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Development of Flipped Classroom-Based Interactive Multimedia to Enhance Learning Independence in Physics Education

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Abstract

Many prospective physics teachers struggle with innovative instructional strategies, as seen in their inability to answer examiners' questions during thesis defences. This study focuses on the course Development of Physics Teaching Programs and aims to develop interactive multimedia based on the flipped classroom model using I-Spring Suite 10 to enhance students' learning independence. The research was conducted in the Physics Department of Universitas Negeri Medan using the ADDIE model. The developed multimedia combines theoretical materials, interactive features, and classroom simulation videos to support an engaging learning experience. Expert validation showed that the product is appropriate for instructional use. After implementation, students demonstrated improved independence and confidence in applying teaching strategies. The effectiveness test using the N-Gain formula showed a medium level of improvement. These results indicate that the multimedia is reasonably effective in helping prospective physics teachers understand and apply instructional strategies in both theoretical and practical teaching contexts.

Keywords: flipped classroom, interactive multimedia, I-Spring Suite 10.

INTRODUCTION

The rapid pace of technological advancement has significantly impacted education, leading to changes in curricula in Indonesia. The curriculum is the cornerstone of the educational process in schools, directly influencing educational outcomes. According to Muhammedi (2016), the curriculum determines the process and results of an educational system. Currently, Indonesia is implementing the Merdeka Curriculum, which emphasizes the importance of integrating technology and innovative teaching models to support learning activities. Chaudhary (2015) compares curriculum evolution to technological advancements, and technology itself has become a vital solution for addressing educational challenges (Hadisi & Muna, 2015).

Learning is the process of providing guidance and assistance to students to help them acquire knowledge, skills, habits, attitudes, and beliefs. Gagne and Briggs (1979) describe learning as a system designed to support the internal learning process of students through structured events and activities. In the era of Industry 4.0 and Society 5.0, education focuses on integrating technology with cyber systems to develop students' knowledge, skills, and attitudes for lifelong learning (Rahmawan & Efendi, 2021).

Teachers play a crucial role in the teaching and learning process. Wang (2024), Dunleavy, Kestin, Callaghan, McCarty, and Deslauriers (2022) highlight that teaching involves reciprocal actions between teachers and students in an educational setting. Teachers fulfil multiple roles, including educator, instructor, and trainer (Sihombing et al., 2025; Kumar, Malabar, Benyo, &

Amal, 2021). Plakhotnik et al. (2022) and Rahman (2021) emphasizes that teachers must innovate their teaching practices by utilizing modern media to create effective and engaging learning experiences. Under the Merdeka Curriculum, teachers are expected to act as facilitators, leveraging innovative teaching models and digital technologies to encourage active student participation.

Despite these advancements, many teachers still struggle to master strategies, models, methods, and approaches to teaching, as well as the use of technology. Observations during in-service teacher training programs revealed that many teachers could not distinguish between teaching models, methods, and approaches. According to Kortemeyer (2023) and Friani, Sulaiman, and Mislinawati (2017), challenges in implementing teaching models often arise during lesson planning, where teachers fail to align instructional steps with the required syntax. Mislinawati and Nurmasyitah (2018) further note that teachers often face difficulties selecting appropriate teaching models for specific topics. Similar issues are evident in universities, where prospective teachers lack a comprehensive understanding of teaching strategies. Interviews with lecturers and classroom observations indicate that many students struggle to articulate and apply teaching strategies during proposal defence sessions.

To address these challenges, there is a need for practical tools like interactive multimedia to aid in understanding teaching strategies (Megalina, Rugaya, Amdani, & Sihombing, 2025; Sihombing, Muslim, & Rahman, 2023). The proposed interactive multimedia will feature materials on teaching models, approaches, strategies, methods, and techniques, along with classroom simulation videos. Designed for smartphones, this multimedia tool will provide students and teachers with a convenient, comprehensive resource for self-directed learning anytime and anywhere.

Interactive multimedia, as defined by Daryanto in Himmah and Martini (2017), is a system equipped with user-operated controls, allowing learners to select and navigate the content. Such multimedia can boost engagement, motivation, and learning outcomes by making lessons more interactive and accessible (Çeken & Taşkın, 2022; Husein, Herayanti, & Gunawan, 2015). The proposed multimedia will adopt a flipped classroom model supported by I-Spring Suite 10. The flipped classroom shifts traditional activities such as lectures to home settings and prioritizes active learning during class time (Turón, Ortiz, Lorenzo, & Fernández, 2024; Wan & Chen, 2024; Cavanagh & Kiersch, 2023). Research has shown that the flipped classroom model enhances student engagement (Awidi & Paynter, 2019; Shyr & Chen, 2018) and critical thinking skills (Aulianisyah, Budiharti, & Fauzi, 2022).

