

Development of Flipped Classroom Based Interactive Multimedia on Biodiversity Concept to Increase Students' Learning Motivation and Critical Thinking

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Abstract. Students' critical thinking skills are essential in 21st-century education. Certain students show a lack of enthusiasm for learning and have limited critical thinking skills. The aim of this study was to assess the impact of interactive multimedia in a flipped classroom setting on understanding biodiversity, with a particular focus on increasing learning motivation and critical thinking skills. The research employed a quasi-experimental method known as the nonequivalent control group design. Collecting samples using the cluster random sampling technique. The collection instruments include interviews, student needs questionnaires, validation questionnaires from media and material experts, learning objectives and teaching module flow questionnaires, teacher and student response questionnaires, learning motivation questionnaires, and critical thinking tests. Data analysis comes in a variety of forms, including initial study data analysis, feasible information analysis, practical information analysis, and effective information analysis. Feasibility has a score of 90.3% (very feasible), and practicality has a score of 91.2% (very practical). As well as the effectiveness of learning motivation with a sig. (2-tailed) of $0.000 < 0.05$ and an N-Gain of 0.764 (high), besides critical thinking with a sig. (2-tailed) of $0.047 < 0.05$ and an N-Gain of 0.706 (high). The research results show that interactive multimedia that utilizes the flipped classroom method is feasible, practical, and successful in increasing learning motivation and critical thinking skills. However, this interactive multimedia has only been implemented at senior high school 4 Muara Teweh, so it needs to be expanded to other schools and developed with other concepts.

Keywords: Interactive multimedia, flipped classroom, learning motivation, and critical thinking.

Introduction

Education is a way for humans to develop and improve their intelligence (Spector & Ma, 2019). Students must participate in educational activities such as the teaching and learning process to understand and obtain something they have learned. In contemporary education, students are expected to possess the essential ability of critical thinking, which proves to be highly advantageous in addressing the challenges in the 21st century (Basri et al., 2019; Perdanasari et al., 2021; Spector & Ma, 2019; Szabo et al., 2020). The process

of learning activities can be carried out by students independently without direct teacher guidance, besides that learning activities can be carried out anywhere and at any time (Challob, 2021; Untari et al., 2020). This helps students to increase learning motivation because students can study comfortably.

Biology is a science that studies living creatures and their environment and is one of the sciences contained in natural sciences. Apart from that, biology is one of the sciences or subjects that students consider difficult and boring because the learning activities are filled with memorization activities (Azizah & Alberida, 2021). Based on the results of interviews and observations at senior high school 4 Muara Teweh, senior high school 4 Yogyakarta, senior high school 7 Yogyakarta, and senior high school 9 Yogyakarta, the results showed that class X students experienced many problems with biodiversity material which was considered complex and teachers did not yet have media or teaching materials that could be used and by the Merdeka curriculum. Aligned with Styers et al. (2021), stated that biodiversity is a subject matter that is difficult to understand because the material is very complex. Biodiversity is material that discusses variations in living things with complex material concepts (Styers et al., 2021; Wiegelmann & Zabel, 2021).

Based on interview data with teachers and observations with students obtained from four schools, two problems were found in the biodiversity material. The first problem is that there are 60% of students whose learning motivation is still low. Learning motivation is an attitude that can encourage students to do something, and this attitude is an important factor for students participating in learning activities in class (Li et al., 2020). The first problem can occur due to a lack of variety in the media used in learning activities on biodiversity material, so students lack focus and concentration when following the learning process. In addition, the student needs questionnaire revealed that 60% of students saw learning activities as tedious. Media or teaching materials that are less interesting cannot increase students' learning motivation to participate in learning activities in class (Perdanasari et al., 2021). Motivation to learn does not only come from the students themselves but also can be influenced from outside themselves or the environment. Apart from that, learning motivation influences the optimal process of learning activities in the classroom (Kern & Wehmeyer, 2021). Indicators of students who have the motivation to learn include having the desire to succeed in learning, having desires and needs in learning, having the desire to achieve goals, having appreciation in learning, having interesting activities in learning, and having a conducive learning environment (Uno, 2006). The second problem is that there are 40% of students whose critical thinking is still low. Critical thinking is a cognitive skill of advanced degree that individuals possess and can utilize to effectively analyze and evaluate information, enabling them to make informed decisions and take appropriate actions in problem-solving scenarios (Perdanasari et al., 2021). According to Szabo et al. (2020), Critical thinking is the capacity to identify and implement effective resolutions to address a problem. The second issue may arise from the absence of instructional models, methods for teaching, learning media, and assessment items that can effectively cultivate and enhance students' capacities for analytical and critical thinking. Applying learning models and methods to train students to conduct analysis and evaluation can improve critical thinking (Basri et al., 2019). Moreover, critical thinking needs to be emphasized in learning activities at an early age to train the ability to analyze and find a solution to a problem (Spector & Ma, 2019). Critical thinking is needed by students not only in class but in everyday life (Basri et al., 2019). Critical thinking indicators such as analysis, evaluation, inference, deduction, induction, formulation of assumptions, and testing arguments (Anwar & Muti'ah, 2022). Meanwhile, according to Perdanasari et al. (2021), critical thinking indicators consist of analysis, interpretation, inference, induction, deduction, and evaluation.

