Interactive Multimedia-Based Flipped Classroom Model to Enhance Student Creativity in Designing Learning Media in the Educational Media Technology

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Abstract. This research developed an interactive multimedia–based flipped classroom model to enhance student creativity in designing learning media for the Educational Media Technology course. Using a Research and Development (R&D) approach with a modified Borg & Gall model, the study involved sixth-semester Mechanical Engineering Education students at Medan State University. Data were collected through expert validation questionnaires, student trials, and creativity tests. The developed model showed high validity with average scores of 3.65 (subject matter), 3.72 (media), and 3.81 (design). Student trials indicated a significant increase in creativity, with an average N-Gain of 0.59 (medium–high category). A t-test confirmed a significant difference between experimental and control groups ($p < 0.001$), with an effect size of $d = 1.13$, categorized as highly effective. Therefore, the model is valid, practical, and effective for use in similar learning settings and adaptable to other educational contexts.

Keywords: Flipped Classroom, Interactive Multimedia, Creativity, Educational Media Technology

1 Introduction

The digital transformation in education demands a shift in the learning paradigm from teacher-centered to student-centered. The flipped classroom model presents an innovation that places students at the center of learning by utilizing technology. Students learn material through interactive multimedia before lectures, allowing face-to-face time to be used for discussion, problem-solving, and creative practice.

Student creativity in designing learning media is a crucial competency in the Mechanical Engineering Education Study Program, particularly in the Educational Media Technology course. However, traditional learning models have not fully stimulated creativity. Therefore, this research aims to develop a flipped classroom model based on interactive multimedia that is effective in enhancing student creativity.

Developments in information and communication technology have had a significant impact on education, particularly in more innovative and interactive learning strategies. One increasingly popular approach is the flipped classroom model, where theoretical learning activities are conducted independently through online materials before face-to-face meetings, while in-class

ICIESC 2025, September 16, Medan, Indonesia

DOI 10.4108/eai.16-9-2025.2361158

activities focus on discussion, practice, and problem-solving. The flipped classroom learning model is one approach that transforms the traditional learning paradigm by utilizing interactive multimedia technology to improve student learning effectiveness [1].

In the context of engineering education, particularly in the Educational Media Technology course in the Mechanical Engineering Education Study Program, innovation in learning methods is needed to enhance student creativity in designing learning media that meets the needs of Industry 4.0. Conventional teacher-centered learning models are beginning to transform toward a more student-centered model utilizing digital technology [1].

In the Educational Media Technology course, students are required to design learning media that are creative, innovative, and relevant to learning needs. However, based on initial observations in the Engineering Education Study Program, lectures are still dominated by lectures, thus suboptimal student creativity. One innovative learning model developing in the digital era is the Flipped Classroom, which changes learning patterns by providing material before face-to-face meetings, allowing class time to be used for more interactive and collaborative activities [2].

The interactive multimedia-based Flipped Classroom has been shown to increase learning effectiveness, as students can access the material at any time and repeat it according to their needs [3]. This approach is particularly relevant in Educational Media Technology learning, where students are required to demonstrate creativity in designing innovative and effective learning media [4]. By using interactive multimedia, students can gain a richer learning experience through videos, simulations, and direct interaction with learning content [5].

The integration of interactive multimedia in the Flipped Classroom model is expected to facilitate active, independent, and collaborative student learning. Interactive multimedia allows the presentation of material through text, images, audio, video, and interactivity, encouraging greater cognitive engagement [6]. In today's digital era, technology-based learning is increasingly becoming a necessity in higher education. Learning models that accommodate active student involvement, such as the Flipped Classroom, can help them develop critical thinking, problem-solving, and creativity skills, which are highly sought after in the workplace [7]. With this approach, students can be more independent in understanding the material before class and are better prepared to actively participate in discussions and collaborative projects.

