

Enhancing Vocational Higher Education Lecturers' Pedagogical Competence through a Digital Platform-Based Flipped Classroom

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ABSTRACT

This study aims to analyse the effectiveness of implementing the flipped classroom model using the Moodle and Google Classroom learning management systems in enhancing pedagogical competence and learning management skills. This model is implemented through pre-class, during-class, and post-class learning stages facilitated by digital materials, interactive forums, and automatic evaluation mechanisms on the platform. The research method used a one-group pretest-posttest design with 37 lecturers in the Faculty of Engineering as subjects. Data analysis was performed using a paired sample t-test, one-sample t-test, and N-Gain calculation to assess competency improvement after the intervention. The results showed a significant increase in lecturers' initial and final competencies after participating in the flipped classroom model, as evidenced by a significant value of ($p = .00 < .05$). The N-Gain value of (.502) was in the moderate category, reflecting a consistent improvement in lecturers' abilities in the aspects of learning design, digital technology utilisation, and feedback provision through the platform. The integration of technology also strengthened the efficiency of classroom management and enabled lecturers to implement more adaptive, collaborative, and vocationally-oriented learning. This research implies that the flipped classroom model can be used as a strategy for developing lecturers' professional skills in instructional design, the use of digital media, and interactive classroom management, and can serve as a basis for vocational higher education institutions to systematically integrate digital

platforms to drive a transformation towards more effective teaching practices.

Keywords

Digital Learning
Flipped Classroom Model
Learning Management
System
Teaching Practices

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Introduction

The development of digital technology and the acceleration of higher education transformation in the era of the Fourth Industrial Revolution have encouraged universities to adopt more innovative, flexible, and learner-centred approaches to learning [1]–[3]. Lecturers, as the main actors in the learning process, are required not only to master scientific substance, but also to be able to utilise digital technology to design learning experiences that are adaptive, collaborative, and relevant to the needs of 21st-century students [4],[5]. However, the reality of learning in various universities still shows the dominance of lecture methods, limited two-way interaction, and the suboptimal use of digital platforms in supporting the teaching and learning process. This condition hinders the development of critical thinking skills, independent learning, and collaborative abilities of students, which should be the main orientation of higher education.

In response to these changes, the flipped classroom model has emerged as a pedagogical approach that offers significant potential for improving the quality of teaching [1], [6]. This model reorganises the learning structure by placing concept exploration and learning material activities in the pre-class phase through videos, digital modules, or online learning resources [7]. Thus, face-to-face time can be focused on interactive activities such as discussions, problem solving, case study analysis, and collaborative projects [8]. This approach provides more space for lecturers to manage learning activities that stimulate active student engagement while increasing their depth of understanding of the material. Not only that, but the flipped classroom approach can put the key principles of andragogy into practice, making it highly effective for lecturers' learning, as it aligns with their unique characteristics and preferences [9],[10]. By integrating this approach, it is possible to enhance the learning experience for lecturers by creating a more dynamic and engaging educational environment.

The effectiveness of the flipped classroom model will be optimised when supported by integrated digital learning platforms such as Learning Management Systems, interactive quiz applications, learning analytics systems, and various other supporting digital tools [7], [11],[12]. Digital platforms serve as a medium for distributing material, providing a space for

academic interaction, continuous assessment, tracking learning progress, and providing automatic feedback [1], [7]. In the context of university teaching, the integration of digital platforms enables lecturers to design data-based learning, differentiate instruction, and provide a more personalised and flexible learning experience for students.

Despite its great potential, the implementation of the flipped classroom in higher education still faces a number of challenges. Previous studies have shown that the quality of digital materials, lecturers' digital readiness, instructional design patterns, and the integration between pre-class and face-to-face activities are crucial factors that determine the success of this model [13],[14]. In addition, there is still a lack of empirical research that specifically evaluates the effectiveness of implementing a flipped classroom based on an integrated digital platform in university teaching practices [15],[16]. The majority of studies focus more on analysing student perceptions or learning at the school level, rather than on the context of lecturer professionalism itself.