Researchers identified problems during the Development of Physics Teaching Programs (P3FIS) course through observations and interviews with lecturers and schoolteachers. Many students had difficulty distinguishing between learning models, approaches, strategies, and methods. This confusion stemmed largely from their limited understanding of instructional strategies. Although various textbooks on learning strategies are available, students often find it difficult to learn independently using only printed resources. What they need is a learning medium that not only explains concepts clearly but also supports self-directed learning engagingly. To address this gap, the study proposes the development of interactive multimedia teaching strategies. Furthermore, a review of the literature shows that research focusing on interactive multimedia for the Development of Physics Teaching Programs (P3FIS), especially tailored for prospective physics teachers, remains limited. This highlights the importance and urgency of this study.

A strong rationale for this topic lies in the potential of technology-enhanced learning. I-Spring Suite 10, a user-friendly tool integrated with Microsoft PowerPoint, enables educators to create multimedia content enriched with images, videos, and audio (Khotimah, 2019). Juraev (2019) also recognizes it as one of the most effective educational tools. When combined with the flipped classroom model, I-Spring Suite 10 is expected to foster a more interactive and effective learning environment. This research, therefore, aims to develop interactive multimedia using I-Spring Suite 10 to improve students' understanding of innovative teaching strategies and to foster learning independence in preparing for real classroom practices. This research aims to develop an interactive multimedia based on the flipped classroom model using I-Spring Suite 10 to improve the understanding of teaching strategies among prospective physics teachers. Specifically, the research aims to: (1) design multimedia content that facilitates comprehension of various innovative teaching strategies; and (2) foster

students' learning independence in preparation for real classroom teaching.

METHOD

This research was conducted at the Department of Physics, Universitas Negeri Medan, and will involve students from the 2021 cohort of the Physics Department, Faculty of Mathematics and Natural Sciences (FMIPA). Specifically, Class D will serve as the experimental group, receiving an interactive multimedia intervention based on the flipped classroom model, while Class B will act as the comparison group. A total of 36 students will participate in the study.

The research model employed in this study is Research and Development (R&D) using the ADDIE development model, which includes analysis, design, development, implementation, and evaluation stages. The study will involve two validators, consisting of two instructional experts who will evaluate the feasibility of the multimedia content, and one media expert to assess the technical aspects of the learning media.

Indicators measured in this study include feasibility, autonomy, and effectiveness of the interactive multimedia. The instruments used to measure these indicators are:

1. Feasibility Instrument: This instrument is designed to assess the quality and usability of the multimedia learning media. It will be completed by two instructional experts, focusing on the content, learning objectives, feedback and adaptation, and motivation aspects.
2. Autonomy Instrument: This instrument will be administered to students to measure their learning independence when using the multimedia. It will consist of a questionnaire evaluating students' ability to engage and manage their learning autonomously with multimedia.
3. Effectiveness Instrument: The effectiveness of the multimedia will be measured using pre-test and post-test questions. The tests will consist of 15 essay questions related to learning strategies, assessing students' conceptual understanding and ability to apply the strategies in various contexts.

These instruments will provide comprehensive insights into the feasibility, autonomy, and effectiveness of the developed interactive multimedia in enhancing students' understanding of learning strategies.

Research Methodology

The research employs the ADDIE development model by Branch (2009), which consists of five phases: Analysis, Design, Development, Implementation, and Evaluation. The steps in this study are Figure 1.

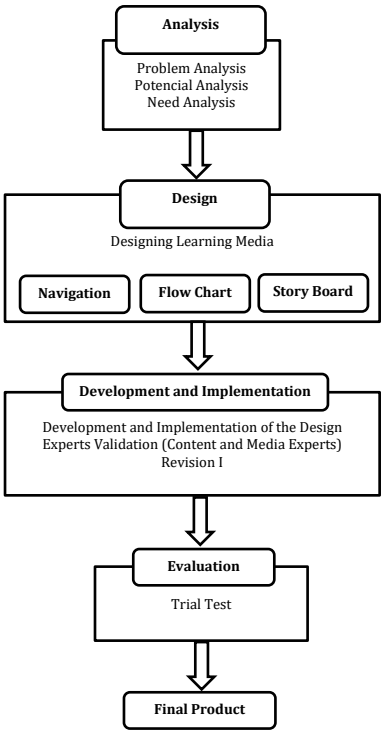


Figure 1. Research Flow

1. Analysis Phase: This phase involves three types of analysis: needs analysis, curriculum analysis, and learner analysis. The needs analysis aims to understand the requirements of students and educators in alignment with the learning objectives. Curriculum analysis evaluates the curriculum used in the Physics Department of FMIPA. Learner analysis identifies the characteristics of students, focusing on aspects relevant to the developed product, such as academic abilities, motivation, and skills related to the topic, media, design, and language in learning.
2. Design Phase: In this phase, the development of an interactive multimedia product is planned and designed. The content is defined, covering teaching strategies, including models, approaches, strategies, methods, and techniques. The initial product design involves creating flowcharts and storyboards, followed by the development of interactive multimedia using specific applications. Additionally, instruments are prepared, including validation instruments for experts, independent