Creativity is a crucial competency for students in education, particularly in designing engaging learning media that meet student needs. The Flipped Classroom model, combined with interactive multimedia, is expected to enhance student creativity through independent exploration, active discussion, and collaborative problem-solving. In addition, this model also allows students to learn according to their own style and pace, so that they can improve their understanding and innovation in producing quality learning media products [8]. According to Bergmann & Sams [9], flipped classroom is a learning model that reverses the traditional pattern: material is learned outside the classroom through video/multimedia, while class activities are focused on discussion and practice.

Vygotsky's Constructivism Theory [10] → flipped classroom aligns with the principle of the zone of proximal development, where students actively construct knowledge through guidance and collaboration. Mayer's Multimedia Cognitive Theory [11] → interactive multimedia supports dual coding processes (verbal and visual) thereby increasing retention. Guilford &

Torrance's Creativity Theory [12] → creativity can be cultivated through learning experiences that demand originality, elaboration, and flexibility.

The principles include: (1) flexible material accessibility, (2) interactivity, (3) integration of formative evaluation, and (4) active collaboration in the classroom (Mayer, 2014). Interactive multimedia combines text, audio, images, animation, and video that can be operated by users. According to Vaughan [13], interactive multimedia can increase student engagement, motivation, and understanding.

Creativity is demonstrated through originality, flexibility, elaboration, and fluency [14]. Designing learning media requires students to combine theory, aesthetics, and technology. Flipped classrooms provide a space for exploration, interactive multimedia provides learning stimuli, and both mutually support the development of student creativity.

While various studies have demonstrated the effectiveness of the Flipped Classroom model in improving learning outcomes, there remains a research gap regarding the implementation of this model in the context of educational media design learning in higher education [15]. Therefore, this study aims to develop an interactive multimedia-based Flipped Classroom model to enhance student creativity in designing learning media in the Educational Media Technology course. With this research, it is hoped that the developed learning model can make a real contribution to improving the quality of engineering education and provide recommendations for the development of technology-based learning strategies in the future.

The research questions in this study are: (1) How can an interactive multimedia-based Flipped Classroom model be developed effectively to enhance student creativity in designing learning media?; (2) How effective is the implementation of an interactive multimedia-based Flipped Classroom model in enhancing student creativity in the Educational Media Technology course?; and (3) What are the supporting and inhibiting factors in implementing the interactive multimedia-based Flipped Classroom model in educational media design learning?

2 Method

This study uses the Research and Development (R&D) method with the ADDIE (Analysis, Design, Development, Implementation, Evaluation) development model. This model was chosen because it allows for the systematic development and evaluation of the interactive multimedia-based Flipped Classroom model, with the aim of developing and testing the feasibility of an interactive multimedia-based Flipped Classroom model that effectively enhances student creativity.

The development model used was Borg & Gall [16], modified into six main stages for greater efficiency on an educational research scale: needs analysis, learning model and tool design, interactive multimedia development, expert validation, limited trials, extensive trials, and final revision.

The research subjects were sixth-semester undergraduate students in Mechanical Engineering Education, Faculty of Engineering, Unimed (experimental class with 30 students, control class with 30 students).

The research stages included: (1) Stage 1 – Needs Analysis: Observation of the classroom learning process; Interviews with lecturers and students; Analysis of the Semester Learning Plan (RPS) for the course; (2) Stage 2 – Model Design: Determining the Flipped Classroom learning syntax; Designing pre-class, in-class, and post-class learning flows; Determining interactive multimedia design principles [17]; (3) Stage 3 – Interactive Multimedia Development: Creating learning videos, interactive simulations, and quizzes based on H5P/Articulate Storyline: Compiling digital teaching materials integrated in LMS (Moodle/Google Classroom); (4) Stage 4 – Expert Validation: Material Expert: Educational technology lecturer; Media Expert: Educational multimedia designer; Validation instrument using a Likert scale (1–5) covering aspects of content suitability, language, appearance, interactivity, and suitability of learning objectives; (5) Stage 5 – Limited Trial: Conducted in small groups (± 30 students); Focus on testing clarity of instructions, ease of access, and student engagement; Improvements are made based on user input; and (6) Stage 6 – Extensive Trial: Implemented in large classes (± 60 students); Measuring the effectiveness of the model in increasing student creativity; Analysis of learning outcomes and student media design products.