This gap in research highlights the need for more in-depth studies on how lecturers implement the flipped classroom in their teaching, how digital platforms support or hinder the success of this implementation, and the extent to which this approach contributes to improving learning effectiveness in a university environment. Thus, this study aims to analyse the application of the flipped classroom model based on an integrated digital learning platform in university lecturers' teaching practices. The findings of this study are expected to provide empirical contributions, practical recommendations, and a basis for the development of more effective and sustainable learning innovations in higher education.

Material and Methods

A. Research Design

This study employed a pre-experimental design using a one-group pretest-posttest design, conducted over 30 days in August 2025, with training sessions spread over 4 days of synchronous sessions and 3 days of asynchronous sessions. This design was chosen based on the ethical consideration that all new lecturers in the Faculty of Engineering are entitled to comprehensive training, whilst also serving to assess the effectiveness of a digital platform-based flipped classroom in enhancing lecturers' competence in lesson preparation. This design compares changes in scores before and after treatment so that it can measure improvements that occur as a direct result of the learning intervention. Procedurally, the study was conducted in three main stages:

- assessing lecturers' initial abilities via a pre-test;
- providing an intervention comprising training and the implementation of the flipped classroom model using an integrated digital learning platform; and
- conducting a post-test to determine changes in competence following the intervention.

During the intervention stage, the training was systematically designed to strengthen lecturers' pedagogical competencies, particularly in the planning, development, and management of digital-based learning. The scope of the training material is presented in Table 1.

Table 1. Scope of the Digital Platform-Based Flipped Classroom Training Programme

No.	Topic	Sub-topic	Description
1.	Digital Classroom Management	a. Use of the Learning Management System (Moodle) b. Organisation of virtual classes (Google Classroom) c. Strategies for delivering digital content	Equipping lecturers with the skills to manage digital classrooms effectively, including the distribution of materials, the organisation of learning activities, and the management of interactions within an online environment.
2.	Development of Digital Learning Content	a. Content design principles (clarity, consistency, engagement) b. Development of video-based materials and digital modules c. Use of interactive tools	Developing lecturers' ability to design engaging learning content that supports students' independent learning during the pre-class phase.
3.	Development of Digital Learning Materials	a. Creation of visual materials (infographics, interactive presentations) b. Production of educational videos and audio	Enhancing lecturers' skills in creating varied and interactive learning materials to strengthen students' understanding.
4.	Development of Assessment Tools and Interactive Quizzes	a. Design of digital questions and assessment rubrics b. Development of interactive quizzes (formative and summative) c. Feedback strategies (automated and personalised)	Equipping lecturers with the ability to design effective digital-based assessments and provide prompt and meaningful feedback.

B. Research Sample

The population for this study consists of new lecturers at the Faculty of Engineering, University of Medan, with a sample size of 37. The sample was selected using purposive sampling, which was based on suitability to the research context, such as experience in online learning, the need for digital pedagogical competency development, and willingness to participate in the entire research process. The number of lecturers involved reflects the characteristics of the target population that need to strengthen their technology-based learning competencies. In addition, the selection of lecturers as research samples is important because they are the main actors in the application of learning innovations in higher education.

C. Research Procedure

This research procedure began with a preparation stage, which involved compiling and preparing all instruments, including pre-tests, post-tests, training guides, and digital learning modules used in the implementation of the flipped classroom model. These instruments were validated and adjusted to the research requirements in order to accurately measure lecturers'

competency levels. After the preparation stage was completed, a pre-test was conducted on the lecturers to measure their initial abilities before being given treatment. This pre-test served as a basis for comparison to assess the effectiveness of the learning model applied.

The next stage was the implementation of the treatment, which focused on training and assistance in implementing the flipped classroom model using a digital learning platform. At this stage, lecturers were given a comprehensive introduction to the concept of the flipped classroom, including its principles, learning flow, and implications for the vocational learning process. Next, lecturers were trained to use the Learning Management System (LMS) as a medium for managing materials, communication, evaluation, and documentation of learning activities. The researchers also guided lecturers in developing relevant digital materials, such as learning videos, interactive modules, and reading materials based on digital platforms. In addition, lecturers conducted hands-on practice in designing flipped classroom learning according to the courses they taught, enabling them to effectively integrate theory and practice. After the entire treatment series was completed, a post-test was administered to measure the increase in competence as a result of implementing the learning model.