instruments for students, and learning outcome test instruments to assess student performance.
3. Development Phase: This phase focuses on developing the interactive multimedia product. Media experts and subject matter experts from the Physics Department at Universitas Negeri Medan will validate the product. Validation results, including scores and feedback, will inform the revisions and improvements to the product.
4. Implementation Phase: The interactive multimedia product will be tested with students of the 2021 cohort, Physics Department, Universitas Negeri Medan. During this phase, the multimedia will be used in the learning process, and instruments will be distributed to measure student responses regarding their autonomy. If necessary, revisions will be made based on feedback from students, while considering previous validator feedback to ensure consistency with earlier improvements.
5. Evaluation Phase: This phase evaluates whether the developed interactive multimedia is successful. The evaluation will analyze data from expert validators, student responses to the multimedia's autonomy, and students' pre-test and post-test results.

Research Instruments and Data Analysis

The research instruments and data analysis in the development of web-based interactive learning media (Google Sites) on the topic of renewable energy are as follows:
1) Feasibility Testing

The feasibility instrument for interactive learning media is provided to subject matter experts and media experts. The instrument for media experts includes six aspects: functionality, reliability, usability, efficiency, maintainability, and portability. For subject matter experts, it consists of four aspects: content/material quality, learning objectives, feedback and adaptability, and motivation.

The feasibility assessment form is used to determine the feasibility level of the developed interactive multimedia. Data obtained from the validation results, as analyzed by subject matter and media experts, are evaluated using a Likert scale. The formula used to calculate the percentage of validation results is as follows:

$$P = \frac{\Sigma F}{N} \times 100\%$$

Formula Explanation:
- P: Percentage score
- ΣF: Total score for the selected category
- N: Total maximum score for the category

The calculated percentage is then used to conclude or categorize the feasibility criteria of the interactive learning media based on the Likert scale aspects. According to Sugiyono (2019), the percentage values are categorized as shown in Table 1:

Table 1. Feasibility Criteria for Interactive Learning Media

Score Range	Descriptions
81%-100%	Very Feasible
61%-80%	Feasible
45%-60%	Fairly Feasible
21%-44%	Not Feasible
< 20%	Very Not Feasible

2) Independence Assessment

The instrument for assessing the effectiveness of the interactive multimedia is the independence assessment sheet, which is provided to the students. The data obtained from the independence test of the use of interactive multimedia are then analyzed using a Likert scale. The formula used to calculate the percentage of the validation results is as follows:

$$P = \frac{\Sigma F}{N} \times 100\%$$

Formula Explanation:
- P: Percentage score
- ΣF: Total score of answers in the selected category
- N: Total score per category

The percentage calculation results can be used to categorize the practicality criteria of the interactive multimedia based on the aspects of the Likert scale. The criteria according to the percentage value are shown in Table 2 below:

Table 2. Interpretation Criteria for Students' Independence towards the Product

Interpretation Criteria	Percentage
Very Independence	81%< P <100%
Independence	61%< P <80%
Well Independence	41%< P <60%
Not Independence	21%< P <40%
Very Not Independence	0% < P <20%

RESULT AND DISCUSSION

The product produced in this study is an interactive multimedia learning strategy based on the Flipped Learning model, which is very feasible, very independent for use, and effective. The results of the tests conducted include the feasibility, independence, and effectiveness of the interactive multimedia. This research used the ADDIE model, which consists of five phases: Analysis, Design, Development, Implementation, and Evaluation. The steps and processes in the development of the interactive multimedia based on flipped learning are explained as follows:

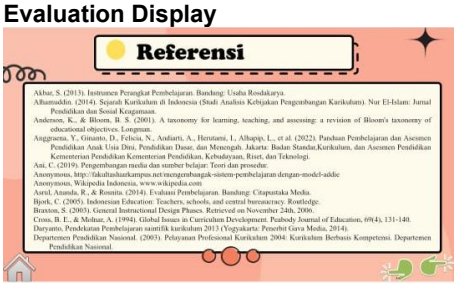
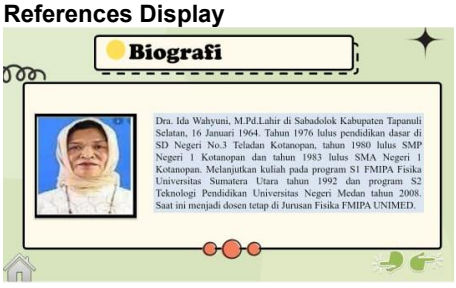
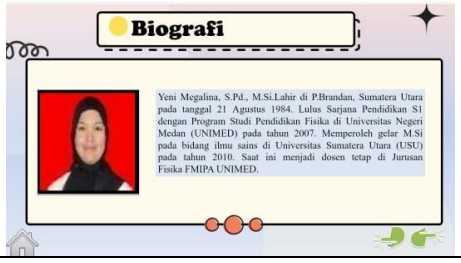
1. Analysis Phase: In the analysis phase, three analyses were conducted: needs analysis, curriculum analysis, and learner analysis. In the needs analysis, problems were identified in the Physics Teaching Program Development (P3FIS) course through observations and interviews with teachers and lecturers. Students had difficulties in mastering Learning Strategies and could not distinguish between teaching models, approaches, strategies, and methods. This was because many students had not yet mastered the learning strategies. Several courses address Learning Strategies, such as Teaching Strategies, P3FIS, Learning Model Studies, Microteaching, and many books on Learning Strategies. In the curriculum analysis, the curriculum used by the Physics Department at Universitas Negeri Medan is KKNI (Indonesian National Qualifications Framework). The KKNI curriculum is competency-based, where students not only master the material but also apply knowledge and skills in their lives. In the learner analysis, the subjects of the study were students in the Physics Department. Students need media that can promote independent learning and is technology-based. The media to be developed is an interactive multimedia based on the flipped classroom model, assisted by I-Spring Suite 10, to help students understand Learning Strategies.