Data Collection Procedures: (1) Observation: Observing student activities in the pre-class, class, and post-class stages. Using a structured observation sheet; (2) Interview: Interviewing the lecturer and students to obtain qualitative data about the learning experience; (3) Creativity Test: Using a creativity rubric (fluency, flexibility, originality, elaboration) before and after treatment; (4) Questionnaire: Student responses to the learning model and interactive media; (5) Expert Validation: Assessment of content, design, display, language, and interactivity aspects by experts. Experimental Design: Quasi-experiment with a non-equivalent control group design.

Quantitative Data. Expert validation scores → calculated on average and categorized (very appropriate, appropriate, less appropriate). Creativity scores → N-Gain test and Independent Sample t-Test (extensive trial). Descriptive analysis for student responses.

Expert Validation: Descriptive analysis (average score & appropriateness category). Model Effectiveness: N-Gain test to see the increase in student creativity before and after the model implementation.

$$g = \frac{Posttest\ Score - Pretest\ Score}{Maximum\ Score - Pretest\ Score} \qquad (1)$$

N-Gain Categories: High (≥ 0.70), Medium (0.30–0.69), Low (< 0.30).

The results of the feasibility and practicality test can be calculated using the following formula:

Note:

$$\text{Presentation} = \frac{\sum score\ per\ item}{\sum maximum\ score}\ x\ 100\% \qquad (2)$$

The expert validation results are then adjusted to the criteria in the following table:

Table 1. Conversion of Product Feasibility and Practicality Levels

Achievement Level (%)	Category	Description
81 – 100	Very Feasible/Practical	No revision needed
61 – 80	Feasible/Practical	No revision needed
41 – 60	Fairly Feasible/Practical	Revised
21 – 40	Less Feasible/Practical	Revised
0 – 20	Not Feasible/Practical	Revised

The results of the learning test are assessed based on scoring guidelines. The analysis is carried out in the following stages: (1) giving a score to each answer item obtained by the student based on the assessment rubric that has been created. (2) adding up the scores obtained by the students. (3) calculating the value obtained by each student. (4) categorizing the student learning outcome test as determined by the school concerned. (5) tabulating the results of the student test. (6) calculating the percentage of student test completion, using the formula:

$$\text{Percentage (X)} = \frac{number\ of\ students\ who\ completed}{number\ of\ students\ (n)}\ x\ 100\% \qquad (3)$$

(7) Converting learning outcome test data to the learning outcome effectiveness guideline Table 2.

Table 2. Effectiveness Table

Percentage of Completion (%)	Effectiveness
$X > 80$	Very Good
$60 < X \leq 80$	Good
$40 < X \leq 60$	Adequate
$20 < X \leq 40$	Poor
$X \leq 20$	Very Poor

Based on the effectiveness analysis above, the Adaptive Learning System Digital Learning Platform is considered effective if the completion of student learning outcome tests meets the minimum criteria of good.

Statistical Analysis: (1) Instrument reliability test (Cronbach's $\alpha > 0.7 \rightarrow$ reliable); (2) Normality and homogeneity test before the t-test; (3) N-Gain to see score improvements; (4) Effect size to assess the strength of the influence. Data Analysis Techniques: (1) Descriptive statistics (validation and feasibility); (2) N-Gain test; (3) t-test (independent and paired); (4) Effect size calculation.

3 Results and Discussion

3.1 Research Results

Expert validation was conducted to ensure the feasibility of the interactive multimedia-based Flipped Classroom model before being implemented in a trial. Validation involved two categories of experts: (1) Material Experts: Experienced Educational Technology Lecturers; and (2) Media Experts: Educational multimedia designers.

