (2).

$$(g) = \frac{post\ test\ score - pre\ test\ score}{maximum\ score - pre\ test\ score} \quad \ldots\ldots\ldots (2)$$

The gain scores are then categorized according to the criteria outlined in Tables 3 and 4, which classify the learning improvements into categories such as low, medium, and high, and determine the overall effectiveness of the instructional media.

**Table 3.** Scores criteria

| No | Range of N-Gain | Interpretation |
|---|---|---|
| 1 | $-100 \le g \le 0.00$ | There was a decrease |
| 2 | $g = 100$ | Consistently, no decrease in scores was observed |
| 3 | $0.00 \le g \le 0.30$ | Low |
| 4 | $0.30 \le g \le 0.70$ | Medium |
| 5 | $0.70 \le g \le 1.00$ | High |

**Table 4.** Criteria for determining the level of effectiveness

| No | Percentage (%) | Interpretation |
|---|---|---|
| 1 | <40 | Not effective |
| 2 | 40-55 | Less effective |
| 3 | 56-75 | Quite effective |
| 4 | >76 | Effective |

Through the ADDIE model, this research systematically develops and evaluates Powtoon animated videos for STEM-integrated physics learning. By following a structured approach, from analyzing learning needs to evaluating the product's impact, this study aims to provide a viable and effective educational tool that enhances student engagement and learning outcomes. The use of both expert validation and empirical testing ensures that the developed media is both pedagogically sound and effective in practice.

## RESULTS AND DISCUSSION

This section presents the findings from the Research and Development (R&D) process, which employed the ADDIE model to develop and implement Powtoon animated videos integrated with STEM concepts for physics learning. The R&D process followed a structured approach, consisting of analysis, design, development, implementation, and evaluation phases, each playing a vital role in producing a high-quality educational media product. This section discusses the results obtained at each stage of the ADDIE model, the validation and testing of the media, and the impact on student learning outcomes.

### Analysis Phase

The analysis phase aimed to collect and analyze information regarding the needs for developing STEM-integrated Powtoon animated videos. Observations conducted at SMP Negeri 2 Watumalang revealed that while physics classes utilized experimental and group discussion methods, students faced several challenges. These included the lengthy time required for experiments and inadequate learning facilities, which affected the learning process. Additionally, an analysis of the eighth-grade students' learning characteristics showed that although the learning environment was initially conducive, student attention and participation waned midway through the lesson. This was particularly evident when traditional learning media, such as textbooks, were used. Many students demonstrated a lack of interest in reading, which further highlighted the need for alternative, more engaging instructional media.

The analysis concluded that developing STEM-integrated Powtoon animated videos could address these challenges by offering a more interactive and visually engaging medium. The integration of real-world examples of simple machines in everyday life, combined with practical experiment videos, was identified as a crucial feature for enhancing students' understanding of physics. The results from this phase informed the subsequent stages of media development.

### Design Phase

In the design phase, the research team developed the structure and flow of the animated videos based on the analysis of students' needs. A flowchart and storyboard were created to outline the sequence of content, beginning with an introduction, followed by the main content, and concluding with a summary. The videos were structured around the topic of simple machines, covering both levers and pulleys, and were designed to integrate STEM principles.

Table 5 presents the structure of the videos, including the scientific concepts, technological applications, practical engineering examples, and mathematical calculations related to simple machines.

The design phase also involved the creation of validation instruments for media, material, and practitioner experts, as well as pre-test and post-test items to assess the effectiveness of the videos. The videos were designed to explain the scientific principles behind levers and pulleys, demonstrate their technological applications, and include interactive practice problems to engage students in the learning process.

