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Research Article

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Evaluation of the effectiveness of flipped learning in constructivism to improve concept understanding in information and computer engineering education

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ABSTRACT

This research focuses on evaluating the effectiveness of flipped learning in enhancing concept comprehension among students of the Informatics and Computer Engineering Education Study Program at Invada Institute of Education and Languages. Utilizing a constructivist framework, this study adopts a quasi-experimental approach to compare two groups of students: an experimental group that utilized flipped learning and a control group that followed traditional learning methods. Data were obtained through pre- and post-test measurements to assess concept comprehension before and after the intervention. In flipped learning, learning content is delivered outside of class via digital media such as videos, allowing class time to be used for interactive discussions and problem-solving. This method aligns with constructivist principles advocating active and collaborative learning. The study results reveal a significant improvement in students' concept comprehension in the experimental group compared to the control group. The experimental group showed a higher average post-test score, proving the effectiveness of the flipped learning strategy in deepening understanding of course material. These findings affirm that flipped learning not only increases student engagement but also strengthens their cognitive abilities in comprehending complex material. Furthermore, the implications of this research suggest that the implementation of flipped learning in the context of engineering education positively contributes to the quality of higher education, especially in the fields of engineering and technology. Thus, the results of this study encourage educators in higher education institutions to adapt the flipped learning approach as a strategic tool for developing more effective curricula. These findings support the importance of innovation in teaching methods to improve student learning outcomes and concept mastery skills.

Keywords: flipped learning, constructivism, learning, classroom

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INTRODUCTION

Learning in higher education, especially in the fields of engineering and technology, often faces challenges in ensuring that students not only understand concepts theoretically but can also apply them practically. Traditional expository teaching methods are often ineffective in encouraging active student engagement, which in turn can hinder a deep understanding of the material being taught (Bruner, 1996).

In response to these challenges, flipped learning has been introduced as a potential (Bishop & Verleger, 2013). Flipped learning shifts activities that are usually conducted in class (such as lectures) to outside the classroom through videos or other digital materials, while class time is used for interactive activities such as discussions, problem-solving, or group projects (Kim et al., 2014). This approach aligns with constructivist theory, which emphasizes the importance of active and collaborative learning experiences in building knowledge (Vygotsky, 1980).

In this context, several studies show that the application of flipped learning not only increases student engagement but also significantly enhances conceptual understanding. According to O'Flaherty and Phillips (2015), flipped learning can be an effective strategy in higher education, with results showing increased student engagement and understanding of the material. Research by Awidi and Paynter (2019) also confirms that this method positively contributes to students' learning experiences, in line with constructivist principles that emphasize active learning. Furthermore, Gilboy et al. (2015) demonstrate that flipped learning can enhance student engagement, which is a key factor in achieving deeper understanding. Thus, the application of flipped learning in the context of Informatics and Computer Engineering Education (PTIK) at the Invada Institute of

Education and Language has great potential to improve the quality of education and students' conceptual understanding.

Research by Zainuddin (2017) and Kim et al. (2014) shows that the application of flipped learning in PTIK can significantly enhance students' conceptual understanding. In this study, two groups of students at the Invada Institute of Education and Language were involved, with the experimental group implementing flipped learning and the control group following traditional teaching methods. Pre- and post-test results showed that the experimental group experienced an average post-test score increase of 88.1, compared to 72.4 in the control group, indicating an increase of 25.6 points. These findings confirm that flipped learning, when applied within a constructivist framework, not only enhances conceptual understanding but also actively engages students in the learning process (Zainuddin & Halili, 2016).

This research makes an important contribution to the development of more effective learning strategies in higher education, particularly in the fields of engineering and technology, by emphasizing active and collaborative learning experiences that align with constructivist principles (Kim et al., 2014). Student involvement in interactive discussions and collaborative activities during flipped learning can strengthen their understanding of the material taught and enhance problem-solving skills that are highly needed in the workplace (Zainuddin, 2017).

Improvement in conceptual understanding: In a study conducted by Robbins et al. (2020), it was found that students participating in flipped learning experienced a 25% increase in conceptual understanding compared to traditional teaching methods. This indicates that flipped learning not only enhances engagement but also learning outcomes.

Student engagement: According to Jensen et al. (2015), 80% of students reported being more engaged in learning when using flipped learning methods compared to traditional methods.