The flipped classroom is a method that invites students to study independently first so that learning activities in class are more interactive and analysis or evaluation activities

can be implemented. Apart from that, the flipped classroom is an innovative and effective learning method to use (Zou, 2020). The principle of the flipped classroom learning method is to create a comfortable atmosphere and motivate students to study independently to gain basic knowledge and deepen the knowledge gained through interactive discussions in the classroom (Challob, 2021). In line with Zou (2020), the flipped classroom method its implementation carries out learning activities to understand material outside of class independently, after which activities in class are carried out more interactively and invite students to think at a higher level. Independent activities carried out using the flipped classroom method can be carried out with the help of media that students can access offline or online (Challob, 2021). There is interaction in learning activities, relaxed and flexible study time, always getting feedback from teachers and peers during discussions, and having lots of reading sources. The four strategies mentioned are the primary determinants in enhancing the motivation of pupils to learn and their academic achievements (Challob, 2021). The key determinant of the flipped classroom's effectiveness lies in the extent to which students comprehend the subject matter and possess self-directed learning abilities (Zou, 2020).

Interactive multimedia is a combination of several media that can provide information to students and can build interaction between media and students (Zainuddin et al., 2019). Interactive multimedia is a combination of images, video, sound, text, tables, graphics, and hyperlinks (Roth et al., 2021). Utilizing interactive teaching materials can enhance students' critical thinking abilities by providing training in critical thinking and presenting the material using interactive sentences so that there is interaction between the teaching materials and students (Wahyuni et al., 2020). Interactive multimedia can be used as a forum for conveying information so that users can achieve success and overcome challenges in multimedia (Roth et al., 2021). Interactive multimedia is very efficient and effective in comparison to conventional media for learning activities. This is because students prefer media that is easy to access and use (Fuad & Akbar, 2022). Making interactive multimedia must pay attention to several factors such as choosing the digital media to combine, and making it according to the purpose and context of its use (Peláez & Solano, 2023). Interactive multimedia can be used to improve students' speaking skills create interaction between students and increase students' knowledge of the material being studied (Mahdi, 2022).

According to research conducted by Afzali & Izadpanah (2021); Etemadfar et al. (2020), the results of the flipped classroom learning method can increase the learning motivation, involvement or activeness in learning activities, learning independence, understanding of concepts, and learning outcomes of students. As well as research on educational activities carried out by Etemadfar et al. (2020); Nugraheni et al. (2022), with the flipped classroom learning method, it is known that this learning method can improve students' critical thinking. According to research conducted by Liu et al. (2021); Praheto et al. (2020), it is known that interactive multimedia can increase students' learning motivation as well as efficiency in learning activities. Roemintoyo et al. (2022) found that interactive multimedia enhances students' interest, motivation, and critical thinking skills. In addition, including interactive multimedia in learning activities helps enhance students' cognitive abilities and improve their problem-solving skills (Untari et al., 2020). When used in conjunction with flipped classroom learning methods, interactive multimedia can enhance interest, learning motivation, critical thinking skills, involvement or activity, and the independence of learners in learning activities.

Previous studies have shown that interactive multimedia and flipped classrooms can be effective strategies for enhancing students' learning motivation and critical thinking skills when it comes to biodiversity knowledge. This study will employ a problem-based learning framework as it is an instructional approach that can enhance students' ability to think critically (Perdanasari et al., 2021). The objective of this study is to assess the

feasibility, practicality, and effectiveness of employing interactive multimedia with a flipped classroom approach to enhance students' motivation and critical thinking skills in class X.