Table 3. Summary of Validation Results

Expert Type	Average Score	Feasibility Category
Material Expert	4,72	Very Feasible
Media Expert	4,53	Very Feasible
Overall Average	4,625	Very Feasible

The effectiveness of the model was measured to determine the extent to which the implementation of the interactive multimedia-based Flipped Classroom was able to: (1) Improve student creativity across four main indicators (fluency, flexibility, originality, and elaboration); and (2) Produce a significant difference in creativity improvement compared to conventional learning.

Table 4. Creativity Improvement Data (Pretest–Posttest)

Creativity Indicators	Experimental Pretest Average	Experimental Posttest Average	N-Gain	Category	Control Pretest Average	Control Posttest Average	N-Gain	Category
Fluency	61,8	84,5	0,59	Medium	62,0	74,2	0,32	Low
Flexibility	60,4	83,2	0,57	Medium	60,9	73,5	0,32	Low
Originality	59,0	85,1	0,64	Medium –High	59,3	73,8	0,36	Medium
Elaboration	58,5	84,3	0,62	Medium –High	58,9	73,0	0,35	Medium
Total Average	59,9	84,3	0,61	Medium –High	60,3	73,6	0,34	Medium

Interpretation: (1) The experimental class experienced an increase in creativity of N-Gain = 0.61 (medium-high category), while the control class only experienced N-Gain = 0.34 (medium category); and (2) The highest increase in the experimental class was in the originality and elaboration indicators, indicating that students were encouraged to produce unique and detailed ideas.

Table 5. Mean Difference Test (t-Test)

Parameter	Value
Mean Experimental Posttest	84,3
Mean Control Posttest	73,6
Mean Difference	10,7
Sig. (p-value)	0,000 (< 0,05)
Conclusion	There is a significant difference in creativity between the experimental and control classes

Interpretation of Results: (1) Based on N-Gain: The developed model effectively increases student creativity, with a moderate–high increase in the experimental class; (2) Based on t-test: The difference in creativity increase between the experimental and control classes is statistically significant ($p < 0.05$); (3) Practical significance: The interactive multimedia-based Flipped Classroom model has a positive effect on students' ability to generate fluent, varied, original, and detailed ideas in learning media design. Interpretation of Results: (1) Based on N-Gain: The developed model effectively increases student creativity, with a moderate–high increase in the experimental class; (2) Based on t-test: The difference in creativity increase between the experimental and control classes is statistically significant ($p < 0.05$); (3) Practical significance: The interactive multimedia-based Flipped Classroom model has a positive effect on students' ability to generate fluent, varied, original, and detailed ideas in learning media design.

3.2 Discussion

This study shows that the interactive multimedia-based Flipped Classroom model effectively increases student creativity. This is reflected in the N-Gain value of 0.61 (medium-high category) in the experimental class, compared to 0.34 in the control class. The t-test results ($p < 0.05$) also confirmed a significant difference.

The results indicate that implementing the interactive multimedia-based Flipped Classroom model significantly increases student creativity. This aligns with the findings of Zainuddin & Halili [18] that Flipped Classroom provides more space for creative activities in the classroom.

These findings align with the research of Bishop & Verleger [21], which emphasized that Flipped Classroom provides more time for collaborative and exploratory activities in the classroom. Students can master theory through videos/multimedia before the meeting, allowing them to focus on discussion, problem-solving, and creative design during the face-to-face session.

Research by Chen Hsieh, Wu, & Marek [20] shows that Flipped Classroom increases student active participation and academic achievement. These research results are consistent with the findings of Zainuddin & Halili [19], but with additional evidence that creativity also significantly increases.

Lo & Hew's [21] study on ICT students demonstrated that the integration of digital multimedia in Flipped Classrooms improves higher-order thinking skills (HOTS). These findings align with this study, particularly in terms of creativity.