**Table 5.** Powtoon animated video on simple machines material integrated with STEM

| Material | Levers | Pulley |
|---|---|---|
| *Science* | • Presenting explanations about the science concepts of first-class levers, second-class levers, and third-class levers. | • Providing explanations of scientific concepts on fixed pulleys, movable pulleys, and compound pulleys. |
| *Technology* | • Presenting the technologies that apply first-class levers, second-class levers, and third-class levers. | • Showcasing the technologies applied in fixed pulleys, movable pulleys, and compound pulleys. |
| *Engineering* | • Displaying a lever experiment video. | • Displaying pulley experiment video. |
| *Mathematic* | • Presenting lever mechanical advantage calculations and example problems. | • Demonstrating pulley mechanical advantage calculations and example problems |

## Development Phase

The development phase involved the actual creation of the Powtoon animated videos based on the designs formulated in the previous phase. The videos were produced using the Powtoon software, which allowed the incorporation of animations, voiceovers, and real-life examples of simple machines. The final product included animations that demonstrated how levers and pulleys work, their applications in daily life, and the mathematical calculations used to determine mechanical advantage.

The developed media underwent validation by three groups of experts: media experts, content experts, and practitioners. The results of the validation are presented in Tables 6, 7, and 8.

**Table 6.** Validation data by media experts

| Aspect | $\bar{x}$ | Percentage | Validity criteria |
|---|---|---|---|
| Software engineering | 3,88 | 97% | Very valid |
| Learning design | 3,86 | 97% | Very valid |
| Visual communication | 4,00 | 100% | Very valid |
| $\Sigma\bar{x}$ | 3,92 | 98% | Very valid |

**Table 7.** Validation data by content experts

| Aspect | $\bar{x}$ | Percentage | Validity criteria |
|---|---|---|---|
| Material/content | 3,24 | 86% | Very valid |
| Learning | 3,66 | 92% | Very valid |
| languange | 3,40 | 85% | Very valid |
| $\Sigma\bar{x}$ | 3,50 | 88% | Very valid |

**Table 8.** Validation data by expert practitioners

| Aspect | $\bar{x}$ | Percentage | Validity criteria |
|---|---|---|---|
| Effectiveness | 2,78 | 70% | Valid |
| Interactive | 2,89 | 72% | Valid |

| Aspect | $\bar{x}$ | Percentage | Validity criteria |
|---|---|---|---|
| Efficient | 3,83 | 71% | Valid |
| Creative | 3,00 | 75% | Valid |
| $\Sigma\bar{x}$ | 2,87 | 72% | Valid |

Media experts rated the video with an average score of 3.92 (98%), categorizing it as "very valid" based on criteria such as software engineering, instructional design, and visual communication. Content experts gave the media an average score of 3.50 (88%), also categorizing it as "very valid." However, practitioners provided a slightly lower average score of 2.87 (72%), which placed the media in the "valid" category, but indicated areas for potential improvement, particularly in terms of effectiveness and interactivity.

Based on the expert feedback, minor revisions were made to the videos before they were finalized for implementation. These revisions included improving the clarity of the voiceover, adding more interactive elements to the practical sections, and ensuring that the mathematical problems were clearly explained. Once the revisions were completed, the final product was uploaded to YouTube for ease of access and distribution (https://youtu.be/fzd8PVPqm48?si=BorpTHFGPwhIQcZX).

## Implementation Phase

The implementation phase involved testing the effectiveness of the developed media in a real classroom setting. The media was implemented in class VIII B of SMP Negeri 2 Watumalang, where the students were divided into an experimental group and a control group. The experimental group used the STEM-integrated Powtoon videos, while the control group received traditional instruction without the animated videos.

The data collected from both groups is summarized in Table 9, which shows the pre-test and post-test scores for both the experimental and control groups. The mean pre-test score for the experimental group was 37.13, while the post-test score increased to 79.47, indicating a significant improvement. In contrast, the control group had a mean pre-test score of 38.83 and a post-test score of 69.23, showing a less substantial increase in performance.