Methods

The research methodology employed is research and development (R&D), utilizing the ADDIE development model. The research process of ADDIE consists of five distinct stages: Analysis, Design, Development, Implementation, and Evaluation (Sa'adah & Wahyu, 2020). The method that was employed is quasi-experimental with an uneven nonequivalent control group design. The research sample included students from class X at senior high school 4 Muara Teweh. The sample in this study comprised Classes X.6 and X.3. The research employs a cluster random sampling technique to pick the sample. This involves selecting the sample based on current classes in the school, which will then be divided into a control class and an experimental class.

At the onset of the meeting, a research procedure was conducted to assess the initial disparities between the experimental class and the control class. This involved administering a pre-test in the form of a learning motivation questionnaire, as well as critical thinking questions presented in multiple-choice and essay formats to the students. Subsequently, the learning activities conducted in the experimental class were implemented through interactive multimedia and various instructional techniques such as lectures, discussions, question-and-answer sessions, and the flipped classroom method. In contrast, the control class utilized PowerPoint (PPT) as the primary instructional medium, which is commonly employed by teachers during their teaching activities. As well as the same methods as the experimental class. Learning methods in the classroom such as lectures, discussions, question-and-answer, and flipped classrooms are taught until the final meeting. Following the lesson, a post-test learning motivation questionnaire and critical thinking questions, consisting of both multiple choice and essay formats, were administered to students in both the experimental and control classes to assess the final state of each class. The pre-test to post-test data from the two classes were analyzed to ascertain the disparities resulting from the implementation of the treatment (Sugiyono, 2019).

The data collection instruments utilized in this study encompassed various tools such as interview instruments, student needs questionnaire, media expert validation questionnaire instruments, material expert validation questionnaire instruments, learning objectives and teaching module flow questionnaire instruments, teacher response questionnaire instruments, student response questionnaire instruments, learning motivation questionnaire instruments, and critical thinking test instruments. Data analysis approaches encompass various types, includes initial study analysis of data, feasible information analysis, practical information analysis, and effective information analysis.

Results and Discussion

Feasibility of Flipped Classroom Based Interactive Multimedia

In this research, the results of the feasibility of flipped classroom based interactive multimedia were carried out by providing a validation questionnaire instrument to material experts and media experts. Below are presented the aspects that are the core of the assessment of media experts and material experts, such as aspects of appearance, programming, language, appropriateness of content, and correctness of concepts. The results of the validation questionnaire from media experts and material experts are presented in Table 1.

Table 1. Feasibility of Flipped Classroom Based Interactive Multimedia

Aspect	Members of the Media		Materials Expert	
	Score (%)	Criteria	Score (%)	Criteria
Appearance	81.8	Very Feasible		
Programming	87.5	Very Feasible		
Linguistics	75	Feasible		
Content Feasibility			98.1	Very Feasible
Truth of the concept			100	Very Feasible
Average	81.4	Very Feasible	99.1	Very Feasible

Table 1 shows the validation results from media expert assessments flipped classroom based interactive multimedia is very suitable for use in terms of display and programming aspects with scores of 81.8 and 87.5%, and decent used in terms of linguistic aspect with a score of 75%. The assessment given by the material expert is known interactive multimedia based on a flipped classroom is very worthy of use in terms of aspects of the appropriateness of content and correctness of concept with scores of 98.1 and 100%. Based on the validation results, it is known interactive multimedia based on a flipped classroom is Very suitable for use with students inside or outside the classroom. In line with this, research conducted by Roemintoyo et al. (2022); Sartono et al. (2022), noted that Interactive multimedia has been proven suitable for use in learning activities with students in the very good category, these results were obtained from the assessment of media experts, material experts, teachers, and students.

Interactive multimedia can be used with any learning approach, learning model, and learning method in classroom learning activities. Interactive multimedia can be used with the project based learning approach and observational learning model and is declared suitable for use with students in the classroom (Septiani et al., 2020; Untari et al., 2020). In line with this Priadko et al. (2022); Xia & Liu (2021), state that multimedia and interactive multimedia can be used in any learning method, even in enhanced learning methods. Apart from that, the flipped classroom method can be combined with any electronic media such as videos, online learning platforms, and other media applications (Aprianto et al., 2020; Leatherman & Cleveland, 2020; Zou et al., 2022).