2. Design Phase: There are several design stages: a) Material Determination, the material to be developed is Learning Strategies, which consists of teaching models, learning approaches, teaching strategies, methods, and teaching techniques. This interactive multimedia uses I-Spring Suite 10, PowerPoint (PPT), Canva, and Website 2 APK Builder. To create the material and animations, PPT and Canva were used. This interactive multimedia discussion is about Learning Strategies, including teaching models, learning approaches, teaching strategies, methods, techniques, and tactics. b) Initial Design, which involves creating a procedural design, flow chart, and storyboard for the interactive multimedia. The storyboard is a sequential illustration of the interactive multimedia to be created. This interactive multimedia consists of materials, images, teaching simulation videos, and exercises. Below is the interactive multimedia on learning strategies.

Table 3. Features of Interactive Multimedia and Indicators That Can Be Trained Using Interactive Multimedia

No	Interactive Multimedia	Features	Indicators
1.	 **Initial Display**	The initial display of this learning media includes the title, audio, and a fingerprint image that functions as a button to proceed to the next screen.	-
2.	 **Initial Display**	This screen presents the application title, department, and faculty, along with an image and the developer's name.	-

No	Interactive Multimedia	Features	Indicators
3.	 **Learning Objectives Display**	This screen shows the learning objectives, consisting of five objectives. It also features a home icon that navigates back to the main menu and a hand icon that functions to go to the previous or next screen.	Clarity of learning goals and students' ability to focus on specific competencies. Helps students clearly understand what they are expected to achieve, improving their focus and goal-oriented learning.
4.	 **Main Menu Display**	The main menu display contains various options available in the multimedia learning media: material, demonstration, practice questions, evaluation, references, and biography.	Encourages students to make independent decisions about their learning path and resources.
5.	 **Material Submenu Display**	The material submenu display consists of five topics: learning strategies, learning models, learning approaches, learning methods, and teaching techniques and tactics.	Enables students to independently explore and comprehend essential teaching concepts at their own pace.
6.	 **Content Display**	This screen displays the content on learning strategies, featuring a talking AI animation and background music.	Stimulates motivation and sustained attention, supporting self-driven learning without external prompts.
7.	 **Demonstration Display**	This screen provides a demonstration video linked to YouTube, with home and hand icons for navigating to the main menu or the next section.	Encourages learners to independently analyze and apply theoretical knowledge in practical contexts.

No	Interactive Multimedia	Features	Indicators
8.	 **Practice Questions Display**	This screen presents the practice question section, which begins with a start button followed by student biodata entry. It includes 10 multiple-choice questions along with feedback for correct or incorrect answers. The final screen shows the score obtained from the completed practice.	Provides students with opportunities to assess their own understanding and learn from feedback without teacher intervention.
9.	 **Evaluation Display**	This screen presents the evaluation section, which also starts with a start button and student biodata entry. It includes 12 essay questions with correct answer feedback. The final screen shows the score from the completed evaluation.	Develops students' capacity to critically reflect and articulate knowledge independently through essay responses.
10	 **References Display**	This screen contains the references used in the development of the interactive multimedia on learning strategies.	-
11.	 	The developer profile screen displays a photo, a biographical description, and the educational background of the developer.	-

No	Interactive Multimedia	Features	Indicators
	 **Biographical Display**		
12.	 **Final Display**	The final screen contains a thank-you message for using or watching the interactive multimedia on learning strategies.	-

In the initial display of this learning media, it contains the title, audio, and an image of a fingerprint that functions as a button to proceed to the next screen. This screen includes the application title, department, faculty, image, and the developer's name. Then, it enters the main menu, which consists of sections for materials, demonstrations, practice questions, evaluation, references, and the developer's biography.

After the main menu, the learning objectives are presented, followed by material on learning strategies. The demonstration consists of a teaching simulation video using the Problem-Based Learning (PBL) model. Through this video, students can understand the implementation of learning strategies. After the demonstration, there are practice questions, evaluations, and references consisting of books and journalism. The last section includes the developer's biography.