**Table 9.** Experimental and control group data

| Parameters | Exp. Group (Pre-Test) | Exp. Group (Post-Test) | Cont. Group (Pre-Test) | Cont. Group (Post-Test) |
|---|---|---|---|---|
| N | 30 | 30 | 30 | 30 |
| Mean | 37.13 | 79.47 | 38.83 | 69.23 |
| Std. Error of Mean | 2.476 | 2.536 | 2.838 | 2.907 |
| Median | 36.50 | 80.00 | 40.00 | 70.00 |
| Mode | 27[a] | 87 | 27 | 60 |
| Std. Deviation | 13.561 | 13.888 | 15.543 | 15.922 |
| Variance | 183.913 | 192.878 | 241.592 | 253.495 |
| Range | 54 | 53 | 60 | 60 |
| Minimum | 13 | 47 | 13 | 40 |
| Maximum | 67 | 100 | 73 | 100 |
| Sum | 1114 | 2384 | 1165 | 2077 |

**Table 10.** t-test results

| Levene's Test | | | t-test for Equality of Means | | | | |
|---|---|---|---|---|---|---|---|
| | F | Sig. | t | Df | Sig. | Mean Diff | SE Diff |
| Equal var. assumed | 0,855 | 0,359 | 2,653 | 58 | 0,005 | 10,233 | 3,857 |
| Equal var. not assumed | - | - | 2,653 | 56,95 | 0,005 | 10,233 | 3,857 |

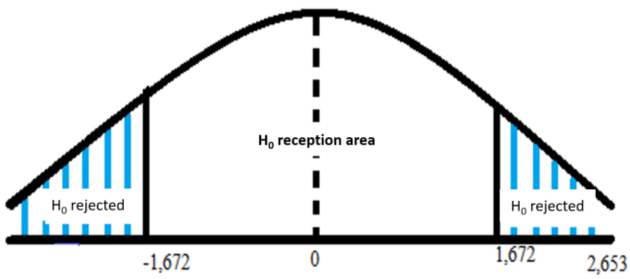


**Figure 1.** t-distribution curve

To determine whether the difference in learning outcomes between the two groups was statistically significant, a t-test was conducted. The results of the t-test, presented in Table 10, show that the calculated t-value was 2.653, which falls within the rejection region of the null hypothesis, indicating that there was a significant difference between the experimental and control groups. The one-sided p-value was 0.005, further confirming the significance of the results. Figure 1 shows the t-distribution curve, which illustrates that the calculated t-value lies beyond the critical value, reinforcing the conclusion that the use of the STEM-integrated Powtoon videos had a statistically significant impact on student learning outcomes.

## Evaluation Phase

The evaluation phase focused on determining the overall effectiveness of the media by analyzing the pre-test and post-test results from both the experimental and control groups. To further assess the improvement in learning outcomes, the normalized gain (N-Gain) scores were calculated using the formula developed by Hake (1999). The results of the N-Gain analysis are presented in Tables 11 and 12.

For the experimental group, the average N-Gain score was 66.95%, which falls within the "moderately effective" category. In contrast, the control group had an average N-Gain score of 49.22%, which is classified as "less effective." Table 13 summarizes the effectiveness of the media, indicating that the STEM-integrated Powtoon videos were more effective in improving student learning outcomes compared to traditional instruction.

**Table 11.** Average N-Gain results in the experimental group

| Students | Pretest score | Posttest score | N-Gain Score | N-Gain (%) |
|---|---|---|---|---|
| 1. | 27 | 73 | 0,63 | 63,01 |
| 2. | 40 | 60 | 0,33 | 33,33 |
| 3. | 40 | 87 | 0,78 | 78,33 |
| 4. | 13 | 73 | 0,69 | 68,97 |