Practicality of Flipped Classroom Based Interactive Multimedia

The practicality of interactive multimedia based on the flipped classroom is known by providing response questionnaire instruments to teachers and students. Assessments are carried out on several existing aspects, such as aspects of appearance, programming, language, and appropriateness of content. The results of assessments by teachers and students on the response questionnaire are presented in Table 2.

Table 2. Practicality of Flipped Classroom Based Interactive Multimedia

Aspek	Biology teacher				Student	
	1		2			
	Score (%)	Criteria	Score (%)	Criteria	Score (%)	Criteria
Appearance	93.2	Very Practice	95.5	Very Practice	90.3	Very Practice
Programming	87.5	Very Practice	81.3	Very Practice	85.6	Very Practice
Linguistics	95	Very Practice	100	Very Practice	89.5	Very Practice
Content	98.1	Very Practice	90.4	Very Practice	87.8	Very Practice
Feasibility						
Average	93.5	Very Practice	91.8	Very Practice	88.3	Very Practice

Table 2 shows the results of the assessment given by the teacher stating that interactive multimedia based on the flipped classroom was very practical to use in terms of aspects of appearance, programming, language, and appropriateness of content with an average score of 93.5% and 91.8%. The assessment given by the students states that flipped classroom based interactive multimedia is very practical to use in terms of aspects of appearance, programming, language, and appropriateness of content with an average score of 88.3%. Based on these results it is known interactive multimedia based on a flipped classroom is very practical to use in learning activities with students. This is in line with the results of research conducted by Brewer et al. (2022); Sartono et al. (2022), who stated that interactive multimedia can be used practically in learning activities, this is based on the assessment results of respondents such as teachers and students.

Effectiveness of Interactive Multimedia Based on Flipped Classroom

The results of this research were carried out by providing a pre-test and post-test from the learning motivation questionnaire and critical thinking test. The paired sample T-test was carried out to determine the increase in pre-test to post-test scores from the learning motivation questionnaire and critical thinking ability test given to students. Several aspects are used as a basis for assessing students' learning motivation, such as having the desire to succeed in learning, having desires and needs in learning, having the desire to achieve goals, having an appreciation for learning, having interesting activities in learning, and have a conducive learning environment (Uno, 2006). Apart from that, there are several aspects used in making critical thinking ability tests, such as analysis, evaluation, inference, deduction, induction, formulation of assumptions, and argumentation testing (Anwar and Muti'ah, 2022).

Based on the test results, the Sig value is known. (2-tailed) learning motivation and critical thinking $0.000 < 0.05$ in the experimental class, while for the control class, the Sig value was obtained. (2-tailed) learning motivation and critical thinking $0.000 < 0.05$. These results show that in both classes there was an increase in learning motivation and critical thinking in students. There was an increase in the average value of students' learning motivation in the experimental class, this is presented in Figure 1.

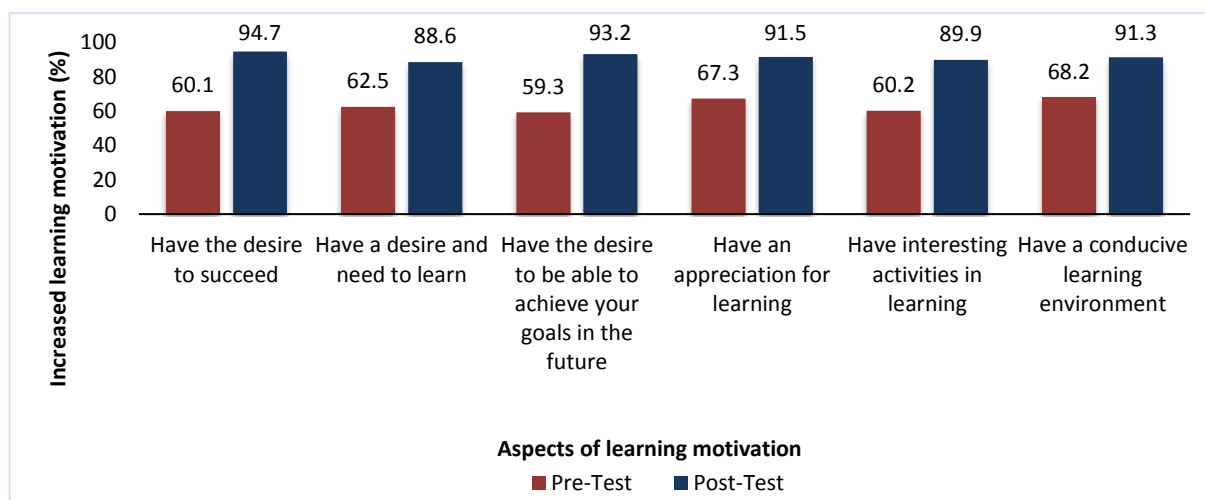


Figure 1. Increase in the Average Score of Students Learning Motivation in the Experimental Class