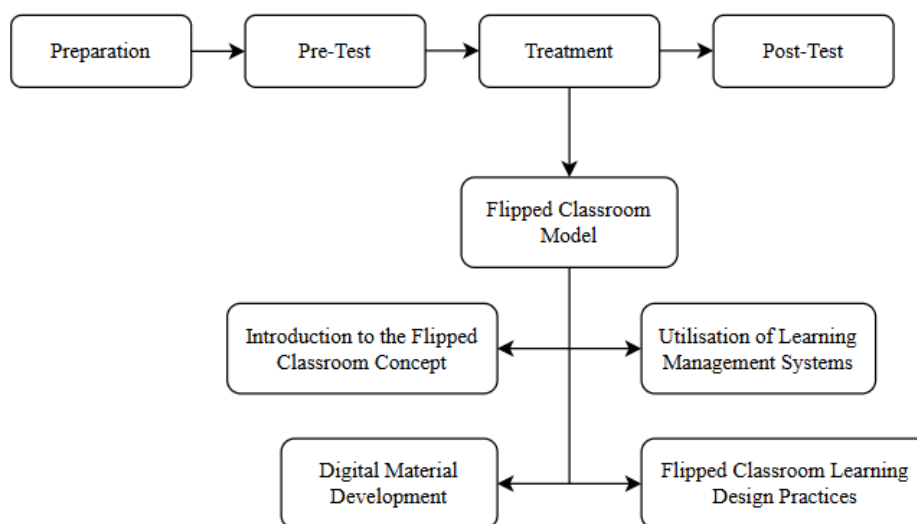


Fig. 1. Flipped Classroom Model Research Procedure

D. Data Analysis

The research data were analysed using a paired sample t-test, one-sample t-test, and N-gain test to evaluate the effectiveness of the treatment given. The paired sample t-test was used to determine whether there was a significant difference between the pre- and post-treatment scores. Through this test, it can be seen whether the implementation of a digital platform-based flipped classroom model has a real effect on improving lecturer competence. Furthermore, the one-sample t-test was used to compare the post-test average score with the minimum criteria score that had been set as the standard for learning success. If the post-test average was significantly higher than the reference value, it could be concluded that the learning model

implemented had met the expected quality. In addition, the N-Gain test was used to assess the level of competency improvement achieved after the treatment. This test provides a quantitative description of the effectiveness of the learning model, thereby facilitating the interpretation of the level of improvement experienced by participants.

Results and Discussions

A. Validity Test

The validity test results show that all items on the indicators of classroom management, content development, media development, and assessment and quiz instrument development have Pearson correlation coefficients that fall within the valid category. The correlation values (.169* ~ .715**) indicate that the instrument has a strong level of validity. This confirms that the statement items are able to measure the construct adequately. In the aspect of classroom management, the correlations ranged from (.236** ~ .664**) and were all significant, indicating stable and consistent validity. The aspect of content development also showed good validity with correlations between (.334* ~ .572**), reflecting that the indicators used were appropriate in explaining the dimensions measured. In terms of media development, the correlation values ranged from (.169* ~ .715**), with most items having moderate to high validity.

Similarly, the assessment and quiz development aspects showed correlations between (.236* ~ .689**), indicating that all indicators were suitable for use as representations of the construct. In addition, the reliability test results show that the instrument in the classroom management aspect has a reliability value of .812. This value is in the highly reliable category. Thus, the instrument can be used in measurements and produce data that has good measurement quality and is suitable for digital education research.

B. Paired Sample t Test

The results of the paired sample t-test show that there is a significant difference between the pretest and posttest scores. The average difference of -19.324 indicates that the posttest scores increased significantly compared to the pretest scores. This difference is supported by a standard deviation of 10.011 and a standard error of 1.646, which indicates the stability of the difference estimate. The 95% confidence interval is in the range of -22.662 to -15.986, all of which are in the negative region, thus strengthening the evidence that the improvement in learning outcomes after treatment did not occur by chance.

Table 2. Paired Sample t Test Results

	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference		t	df	Sig. (2-tailed)
				Lower	Upper			
PreTest - PostTest	-19.324	10.011	1.646	-22.662	-15.986	-11.741	36	.000

The statistical test yielded a t-value of -11.741 with degrees of freedom (df) = 36 and a significance value of ($p = .000$; $< .05$), which means that the difference before and after the treatment was statistically significant. Thus, it can be concluded that the learning intervention had a significant effect on improving student learning outcomes.