The final step in the Design phase is c) Developing Instruments. The instruments developed include a feasibility instrument for learning experts, which is given to two lecturers. This instrument consists of an assessment by experts with response options ranging from strongly agree to strongly disagree. The next instrument is the independent instrument, which is given to students to gather feedback on the developed product. Then, the effectiveness instrument is prepared, which aims to measure the media's effectiveness using pretest and posttest questions given to students. These questions are essay-type and consist of 15 questions.

The development of interactive multimedia learning strategies uses the ADDIE R&D model, which consists of five stages: Analysis, Design, Development, Implementation, and Evaluation. The stages carried out include a) Analysis Stage, which consists of needs analysis, curriculum analysis, and learner analysis. Based on the learner analysis, students need interactive multimedia assisted by the I-Spring Suite 10 to understand learning strategies. b) Design Stage, the researcher selects material according to the analysis stage. The selected material is about learning strategies, which includes discussions on models, approaches, strategies, methods, and techniques of teaching. Then, a flow chart and storyboard are prepared. Several applications are used to create the product, such as PPT for material creation, I-Spring Suite 10 for making it more engaging, and a website application, 2 APK Builder, which is used to convert web-based files (HTML 5) into Android app form. Thus, this interactive multimedia will be available on students' mobile devices so they can learn according to their needs. This interactive multimedia is based on the flipped classroom model. The multimedia is also equipped with a teaching simulation video using one of the models, Problem-Based Learning (PBL). By applying the PBL model, students' critical thinking skills can be improved (Junaidi, 2020). This video is created so that students can observe real implementation and differentiate between models, approaches, strategies, methods, and techniques.

In terms of interactivity, this multimedia combines various learning features that allow students to actively engage with the material. The media includes content such as text, images, graphics, audio, video, animation, and simulations, all integrated into a single platform. One of the main features is teaching simulation videos that demonstrate the application of various instructional strategies in the classroom, helping students to grasp concepts more concretely. The multimedia also includes quizzes and automatic feedback that help students immediately assess their understanding. By being accessible on smartphones, this multimedia facilitates independent learning anytime and anywhere, providing comprehensive and interactive learning.

Development Stage

This stage involved two expert Physics education lecturers to assess the feasibility of the interactive multimedia on learning strategies. The validation results from the first expert yielded a percentage score of 89.85%, categorized as very feasible, as illustrated in the diagram below:

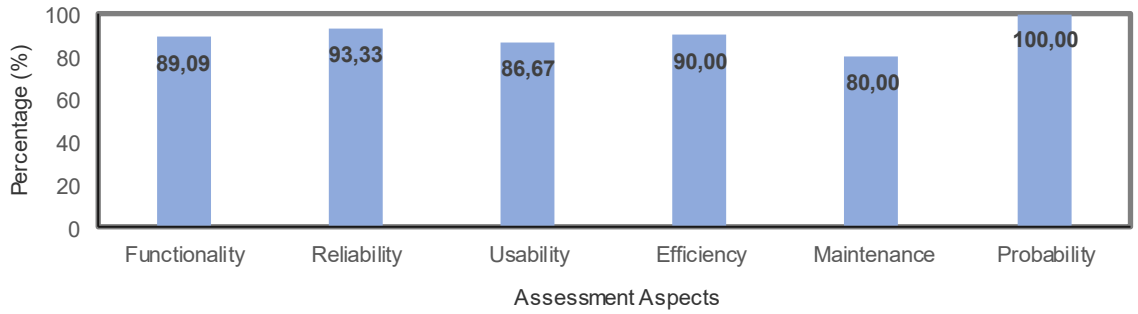


Figure 4. Feasibility Test Results of Interactive Multimedia by Media Expert

The results of the expert assessment, as shown in the graph, indicate high scores across most of the media's key attributes, with the highest rating given to Probability (100%) and Reliability (93.33%). These results suggest that the multimedia product is highly reliable and dependable, making it a suitable choice for educational purposes. The slightly lower ratings in Efficiency (90%) and Usability (86.67%) indicate that while the product functions well overall, there may still be minor areas for improvement in terms of streamlining user interaction and ensuring optimal performance in diverse environments.

To achieve optimal results, it is recommended that improvements be made in Efficiency by refining system responsiveness and load times, particularly when the multimedia is accessed under different network conditions. For Usability, user feedback can be incorporated into design revisions, focusing on simplifying navigation and enhancing the accessibility of learning materials. Further, Maintenance could be optimized through regular updates and ensuring the multimedia remains adaptable to future technological developments.