However, the application of flipped learning in the context of PTIK is still relatively new, especially in Indonesia. The Invada Institute of Education and Language, as a higher education institution focused on human resource development in technology and language, has great potential to implement this approach to improve educational quality (Lage et al., 2000). Considering the characteristics of PTIK students who are required to have a deep understanding and strong problem-solving skills, the application of learning methods that encourage active engagement such as flipped learning is highly relevant (Robbins et al., 2020).

Research Problem

Despite the recognized benefits of flipped learning, there is still a lack of literature exploring its application in the context of PTIK, especially in Indonesia (Zainuddin, 2017). The main question that arises is: to what extent can the implementation of flipped learning enhance the conceptual understanding of PTIK students at the Invada Institute of Education and Language? (Zainuddin & Halili, 2016).

Research Objective

This research aims to evaluate the effectiveness of flipped learning within a constructivist context for PTIK students at the Invada Institute of Education and Language. Specifically, this study will measure the improvement in students' conceptual understanding after the application of this method and compare it with traditional teaching methods (Kaplan, 1971; Lopez, 2022; Srivastava, 2012; VanTassel-Baska, 1997).

Research Benefits

The findings from this research are expected to contribute to the literature on flipped learning in the field of technical education and provide practical insights for educators and educational institutions in developing more effective learning strategies (Bishop & Verleger, 2013; Gilboy et al., 2015; O'Flaherty & Phillips, 2015). Additionally, the results of this study can serve as a basis for developing curricula that focus more on active and collaborative learning (Kaplan, 1971; Oigara, 2018; VanTassel-Baska, 1997).

LITERATURE REVIEW

Flipped Learning

Flipped learning is a pedagogical approach that shifts the traditional role of the classroom from a place for information delivery to a place for active application of knowledge. In flipped learning, learning content such as lectures or theoretical explanations is delivered outside the classroom, usually through videos, online modules, or readings, allowing students to learn the basic material before face-to-face meetings (Bishop & Verleger, 2013; Lage et al., 2000; Lopez, 2022). During class time, students engage in more interactive and collaborative activities, such as group discussions, case studies, or problem-solving (Gilboy et al., 2015; O'Flaherty & Phillips, 2015). Similarly, research conducted by Hu et al. (2025) and Holroyd et al. (2025) reported a difference in treatment between the experimental class, which utilized the flipped classroom method, and the control class, which used traditional teaching methods, where the findings of this research clearly showed a significant improvement in the scores of the experimental group, supporting the flipped classroom teaching method.

Studies conducted by Bishop and Verleger (2013) show that flipped learning can increase student engagement and deepen understanding of the material. This is supported by other research, such as that by Abeysekera and Dawson (2014), which found that flipped learning not only helps students understand concepts more deeply but also increases independence in learning. However, implementing flipped learning requires careful planning, especially in designing class activities that truly support active learning (Bishop & Verleger, 2013; DeLozier & Rhodes, 2016).

Constructivism Theory in Education

Constructivism is a learning theory that emphasizes that knowledge is constructed by individuals through interaction with their environment. According to this theory, learning is an active process where students actively build their own understanding based on previous experiences and new knowledge they acquire (Kaplan, 1971; Oigara, 2018; VanTassel-Baska, 1997).

In the context of higher education, constructivism encourages the use of learning methods that allow students to engage directly in the learning process through direct experience, collaboration, and reflection (Jarutkamolpong & Kwangmuang, 2025; Oigara, 2018; von Glasersfeld, 1989; Windschitl, 2002; Zhou et al., 2024). Flipped learning aligns well with constructivist principles because it provides space for students to develop understanding through classroom activities that

require them to apply, analyze, and synthesize information they have learned outside of class (Abeysekera & Dawson, 2014; Bishop & Verleger, 2013; Lage et al., 2000).

Flipped Learning in the Context of Constructivism

The combination of flipped learning and constructivism offers great potential to enhance learning effectiveness. According to a study by Lage et al. (2000), flipped learning provides a learning environment that supports constructivist principles by activating more intensive student participation (Awidi & Paynter, 2019; Long et al., 2016; Moravec et al., 2010; Ukwandu et al., 2025). Classroom activities, such as group discussions or collaborative projects, allow students to share their perspectives and build knowledge together, in line with constructivist theory (Alkaabi, 2022; Gilboy et al., 2015; Jensen et al., 2015).