| Students | Pretest score | Posttest score | N-Gain Score | N-Gain (%) |
|---|---|---|---|---|
| 5. | 33 | 60 | 0,40 | 40,30 |
| 6. | 27 | 100 | 1,00 | 100,00 |
| 7. | 47 | 73 | 0,49 | 49,06 |
| 8. | 27 | 80 | 0,73 | 72,60 |
| 9. | 60 | 80 | 0,50 | 50,00 |
| 10. | 67 | 93 | 0,79 | 78,79 |
| 11. | 33 | 60 | 0,40 | 40,30 |
| 12. | 53 | 87 | 0,72 | 72,34 |
| 13. | 20 | 87 | 0,84 | 83,75 |
| 14. | 27 | 97 | 0,96 | 95,89 |
| 15. | 47 | 67 | 0,38 | 37,74 |
| 16. | 33 | 53 | 0,30 | 29,85 |
| 17. | 27 | 47 | 0,27 | 27,40 |
| 18. | 33 | 100 | 1,00 | 100,00 |
| 19. | 53 | 80 | 0,57 | 57,45 |
| 20. | 27 | 80 | 0,73 | 72,60 |
| 21. | 60 | 93 | 0,83 | 82,50 |
| 22. | 40 | 80 | 0,67 | 66,67 |
| 23. | 47 | 80 | 0,62 | 62,26 |
| 24. | 40 | 87 | 0,78 | 78,33 |
| 25. | 33 | 87 | 0,81 | 80,60 |
| 26 | 40 | 87 | 0,78 | 78,33 |
| 27. | 47 | 87 | 0,75 | 75,47 |
| 28. | 40 | 73 | 0,55 | 55,00 |
| 29. | 20 | 100 | 1,00 | 100,00 |
| 30. | 13 | 73 | 0,69 | 68,97 |

**Table 12.** Average N-Gain results in the control group

| Students | Pretest score | Posttest score | N-Gain Score | N-Gain (%) |
|---|---|---|---|---|
| 1. | 53 | 80 | 0,57 | 57,45 |
| 2. | 27 | 57 | 0,41 | 41,10 |
| 3. | 40 | 60 | 0,33 | 33,33 |
| 4. | 53 | 60 | 0,15 | 14,89 |
| 5. | 40 | 60 | 0,33 | 33,33 |
| 6. | 27 | 93 | 0,90 | 90,41 |
| 7. | 27 | 47 | 0,27 | 27,40 |
| 8. | 40 | 73 | 0,55 | 55,00 |
| 9. | 13 | 40 | 0,31 | 31,03 |
| 10. | 27 | 67 | 0,55 | 54,79 |
| 11. | 53 | 47 | -0,13 | -12,77 |
| 12. | 40 | 87 | 0,78 | 78,33 |
| 13. | 53 | 73 | 0,43 | 42,55 |
| 14. | 53 | 100 | 1,00 | 100,00 |
| 15. | 13 | 60 | 0,54 | 54,02 |
| 16. | 47 | 67 | 0,38 | 37,74 |

| Students | Pretest score | Posttest score | N-Gain Score | N-Gain (%) |
|---|---|---|---|---|
| 17. | 13 | 53 | 0,46 | 45,98 |
| 18. | 73 | 93 | 0,74 | 74,07 |
| 19. | 27 | 60 | 0,45 | 45,21 |
| 20. | 27 | 73 | 0,63 | 63,01 |
| 21. | 27 | 47 | 0,27 | 27,40 |
| 22. | 40 | 100 | 1,00 | 100,00 |
| 23. | 40 | 60 | 0,33 | 33,33 |
| 24. | 27 | 73 | 0,63 | 63,01 |
| 25. | 73 | 74 | 0,04 | 3,70 |
| 26 | 33 | 87 | 0,81 | 80,60 |
| 27. | 33 | 73 | 0,60 | 59,70 |
| 28. | 53 | 80 | 0,57 | 57,45 |
| 29. | 53 | 73 | 0,43 | 42,55 |
| 30. | 40 | 60 | 0,33 | 33,33 |

**Table 13.** Results of the n-gain score test analysis

| Group | N-Gain average | Criteria |
|---|---|---|
| Experimental | 66,95% | Moderately effective |
| Control | 49,22% | Less effective |

The evaluation phase also involved qualitative feedback from students and teachers regarding the use of the videos. Students reported that the videos were engaging, easy to follow, and helped them better understand the physics concepts. Teachers noted that the videos provided a useful supplement to traditional instruction, particularly in explaining complex topics such as mechanical advantage and the practical applications of levers and pulleys.