The feasibility assessment of the interactive multimedia by the second learning expert resulted in a percentage score of 82.92%, categorized as very feasible, as shown in the figure below:

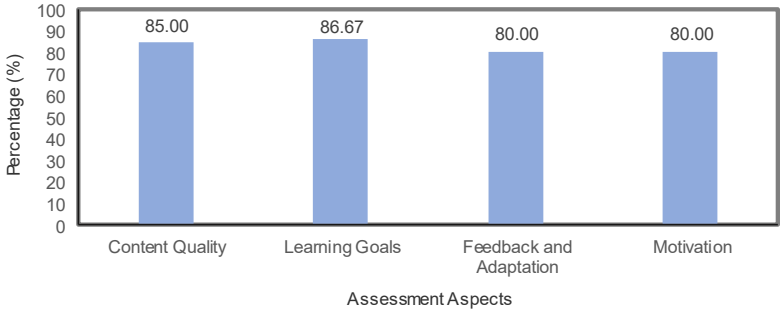


Figure 5. Feasibility Test Results by Material Expert on Interactive Multimedia for Learning Strategies

The high feasibility score from both content and media experts indicates that the interactive multimedia meets the essential criteria for effective learning use. The strong content quality and clarity of learning objectives show that the material is relevant and aligns well with pedagogical goals. However, the slightly lower score on feedback and adaptation suggests that user interaction could be improved, particularly in how the media responds to user inputs or supports varied learning pathways. In this field, this can be addressed by integrating more interactive prompts or checkpoints that guide students through learning challenges.

Meanwhile, the media aspects, such as functionality, usability, and reliability, received excellent ratings, reflecting smooth navigation and intuitive design. Nonetheless, comments from media experts regarding video presentation and textual clarity highlight a key area for improvement. To optimize the learning experience, videos should be presented in a clean layout without unnecessary visual distractions, and written materials, especially in the teaching syntax section, should be elaborated with more precise definitions and step-by-step explanations that are visually reinforced through accompanying video segments. These refinements would not only enhance user engagement but also facilitate students' more effective internalization of instructional strategies.

Implementation Stage

The implementation was conducted with students from the 2021 Physics Department, classes B and D, to test the independence provided by the interactive multimedia. The effectiveness was tested only in class D, which was selected using a random sampling technique. The implementation took place in the Physics Department classroom at Unimed. The process involved sharing the interactive multimedia through the class group on WhatsApp. The interactive multimedia, which is based on the flipped classroom model, was downloaded by the students. After downloading, the "Learning Strategies" application appeared on the students' smartphone desktops.

In the Implementation Stage, this interactive multimedia is given to two classes, B and D, selected based on purposive sampling. This multimedia is based on the flipped classroom model. According to Farida, Alba, Kurniawan, and Zainuddin (2021), the flipped classroom model is, in fact, an in-class activity where students engage in group discussions and critical thinking, rather than activities conducted outside the classroom. The steps in the flipped classroom model in this study are a) the first step, the lecturer selects materials according to the needs analysis and then creates interactive multimedia using several applications, and sends the materials via WhatsApp in APK format. b) The second step, students understand the material at home by downloading the interactive multimedia to be saved on their phones. Students learn about learning strategies and complete practice questions independently at home. c) The third step, in class, the lecturer facilitates group discussions to deepen the material on learning strategies. d) The lecturer then assigns students to create a simulation of the syntax of the models, approaches, and strategies learned. To assess student independence, students are given a questionnaire. To measure the effectiveness of the interactive multimedia, students are given pretests and posttests to observe improvements in their understanding of the material.

Evaluation Stage

After the interactive multimedia was validated by two learning experts, faculty members in the Physics Department, it was implemented to collect data on the independence provided by the multimedia among the students. The results of the independence questionnaire showed that the interactive multimedia achieved a score of 84.32 for class B, categorized as "very independent," and 88.04 for class D, also categorized as "very independent."

In this evaluation stage, the effectiveness of the multimedia was tested on 36 students from class D, 2021 cohort, by administering a pretest and posttest. The average pretest score was 49.12, while the average posttest score was 72.25. The pretest and posttest scores were analyzed to determine the N-gain score, which resulted in 0.44, categorized as moderate. Therefore, this interactive multimedia was deemed effective.

In the Evaluation Stage, the multimedia is evaluated by two expert lecturers to assess its feasibility, with a questionnaire for assessing independence, and tests to measure improvements in learning outcomes. The results of the independence questionnaire for interactive multimedia for class B = 84.32, categorized as very independent, and for class D = 88.04, also categorized as very independent. The N-gain score is 0.44, categorized as moderate and effective.

The advantages of the developed Android-based interactive learning multimedia are as follows: 1) The multimedia can be used offline, 2) It has a relatively small size of 43.7 MB and can be used anytime and anywhere without a time limit, 3) It supports students in learning independently, 4) The flipped classroom-based interactive multimedia engages students, which is consistent with Putri and Gusnedi (2020), who found that interactive multimedia with I-Spring Suite 9 is very engaging for learning. The disadvantages of the developed interactive multimedia are as follows: 1) It can only be run on Android phones. It is not compatible with iOS, Windows phones, etc., 2) By using the flipped classroom model, the multimedia can save time to achieve learning objectives and improve learning outcomes, which is in line with Meilisa and Pernanda (2020), who stated that the flipped classroom model is an alternative to make the limited face-to-face learning time more effective and to help improve student learning outcomes.