On the other hand, O'Flaherty and Phillips (2015) state that flipped learning can help overcome some of the weaknesses of traditional teaching methods, such as limited interaction time in class and passive student involvement (Al-Zahrani, 2015; DeLozier & Rhodes, 2016; van Vliet et al., 2015). Through flipped learning, students not only get more time to understand the material independently but also have the opportunity to develop critical thinking and problem-solving skills through activities based on constructivist principles (Dickenson, 2014; Rahman et al., 2015; Zainuddin, 2017).

Implementation of Flipped Learning in Informatics and Computer Engineering Education

In the context of PTIK, where a deep understanding of concepts and technical skills is crucial, flipped learning can be an effective tool to enhance students' skills. A study by Gilboy et al. (2015) shows that in the fields of engineering and computer science, flipped learning not only enhances theoretical understanding but also improves students' practical abilities (Phillips, 1995; Ronaghi, 2024; Vygotsky, 1980; Windschitl, 2002).

However, although the benefits of flipped learning are widely recognized, specific research exploring its application in the context of PTIK in Indonesia is still limited (Bishop & Verleger, 2013; Maimaiti & Hew, 2025; O'Flaherty & Phillips, 2015; Prawat & Floden, 1994). Therefore, this research seeks to fill this gap by evaluating the effectiveness of flipped learning in enhancing the conceptual understanding of PTIK students at the Invada Institute of Education and Language (Chen et al., 2014; DeLozier & Rhodes, 2016; Gilboy et al., 2015).

MATERIALS AND METHODS

Research Design

This study uses a quasi-experimental design with a pre- and post-test approach on two groups: the experimental group and the control group. The experimental group will receive treatment in the form of flipped learning implementation, while the control group will follow traditional teaching methods. This design was chosen to evaluate the difference in conceptual understanding between students who follow flipped learning and those who follow traditional learning (Alkaabi, 2022; Enfield, 2013; Strayer, 2012).

Population and Sample

The population in this study consists of all students in the PTIK program at the Invada Institute of Education and Language. The sample is selected through purposive sampling, where two classes with similar characteristics are chosen as the sample. The first class (experimental group) consists of 30 students who will participate in flipped learning, while the second class (control group) consists of 30 students who will follow traditional teaching methods (Abeysekera & Dawson, 2014; Al-Zahrani, 2015; Herreid et al., 2014).

Inclusion Criteria

1. Students enrolled in the PTIK program at the Invada Institute of Education and Language.
2. Students are willing to participate in the study and follow all learning stages, including pre- and post-test.
3. Students who have access to learning materials provided in digital form for the experimental group.

Exclusion Criteria

1. Students who are absent during the pre- or post-test.
2. Students with a different educational background (e.g., students from other study programs) that may affect the research results.
3. Students with health issues that may interfere with their participation in learning activities.

Research Instruments

The primary instrument used in this study is a conceptual understanding test consisting of a pre- and post-test. This test is designed to measure the level of student understanding of key concepts in the course. Additionally, a questionnaire is used to assess student responses to their learning experiences, both in flipped and traditional learning methods (Jensen et al., 2015; Kim et al., 2014; Moravec et al., 2010).

To ensure the validity and reliability of the research instruments, we performed construct validity testing through factor analysis and validation by experts (content validity) to ensure that the conceptual understanding test truly measures the intended aspects. Additionally, the reliability of the instruments is measured using Cronbach's alpha coefficient, showing a value of 0.87 for the pre-test and 0.92 for the post-test, indicating good reliability. Questionnaire data is also tested for reliability with a Cronbach's alpha coefficient of 0.85, indicating high internal consistency. Furthermore, triangulation techniques are applied in qualitative data analysis to ensure the accuracy and consistency of findings from the questionnaires filled out by students regarding their learning experiences.

Research Procedure

The research is conducted in several stages:

1. **Preparation stage:** Learning materials for flipped learning are prepared, including lecture videos, learning modules, and reading materials. The experimental group students are given access to these materials before class meetings, while the control group receives teaching through in-class lectures as usual (DeLozier & Rhodes, 2016; Lage et al., 2000; Zainuddin, 2017).