Based on Figure 1 above, it is known that there is an increase in the average value of students' learning motivation in the experimental class. In the aspect of having the desire to succeed in learning, there was an increase in score of 34.6%, in the aspect of having desires and needs in learning there was an increase in score of 26.1%, in the aspect of having the desire to achieve goals there was an increase in score of 33.9%, in the aspect of having appreciation in learning there was an increase in score of 24.2%, in the aspect of having interesting activities in learning there was an increase in score of 29.7%, and in the aspect of having a conducive learning environment there was an increase in score of 23.1%. A very significant increase occurred in the aspect of having the desire to succeed in learning. Figure 2 shows the increase in the average value of students' learning motivation in the control class.

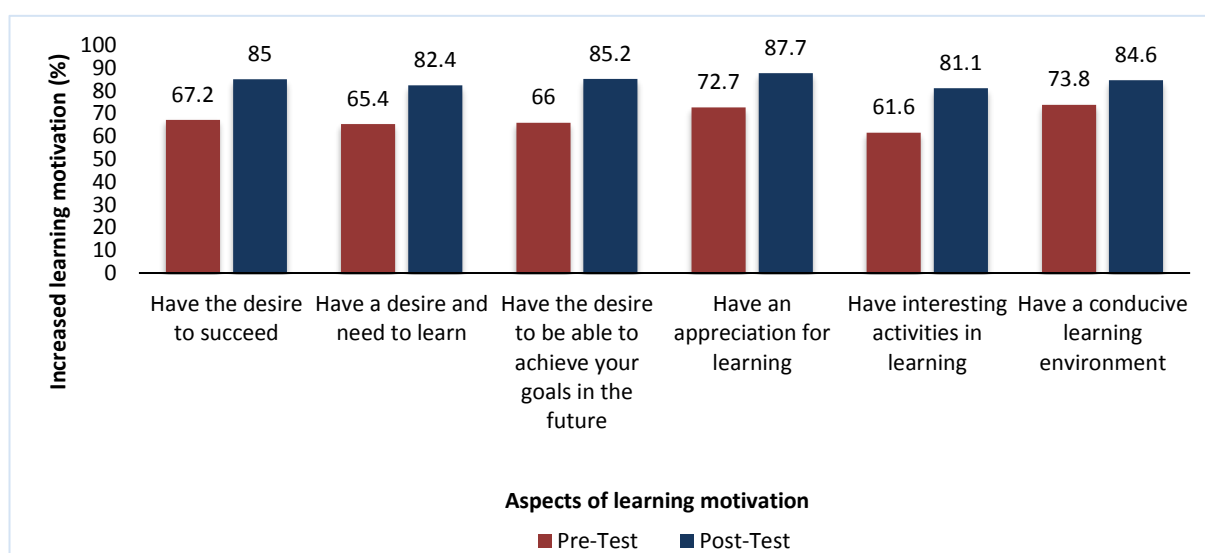


Figure 2. Increase in the Average Score of Students Learning Motivation in the Control Class

Based on Figure 2, it is known that there is an increase in the average value of students' learning motivation in the experimental class. In the aspect of having a desire to succeed in learning, there was an increase in score of 17.8%, in the aspect of having desires and needs in learning, there was an increase in score of 17%, in the aspect of having the desire to achieve goals, there was an increase in score of 19.2%, in the aspect of having appreciation in learning, there was a 15% increase in score, the aspect of having interesting activities in learning saw a 19.5% increase in score, and the aspect of having a conducive learning environment saw a score increase of 10.8%. A very significant increase occurred in the aspect of having interesting activities in learning. In Figure 1 and Figure 2, it is known that there is an increase in the average value of students' learning motivation in the experimental and control classes, apart from that there is a significant increase in the aspect of having the desire to succeed in learning and having interesting activities in learning. The average critical thinking score of students in the experimental class has increased, this is presented in Figure 3.