CONCLUSION

This research concludes that multimedia developed using an innovative learning model, based on the Research and Development (R&D) ADDIE model, can be effectively utilized by students and lecturers on smartphones or laptops. The research findings are a) The interactive multimedia received a score of 82.92% from content experts, and the multimedia feasibility evaluation by media experts achieved a score of 89.85%, categorized as very feasible. b) The results of the independence questionnaire for interactive multimedia are for class B = 84.32%, categorized as very independent, and for class D = 88.04%, also categorized as very independent. c) The N-gain score is 0.44, categorized as moderate. Several recommendations are provided, namely: a) Interactive multimedia can be applied in all classes, and the teaching team delivering the course can provide interactive multimedia to the students. b) To avoid confusion among students, this interactive multimedia can be supplemented with a guidebook. c) This interactive multimedia can also be paired with learning models and approaches to make the product more engaging and motivate students' learning.

REFERENCES

Aulianisyah, R., Budiharti, R., & Fauzi, A. (2022). Penerapan Strategi Pembelajaran Flipped Classroom untuk Meningkatkan Kemampuan Berpikir Kritis Siswa Kelas IX. *Jurnal Sains Edukatika Indonesia, 4*(2), 32-37. https://jurnal.uns.ac.id/jsei/article/view/70942.

Awidi, I. T., & Paynter, M. (2019). The Impact of A Flipped Classroom Approach on Student Learning Experience. *Computers & Education, 128(2019)*, 269-283. https://doi.org/10.1016/j.compedu.2018.09.013.

Cavanagh, T. M., & Kiersch, C. (2023). Using Commonly Available Technologies to Create Online Multimedia Lessons Through The Application of The Cognitive Theory of Multimedia Learning. *Education Tech Research Development, 71(2023)*, 1033–1053. https://doi.org/10.1007/s11423-022-10181-1.

Çeken, B., & Taşkın, N. (2022). Multimedia Learning Principles in Different Learning Environments: A Systematic Review. *Smart Learning Environments, 9*(19), 1-22. https://doi.org/10.1186/s40561-022-00200-2.

Chaudhary, G. K. (2015). Factors Affecting Curriculum Implementation for Students. *International Journal of Applied Research, 1*(12), 984–986. Retrieved from http://www.allresearchjournal.com/archives/2015/vol1issue12/PartN/2-5-158-343.pdf.

Dunleavy, S., Kestin, G., Callaghan, K., McCarty, L., & Deslauriers, L. (2022). Increased Learning in a College Physics Course with Timely Use of Short Multimedia Summaries. *Physical Review Physics Education Research, 18*(1), 1–12. https://doi.org/10.1103/PhysRevPhysEducRes.18.010110.

Farida, R., Alba, A., Kurniawan, R., & Zainuddin, Z. (2019). Pengembangan Model Pembelajaran Flipped Classroom dengan Taksonomi Bloom pada Mata Kuliah Sistem Politik Indonesia. *Kwangsan: Jurnal Teknologi Pendidikan, 7*(2), 104-122. https://doi.org/10.31800/jtp.kw.v7n2.p104--122.

Friani, F. I., Sulaiman, & Mislinawati. (2017). Kendala Guru dalam Menerapkan Model Pembelajaran pada Pembelajaran Tematik Berdasarkan Kurikulum 2013 di SD Negeri 2 Kota Banda Aceh. *Vik. Jurnal Ilmiah Pendidikan Guru Sekolah Dasar FKIP Unsyiah, 2*(1), 88-97. Retrieved from https://jim.usk.ac.id/pgsd/article/view/2536/2029.

Hadisi, L., & Muna, W. (2015). Pengelolaan Teknologi Informasi dalam Menciptakan Model Inovasi Pembelajaran (E-Learning). *Al-TA'DIB: Jurnal Kajian Ilmu Kependidikan, 8*(1), 117-140. http://dx.doi.org/10.31332/atdb.v8i1.396.

Husein, S., Herayanti, L., & Gunawan, G. (2015). Pengaruh Penggunaan Multimedia Interaktif Terhadap Penguasaan Konsep dan Keterampilan Berpikir Kritis Siswa pada Materi Suhu dan Kalor. *JPFT, 1*(3), 221–225. https://doi.org/10.29303/jpft.v1i3.262.

Juraev, A. R. (2019). Using The iSpring Suite Software to Evaluate Future Teachers' Professional Competencies. *Central Asian Problems of Modern Science and Education, 4*(2), 752-759. Retrieved from https://doi.org/10.26877/jp2f.v15i1.17458.

Kortemeyer, G. (2023). Toward AI Grading of Student Problem Solutions in Introductory Physics. *Physical Review Physics Education Research, 19*(2), 1–13. https://doi.org/10.1103/PhysRevPhysEducRes.19.020163.

Kumar, T., Malabar, S., Benyo, A., & Amal, B. K. (2021). Analyzing Multimedia Tools and Language Teaching. *Linguistics and Culture Review, 5*(1), 331–341. https://doi.org/10.37028/lingcure.v5nS1.1400.