Table 1. Questionnaire instrument grid

Measured aspect	Indicator	Item No	Questionnaire statement	Reference
Engagement in discussion	Flipped learning increases my engagement in class discussions	1	How often do you feel encouraged to participate in class discussions after preparing the material independently before the meeting?	Parrish (2010)
	I am more actively involved in discussions after studying the material independently	2	Do you feel more confident in expressing your opinions during class discussions after studying the material beforehand?	
	Class discussions are more effective when I have understood the material before the meeting	3	How effective are class discussions in helping you better understand the material?	
	I feel more comfortable discussing with peers when using traditional learning methods	4	Do you feel that class discussions help improve your communication skills?	
Concept understanding	Flipped learning helps me better understand difficult concepts	5	To what extent does flipped learning help you understand difficult concepts?	Novak and Gowin (1984)
	After participating in flipped learning, I feel more confident in my understanding of the material	6	Do you feel more confident in your understanding of the material after participating in flipped learning?	
	Traditional learning provides me with a deeper understanding of fundamental concepts	7	How significant is the role of traditional learning in helping you understand fundamental concepts?	
	I find it easier to remember concepts learned through flipped learning	8	Do you find it easier to remember concepts learned through flipped learning?	
Skill development	Flipped learning helps me develop critical thinking skills	9	How effective is the learning method used in class in helping you develop critical thinking skills?	Landesman (2006)
	Flipped learning encourages me to be more independent in learning	10	Do you feel more capable of connecting theory with practice after following this learning method?	
	I feel that traditional learning methods are more effective in developing technical skills	11	To what extent does this learning method contribute to enhancing your ability to solve problems independently?	
	Flipped learning enhances my ability to connect theory with practice	12	To what extent do you feel that this learning has helped you develop teamwork skills?	

2. **Pre-test:** Before treatment is given, both groups take an initial test to measure their conceptual understanding before learning begins (Gilboy et al., 2015; O'Flaherty & Phillips, 2015; Roehl et al., 2013).
3. **Learning implementation:** The experimental group conducts flipped learning for one semester, where they study materials independently outside the classroom and use class time for discussions, problem-solving, and other interactive activities. The control group follows traditional learning where materials are taught through in-class lectures (Awidi & Paynter, 2019; Cheng et al., 2014).
4. **Post-test:** After learning is completed, both groups will take the same final test as the initial test to measure the improvement in conceptual understanding (Lo & Hew, 2017; Robbins et al., 2020; Yilmaz et al., 2015).
5. **Data collection:** Quantitative data from the pre- and post-test, as well as qualitative data from questionnaires, are collected for further analysis (Giannakos et al., 2014; Srivastava, 2012; Zainuddin, 2017).

Data Analysis Techniques

Quantitative data from the pre- and post-test will be analyzed using statistical tests, such as t-tests, to compare the improvement in conceptual understanding between the experimental and control groups. This statistical analysis is conducted to determine whether there is a significant difference in conceptual understanding between the two groups (Bishop & Verleger, 2013; Long et al., 2016; Rahman et al., 2015).

Qualitative data will be analyzed using content analysis methods to understand students' perceptions of their learning experiences (Dickenson, 2014; van Vliet et al., 2015; Vygotsky, 1980).

Validity and Reliability

Table 2. Average pre- and post-test scores in the experimental and control groups

Group	Pre-test mean	Post-test mean	N	SD
Experimental group	62.5	88.1	30	9.5
Control group	63.8	72.4	30	10.5

To ensure the validity and reliability of the research instruments, the conceptual understanding test will undergo construct validity and reliability testing using Cronbach's alpha coefficient. Additionally, triangulation techniques will be used in qualitative data analysis to ensure the accuracy and consistency of findings (Kaplan, 1971; Phillips, 1995; Velegol & Zappe, n.d.).

Table 1 shows the questionnaire instrument grid.

RESULTS

Pre- and Post-Test Results

After implementing flipped learning for one semester, pre- and post-test assessments were conducted to measure students' conceptual understanding. The data from the pre- and post-test for both the experimental and control groups are presented in **Table 2**.

From the pre-test results, it is evident that the initial conceptual understanding of students in both groups was not significantly different. The experimental group had an average pre-test score of 62.5, while the control group had an average of 63.8. This indicates that both groups had relatively equal levels of understanding before the treatment was administered.

To provide a deeper analysis of the differences in conceptual understanding between the experimental and control groups, a t-test was conducted on the post-test results. The t-test results showed a p-value < 0.05, indicating a significant difference between the average

post-test scores of the experimental and control groups. This further supports the finding that the implementation of flipped learning significantly enhances students' conceptual understanding compared to traditional teaching methods.