C. One-Sample t Test

The results of the one-sample t-test with a comparison value of 75 show that the pre-test scores were well below the expected value. This is indicated by a t-value of -10.159 with $p = .000$ ($p < .05$) and a mean difference of -12.838 . The 95% confidence interval ranges from -15.40 to -10.27 , all of which are negative values, indicating that the initial achievement of students is significantly lower than the established standard.

Table 3. One-Sample t Test Results

	t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
Pre-Test	-10.159	36	.000	-12.838	-15.40	-10.27
Post-Test	6.608	69	.000	6.214	4.34	8.09

Nb: Test Value: 75

Conversely, the post-test results showed a significant positive difference compared to the reference value. The t-value = 6.608 with $p = .000$ ($p < .05$) and a mean difference of 6.214 indicates that the post-test scores exceeded the standard value of 75. The 95% confidence interval ($4.34 - 8.09$), which is entirely positive, further confirms that the improvement in learning outcomes after the treatment is statistically significant.

D. N-Gain Test

The N-Gain analysis results show an average value of 0.5025, which is in the moderate improvement category. The 95% confidence interval is between 0.4263 and 0.5787, indicating that the estimated improvement in learning outcomes is within a relatively stable and reliable range. The interquartile range of 0.40 indicates moderate variation in improvement among participants. Overall, these results indicate that learning interventions provide consistent improvements in learning outcomes at a sufficiently effective level.

Table 4. N-Gain Test Results

	Mean	95% Confidence Interval for Mean		5% Trimmed Mean	Interquartile Range	Skewness	Kurtosis
		Lower Bound	Upper Bound				
N-Gain	.5025	.4263	.5787	.5085	.40	-.226	-.943

The implementation of the flipped classroom model with the support of an integrated digital learning platform in the context of vocational education provides important insights into the readiness, competence, and responses of lecturers in adapting technology-based

pedagogical innovations [1], [17]. Lecturers act as learning designers, instructional decision-makers, and facilitators of vocational competency development [18],[19]. Therefore, the effectiveness of digital models and systems depends not only on the quality of the material but also on pedagogical understanding, technological skills, and the ability of lecturers to manage the learning process professionally. The findings of this study indicate that the integration of the flipped classroom and digital platforms strengthens lecturers' capabilities in designing learning experiences that are more creative, efficient, and in line with the demands of 21st-century learning.

However, the improvement achieved remains moderate. This is understandable given that the research subjects were new lecturers who were still in the early stages of developing their pedagogical competencies. Although they are relatively more adaptable to digital technology, new lecturers generally still have limited experience in teaching, instructional design, and comprehensive classroom management. Consequently, the challenges faced lie not merely in technological barriers but in the integration of pedagogical understanding, content mastery, and the application of technology in effective teaching practice.

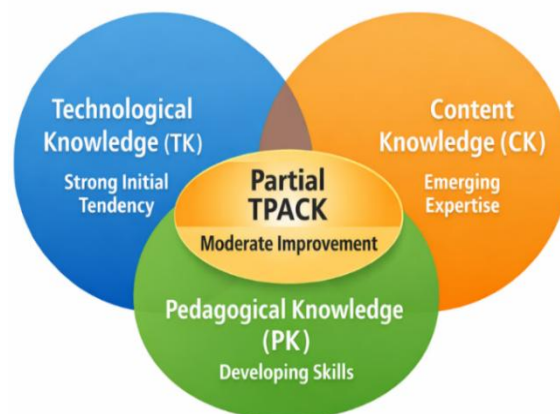


Fig. 2. Significant improvement in pedagogy with moderate effect size

When viewed through the TPACK framework in Figure 2, new lecturers tend to demonstrate initial strengths in the technology aspect, as reflected in their ability to utilise digital platforms. However, the pedagogical and learning content aspects are still at the developmental stage. Furthermore, the process of adapting to the flipped classroom model also requires time to establish new habits in designing pre-class activities, managing classroom interactions, and providing meaningful feedback. Research conducted by [20] indicates that the implementation of the flipped classroom requires an adaptation period before achieving optimal effectiveness, with improvements in teachers' competencies at the initial stage tending to be moderate. Furthermore, [21] emphasises that the success of integrating technology into learning is heavily influenced by pedagogical readiness, not merely technological proficiency. Thus, this study reinforces previous findings that the development of lecturers' competencies

through a technology-based approach is a gradual process requiring continuous experience and practice.