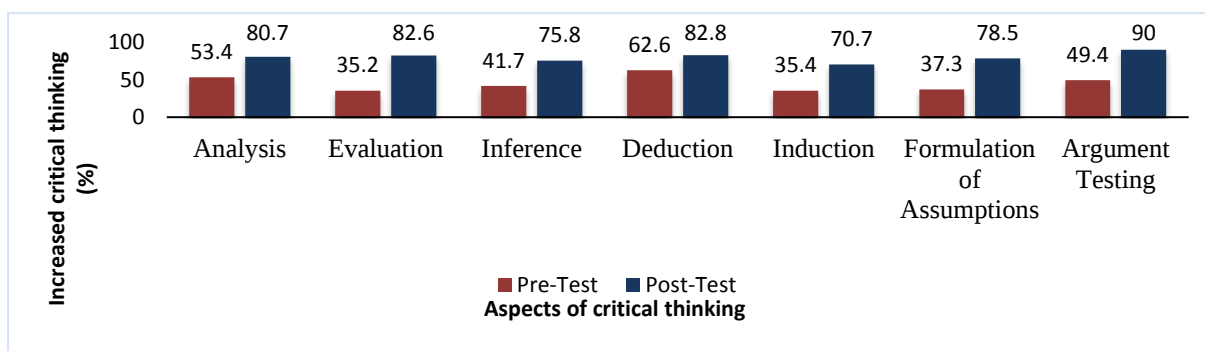


Figure 3. Increase in the Average Critical Thinking Score of Students in the Experimental Class

There was an increase in the average critical thinking score of students in the experimental class, this can be seen in Figure 3. The increase occurred in the analysis aspect, where there was an increase in score of 27.3%, in evaluation there was an increase in score of 47.4%, in inference there was an increase in score of 34, 1%, deduction had an increase in score of 20.2%, induction had an increase in score of 35.3%, formulation of assumptions had an increase in score of 41.2%, and argumentation testing had an increase in score of 40.6%. A very significant increase occurred in the evaluation aspect. Figure 4 shows the increase in the average critical thinking score of students in the control class.

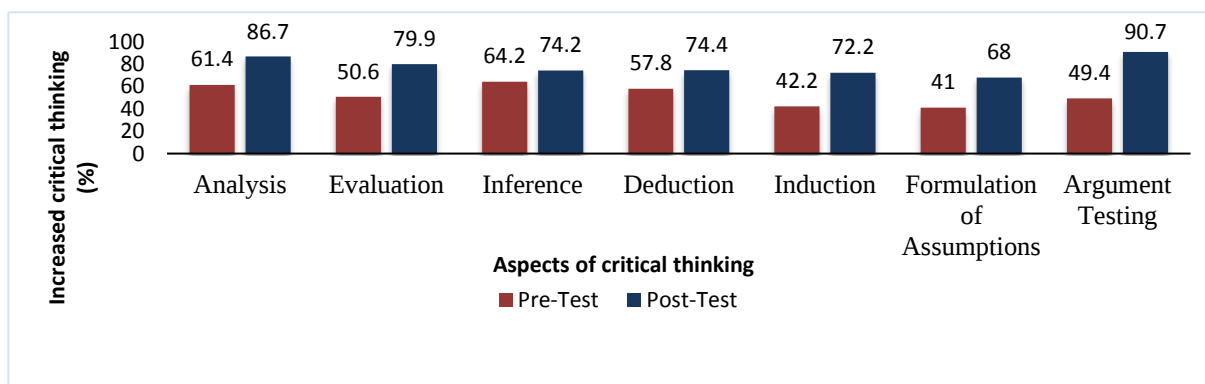


Figure 4. Increase in the Average Critical Thinking Score of Students in the Control Class

Based on Figure 4, it is known that there has been an increase in the average critical thinking score of students in the control class. Improvements occurred in the analysis aspect, there was an increase in score of 25.3%, evaluation there was an increase in score of 29.3%, inference there was an increase in score of 10%, deduction there was an increase in score of 16.6%, induction there was an increase in score of 30%, formulation of assumptions there was an increase in score 27%, and argumentation testing saw an increase in score of 41.3%. A very significant increase occurred in the argument testing indicators. Based on the average values presented in Figure 3 and Figure 4, it is known that there was an increase in the critical thinking abilities of students in the experimental and control classes, apart from that there was a significant increase in the evaluation and argument testing aspects.