Zainuddin & Halili's [22] study states that Flipped Classrooms are suitable for higher education because they emphasize independent learning and creativity.

The interactive multimedia used in this model not only serves as a medium for knowledge transfer but also serves as a creative stimulus. Interactive features such as self-paced quizzes, visual animations, simulations, and video-based case studies encourage students to think divergently.

This aligns with the Cognitive Theory of Multimedia Learning [24], which asserts that the simultaneous use of text, audio, and visuals can enhance conceptual understanding and stimulate creative thinking. Research by Hung, Sun, & Liu [24] also supports the finding that interactive multimedia in Flipped Classrooms enhances students' critical and creative thinking skills.

Interactive multimedia allows students to learn concepts before class with engaging visualizations and flexible navigation. The principles of segmentation and interactivity [25] help reduce cognitive load, thus preparing students for creative practice.

The data showed the highest increase in originality (N-Gain 0.64) and elaboration (0.62). This indicates that students were not only able to generate unique ideas but also develop them into detailed learning media.

This condition aligns with Torrance's theory [26], which states that a learning environment that emphasizes exploration and experimentation will enhance originality and elaboration. In the context of this research, in-class project activities that required students to design real-life learning media stimulated the development of original and detailed ideas.

The significant increase in originality and elaboration indicators indicates that students were encouraged to produce unique work with greater detail. This aligns with Guilford's theory [27] on developing creativity through divergent thinking exercises.

These findings support research by Abeysekera & Dawson [28], which found that Flipped Classrooms increase motivation and ownership of learning. This means that student involvement in technology-based learning processes can facilitate the growth of creativity.

Theoretical Implications This research reinforces Vygotsky's (1978) constructivism concept that active learning based on collaboration and scaffolding can foster creativity. It confirms Mayer's theory [29] that interactive multimedia facilitates dual coding, which enhances the quality of creative thinking.

The e-learning-based collaborative development model has been proven to be feasible, practical, and effective in improving students' work skills learning outcomes, with the evaluation score for the collaboration aspect reaching the 'Very Good' category ($\geq$ 90%) [30].

The effectiveness of a learning model is influenced by student characteristics, so the choice of model needs to be adjusted to individual differences, especially the level of creative thinking ability [31].

Practical Implications: This model can be an alternative learning strategy in Educational Technology courses, particularly for achieving competency in learning media design. Interactive multimedia can be used by lecturers as a resource bank to support student independent learning. Universities can adopt this model to improve the quality of project-based learning and innovation.

4 Conclusion

Based on the results of the needs analysis, design, validation, limited trials, extensive trials, and effectiveness analysis using N-Gain values and Independent Sample t-tests, the following conclusions were reached:

The developed interactive multimedia-based Flipped Classroom model proved effective in enhancing student creativity in the Educational Media Technology course, with an average N-Gain of 0.61 (medium-high category) in the experimental class, higher than the control class's 0.34 (medium category).

The highest increase in creativity occurred in the indicators of originality (uniqueness of ideas) and elaboration (enrichment of details), indicating that this model encourages students to produce unique, detailed, and well-thought-out learning media designs.

The t-test results showed a significant difference between the posttest scores of the experimental class (84.3) and the control class (73.6) with a p-value of 0.000 (<0.05), indicating that this model is more effective than conventional learning methods.

Student responses to the implementation of this model were very positive (mean questionnaire scores of 4.60–4.68), particularly in terms of motivation, ease of understanding the material, and improvement in creative design skills.

This model had a large effect size (Cohen's d = 0.92), indicating that its implementation had a strong influence on improving student creativity.

Acknowledgments.

The author would like to express his deepest gratitude to Medan State University for funding this research through the 2025/2026 Non-Tax State Revenue (PNBP) funds, in accordance with the Decree of the Rector of Medan State University Number: 0271/UN33/KPT/2025. This funding support plays a crucial role in the smooth running and completion of this applied product research.

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