The results of this study demonstrate that the use of STEM-integrated Powtoon animated videos significantly improved student learning outcomes in physics. The increase in post-test scores and the positive N-Gain scores for the experimental group highlight the effectiveness of the videos in enhancing students' understanding of the subject matter. This is consistent with previous research, which has shown that animated videos can increase student engagement and motivation, leading to better learning outcomes (Firdaus, 2023; Wardani et al., 2024).

The integration of STEM principles into the videos played a crucial role in making the content more relevant and engaging for students. By connecting physics concepts to real-world applications in technology and engineering, the videos helped students see the practical value of what they were learning. This approach is aligned with the goals of STEM education, which seeks to prepare students for the challenges of the 21st century by fostering critical thinking and problem-solving skills (Muttaqin, 2023).

Furthermore, the use of Powtoon as a platform for creating the videos proved to be an effective choice. The software allowed for the creation of visually appealing and interactive animations that captured students' attention and facilitated their understanding of complex topics. The positive feedback from both students and teachers suggests that Powtoon videos could be a valuable addition to the toolkit of physics educators, particularly when teaching abstract concepts that are difficult to explain through traditional methods.

The results of this study indicate that the STEM-integrated Powtoon videos are a highly effective instructional medium for improving student learning outcomes in physics. The videos not only made learning more engaging but also helped students develop a deeper understanding of the subject matter by linking it to real-world applications. The findings suggest that similar approaches could be applied to other subjects within the STEM curriculum, potentially leading to broader improvements in student engagement and achievement across multiple disciplines.

## CONCLUSION

The development of Powtoon animated videos for STEM-integrated physics learning has proven to be an effective strategy for enhancing student learning outcomes. The integration of scientific, technological, engineering, and mathematical principles into the content allowed students to engage with complex physics concepts in a more interactive and meaningful way. The findings from this study demonstrate that the use of these videos led to a significant improvement in students' understanding, as indicated by the higher post-test scores and positive N-Gain results in the experimental group. The videos provided not only academic benefits but also helped increase student motivation and engagement during the learning process, highlighting the potential of multimedia tools in modern education.

In conclusion, the STEM-integrated Powtoon videos successfully addressed the challenges often associated with traditional physics instruction, such as disengagement and difficulty in understanding abstract concepts. By making learning more accessible and relatable through practical applications of physics, the videos contributed to the development of critical thinking and problem-solving skills, which are essential for 21st-century learners. The results of this study suggest that similar multimedia approaches can be expanded to other subjects within the STEM curriculum, offering educators innovative tools to improve both engagement and learning outcomes across various disciplines.

## RECOMMENDATION

Based on the findings of this study, it is recommended that physics teachers incorporate Powtoon animated videos into their instructional practices, particularly for STEM-integrated physics lessons on topics such as simple machines. The validation results confirmed that the media is effective and valid for use in the classroom, offering an innovative and engaging approach to teaching complex scientific concepts. By utilizing these animated videos, teachers can create a more dynamic and interactive learning environment that enhances student engagement and motivation, ultimately leading to improved learning outcomes.

Furthermore, teachers are encouraged to explore the use of this media as a creative tool to diversify their teaching methods. The use of Powtoon videos provides an opportunity to break away from traditional textbook-based instruction and introduce a multimedia element that resonates with 21st-century learners. As physics concepts can often be abstract and challenging, incorporating visually appealing and interactive media can make the subject more accessible and enjoyable for students. Therefore, it is recommended that schools and educators invest in the development and implementation of similar multimedia resources to foster a more engaging and effective physics learning experience.

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