Maharani, P. A., Risdianto, E., & Setiawan, I. (2024). Pengembangan Media Pembelajaran Interaktif Berbantuan Google Sites untuk Meningkatkan Hasil Belajar Siswa pada Materi Momentum dan Impuls. *Jurnal Penelitian Pembelajaran Fisika, 15*(1), 31–42. https://doi.org/10.26877/jp2f.v15i1.17458.

Megalina, Y., Rugaya, R., Amdani, K., & Sihombing, R. A. (2025). Development of a Multimedia Learning Tool by Utilizing Artificial Intelligence (AI) Towards Basic Teaching Skills in Microteaching Courses for Physics Learning. *Jurnal Penelitian dan Pembelajaran IPA, 11*(1), 113–131. https://doi.org/10.30870/jppi.v11i1.31591.

Meilisa, R., & Pernanda, D. (2020). Model Pembelajaran Flipped Classroom pada Mata Kuliah Algoritma dan Struktur Data. *Jurnal Ilmiah Pendidikan Dan Pembelajaran, 4*(3), 571–577. https://doi.org/10.23887/jipp.v4i3.26928.

Misnilawati, & Nurmasyitah. (2018). Kendala Guru dalam Menerapkan Model-Model Pembelajaran Berdasarkan Kurikulum 2013 pada SD Negeri 62 Banda Aceh. *Jurnal Pesona Dasar, 6*(2), 22-32. https://doi.org/10.24815/pear.v6i2.12194.

Muhammedi. (2016). Perubahan Kurikulum di Indonesia: Studi Kritis tentang Upaya Menemukan Kurikulum Pendidikan Islam yang Ideal. *Raudhah, 4*(1), 49–70. http://dx.doi.org/10.30829/raudhah.v4i1.61.

Plakhotnik, V., Strazhnikova, I., Yehorova, I., Semchuk, S., Tymchenko, A., Logvinova, Y., & Kuchai, O. (2022). The Importance of Multimedia for Professional Training of Future Specialists. *IJCSNS International Journal of Computer Science and Network Security, 22*(9), 43–50. https://doi.org/10.22937/IJCSNS.2022.22.9.7.

Putri, D. A., & Gusnedi. (2023). Development of Interactive Multimedia Based on Ispring Suite Integrated Prompting Question to Facilitate Students' Concept Understanding Ability. *Physics Learning and Education, 1*(3), 224–240. https://doi.org/10.24036/ple.v1i4.96.

Rahman, K. (2021). Peran Guru sebagai Pengajar dalam Pengembangan Inovasi Pendidikan di Era 4.0. *Jurnal Inovasi Pendidikan, 1*(2), 1-6. https://doi.org/10.31219/osf.io/3phq2.

Rahmawan, A. Z., & Effendi, Z. (2022). Implementasi Society 5.0 dalam Kebijakan dan Strategi Pendidikan pada Pandemi Covid-19. *STRATEGY: Jurnal Inovasi Strategi dan Model Pembelajaran, 2*(1), 34-43. https://jurnalp4i.com/index.php/strategi/article/view/861.

Shyr, W. J., & Chen, C. H. (2018). Designing a Technology-Enhanced Flipped Learning System to Facilitate Students' Self-Regulation and Performance. *Journal of Computer Assisted Learning, 34*(1), 53-62. https://doi.org/10.1111/jcal.12213.

Sihombing, R. A., Wahidin, N. R., Winarno, N., Hamdiyati, Y., Rahmat, A., & Liu, S.-Y. (2025). Discovering The Relationship: Self-Efficacy, Metacognitive Awareness, and Science Learning Processes in Indonesian Science Classrooms. *ECPS Journal – Educational, Cultural and Psychological Studies, 31*(2025), 111-129. https://doi.org/10.7358/ecps-2025-031-siho.

Sihombing, R. A., Muslim, & Rahman, T. (2023). The Development of Interactive Audio-Visual-Based Media Using Videoscribe to Reduce Misconceptions on Electrical Potential and ECG Material. *Tarbiyah: Jurnal Ilmiah Kependidikan, 12*(2), 69–80. https://doi.org/10.18592/tarbiyah.v12i2.10301.

Sugiyono. (2017). *Metode Penelitian Kuantitatif, Kualitatif, dan R&D*. Alfabeta.

Turón, A. L., Ortiz, J. M., Lorenzo, O., & Fernández, F. A. (2024). *Proposal for a Flipped Classroom Program with Massive Open Online Courses to Improve Access to Information and Information Literacy in Primary School Teachers*. *Societies, 14*(5), 1-12. https://doi.org/10.3390/soc14050068.

Wan, T., & Chen, Z. (2024). Exploring Generative AI-Assisted Feedback Writing for Students' Written Responses. *Physical Review Physics Education Research, 20*(1), 1–13. https://doi.org/10.1103/PhysRevPhysEducRes.20.010152.

Wang, F. (2024). The Relationship Between Students and Teachers and Its Implications. *Journal of Education, Humanities and Social Sciences*, *29*(2024), 390–396. https://doi.org/10.54097/rzvpb402.