After the treatment, which involved the application of flipped learning in the experimental group and traditional learning in the control group, the post-test results showed a significant difference. The experimental group showed a significant increase with an average post-test score of 88.1, while the control group only reached an average of 72.4. This increase indicates that the flipped learning method is more effective in enhancing students' conceptual understanding compared to traditional teaching methods.

DISCUSSION

The significant improvement in the experimental group can be explained by the characteristics of flipped learning, which encourage students to be more actively involved in the learning process. In flipped learning, students are given the opportunity to study the material independently before class meetings, preparing them for more in-depth and interactive discussions in class (Giannakos et al., 2014; Herreid et al., 2014; Strayer, 2012; van Vliet et al., 2015).

According to constructivist theory, learning that involves active participation and self-reflection is highly effective in helping students construct their own understanding. Flipped learning, with its focus on independent preparation and interactive discussion, aligns with these constructivist principles, ultimately contributing to better conceptual understanding (Dickenson, 2014; Prawat & Floden, 1994; Velegol & Zappe, n.d.).

The results of this study indicate that the application of flipped learning within the constructivist context significantly improves the conceptual understanding of PTIK students at the Invada Institute of Education and Language. With an average post-test score of 88.1 for the experimental group, compared to 72.4 for the control group, it is clear that the flipped learning method is more effective in enhancing conceptual understanding.

The implications of these findings are significant in the context of higher education in Indonesia, where many institutions still use traditional teaching methods that tend to be expository. The implementation of flipped learning can be an effective alternative to increase student engagement and understanding of the material taught. By encouraging students to prepare material before class meetings, they can engage more actively in deep discussions and interactions, in line with constructivist principles.

Other institutions can adopt this approach by adapting the materials and teaching methods to suit their students' characteristics. For example, in other departments with different curricula, instructors can design relevant videos and learning modules and create interactive classroom activities to facilitate discussion and collaboration. This will not only enhance conceptual understanding but also prepare students to face challenges in an increasingly complex work environment where problem-solving and collaboration skills are highly needed.

The results of this study are consistent with previous research showing the effectiveness of flipped learning in enhancing conceptual understanding across various fields, including engineering and informatics (Reigeluth, 2013; Jeong et al., 2018; Moraros et al., 2015). This also supports findings that state learning that provides opportunities for students to actively seek information and discuss with classmates can strengthen the understanding and application of learned concepts (Bowen, 2014; Brame, 2019; Kanjug et al., 2018).

Furthermore, a study by Kanjug et al. (2018) confirms that learning that provides opportunities for students to actively seek information and engage in discussions can strengthen the understanding and application of learned concepts. This supports the findings of this study, showing that flipped learning, when applied within a constructivist framework, provides significant benefits in enhancing students' conceptual understanding.

Therefore, this study not only provides additional evidence of the effectiveness of flipped learning but also strengthens the argument that this method can be adapted and applied in various study programs in higher education, particularly in Indonesia, to improve the quality of learning and student outcomes.

Overall, the results of this study show that the implementation of flipped learning within the constructivist context can provide significant benefits in enhancing the conceptual understanding of PTIK students. Therefore, this method can be considered an effective alternative to improve the quality of learning in the PTIK program.

CONCLUSIONS

Based on the research results and discussion, it can be concluded that the implementation of flipped learning within a constructivist context significantly enhances conceptual understanding among students in the PTIK program. This is evidenced by the significant difference between the post-test results of the experimental and control groups, with the group using the flipped learning method achieving a higher average score.

Flipped learning allows students to prepare thoroughly before class meetings, which in turn encourages active participation in discussions and a deeper understanding of the material. In line with constructivist principles, this method has proven effective in helping students develop a better understanding through active participation and meaningful interaction in the classroom.

Therefore, the application of flipped learning in the PTIK environment can be an effective strategy to enhance the quality of learning and students' conceptual understanding. This method can also serve as a reference for instructors in other study programs to adapt according to their students' needs and characteristics.

Recommendations for Future Research and Educational Practice

From these findings, it is recommended that further research be conducted to explore the application of flipped learning methods in various disciplines and different educational contexts. Instructors are also encouraged to develop various forms of learning materials that can be used in the flipped learning model and to create classroom environments that support interaction and collaboration among students. Additionally, it is important for instructors to conduct regular evaluations of the effectiveness of this method in enhancing student understanding and engagement, so it can continually be adjusted to the dynamics of the classroom and developments in educational technology.

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Declaration of interest: Authors declared no competing interest.

Data availability: Data generated or analyzed during this study are available from the authors on request.

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