A statistical test in the form of an independent sample t-test was carried out to determine whether or not there was a difference in the average score of students from the experimental class which used interactive multimedia based on the flipped classroom, and the control class which used PowerPoint in their learning activities (Korban et al., 2021). In Table 3 below, the results of the independent sample t-test between interactive multimedia based on flipped classroom and PowerPoint are presented.

Table 3. Differences between Flipped Classroom and PowerPoint Based Interactive Multimedia

Variable		Sig. (2-tailed)
Motivation to Learn	Results	
	Equal variances assumed	0.000
	Equal variances not assumed	0.000
Critical thinking	Results	
	Equal variances assumed	0.047
	Equal variances not assumed	0.044

The results of the independent sample t-test show that there is a significant difference in the post-test results between the experimental class and the control class. This can be seen from the Sig value. (2-tailed) learning motivation $0.000 < 0.05$, and Sig. (2-tailed) critical thinking $0.047 < 0.05$. Based on these results, it is known that the average post-test score for learning motivation and critical thinking between the experimental class and the control class is different.

The N-Gain score test was carried out to determine the level of effectiveness of using interactive multimedia based on flipped classroom and PowerPoint in learning activities with students (Abdurrahman et al., 2020). The N-Gain score results between interactive multimedia based on the flipped classroom and PowerPoint will be presented in Table 4.

Table 4. N-Gain Score Interactive Multimedia Based on Flipped Classroom and PowerPoint

Variable	Class	N-Gain score	Category
Motivation to Learn	Experiment	0.764	High
	Control	0.492	Average
Critical thinking	Experiment	0.706	High
	Control	0.590	Average

Interactive multimedia has been proven to be able to be used to increase students' learning motivation (Liu et al., 2021; Mahdi, 2022). Apart from that, the flipped classroom has also been proven to be able to be used to increase students' learning motivation, as well as make students more active in participating in learning activities (Afzali & Izadpanah, 2021; Challob, 2021). This is following the results presented in Table 4. It is known that the learning motivation of experimental class students got an N-Gain score of 0.764 in the high category, while the control class got an N-Gain score of 0.492 in the medium category. Based on these results, it is known that the use of interactive multimedia in a flipped classroom can be used to increase students' learning motivation and is more effective than using PowerPoint to increase students' learning motivation (Anggraeni et al., 2022)

Interactive teaching materials and interactive multimedia can be used to improve students' critical thinking skills when participating in learning activities (Choiriyah et al., 2022; Roemintoyo et al., 2022; Wahyuni et al., 2020). Apart from that, the flipped classroom can be used to improve students' critical thinking skills in participating in learning activities (Etemadfar et al., 2020; Nugraheni et al., 2022). This is by the results of students' critical thinking abilities in the experimental class getting an N-Gain score of 0.706 in the high category, while the control class got an N-Gain score of 0.590 in the medium category. Based on these results, it can be stated that the use of interactive multimedia based on a flipped classroom can be used to improve students' critical thinking abilities, and is more effective than using PowerPoint to improve students' critical thinking abilities (Anggraeni et al., 2022).

Conclusion

The utilization of the ADDIE development model in the research resulted in the creation of an interactive multimedia product based on the method of the flipped classroom, specifically focusing on the topic of biodiversity. According to the findings of the feasibility test conducted by material experts and media experts, it has been determined that interactive media utilizing the flipped classroom approach is highly appropriate for learning activities. Furthermore, the practicality test conducted by teachers and students has confirmed that the interactive multimedia based on the Flipped Classroom is highly practical for use in learning activities. The results of the effectiveness test demonstrated that the multimedia interactive program based on The Flipping Classroom was successful in enhancing the learning motivation of pupils, as indicated by a significant (2-tailed) p-value of 0.000, which is less than the threshold of 0.05. Additionally, the program was found to be effective in improving the critical thinking ability of pupils, with a significant

(2-tailed) p-value of 0.000, also below the threshold of 0.05. The N-Gain scores for both learning motivation and critical thinking ability were 0.764 and 0.706, respectively, indicating a high level of improvement in both categories. The implementation of the interactive multimedia-based flipped classroom is only carried out at senior high school 4 Muara Teweh, requiring expansion to other schools for wider adoption. Additionally, the interactive multimedia-based flipped classroom relies entirely on the concept of biodiversity, with interaction occurring only between students and the media rather than directly with the material itself. Therefore, it is necessary to further develop interactive multimedia based on the flipped classroom with other concepts that can create interaction between students and the material being studied directly.

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