E. The Effectiveness of the Flipped Classroom Model in Developing Lecturers' Pedagogical Competence

The flipped classroom model has brought about significant changes in the way lecturers plan and implement learning [22]. This approach requires lecturers to develop digital teaching materials as prerequisite learning, before facilitating discussions, practices, or in-depth analyses in face-to-face sessions [23],[24]. This encourages lecturers to improve their skills in compiling digital content, designing instructional flow, and integrating multimedia-based independent learning strategies [25]. The results of the study show that lecturers are able to utilise the flipped classroom structure to improve the quality of student engagement in face-to-face learning. By providing materials in the form of videos, interactive presentations, or digital modules before meetings, lecturers become more focused on providing enrichment, clarification, and guidance in class activities. This model creates a more effective learning flow, where face-to-face time is no longer taken up by long lectures but is used for problem-solving activities, industry case analysis, or in-depth study of vocational concepts.

In addition, the implementation of the flipped classroom has been proven to assist lecturers in developing learning that is more adaptive to student needs [26],[27]. With the availability of pre-learning materials that can be accessed at any time, students have the opportunity to learn at their own pace and in their own learning style [28]. This allows lecturers to differentiate instruction during face-to-face activities, such as providing more intensive assistance to students who need it, while challenging students who already understand the material through advanced analytical tasks [29]. This approach not only enhances the effectiveness of classroom interactions but also strengthens an active learning culture and encourages students to develop greater learning independence, two competencies that are highly relevant to the demands of vocational learning in the digital age.

F. The Role of Integrated Digital Platforms in Supporting Lecturer Professionalism

Digital learning platforms contribute significantly to the successful implementation of the flipped classroom, particularly in terms of material management, evaluation, and academic communication [30],[31]. For lecturers, access to digital systems makes it easier for them to store materials, design quizzes, provide automatic feedback, and monitor student progress systematically [15], [32]. Research findings show that lecturers find features such as learning analytics, automated assessment, and cloud-based content storage helpful in improving their work efficiency. In addition to facilitating the management of learning administration, digital platforms also strengthen lecturers' ability to implement evidence-based teaching, which is the making of instructional decisions based on data on student learning activities [33]. The

integration of discussion forums, virtual meetings, and other collaborative features expands the space for academic interaction between lecturers and students. This flexibility is important in vocational education, which demands contextual learning, quick responses to student needs, and content adaptation to developments in industrial technology.

G. Technological Readiness and Active Participation of Lecturers

The implementation of the flipped classroom requires lecturers to be prepared in two main dimensions: digital literacy and pedagogical readiness. The results of the study show that lecturers in this context can adapt well to the use of digital platforms and the development of multimedia-based content. They demonstrate a high level of active participation in learning about LMS features, utilising digital evaluation tools, and managing online learning independently. Lecturers who have experience in learning show a more productive response to the use of technology, as they are accustomed to curriculum adjustments and innovative practices. In addition, self-regulated teaching that emerged from the adaptation of this model encouraged lecturers to be more reflective, innovative, and aware of developments in educational technology [34],[35]. Apart from increasing efficiency, this technological readiness has strengthened lecturers' digital professionalism, which has now become a mandatory competency in higher education.

The readiness of lecturers in implementing the flipped classroom is also reflected in their ability to manage the dynamics of face-to-face learning so that it is more student-centred [36]. After the material has been absorbed in advance through digital content, lecturers are able to shift the focus of learning to collaborative activities such as structured discussions, practical experiments, and contextual problem solving that are relevant to the needs of the field of expertise. This readiness shows that lecturers are able to transfer material to a digital format and design learning experiences that trigger high-level cognitive engagement. Thus, the flipped classroom does not merely change the distribution of learning time, but also improves the quality of pedagogical interactions through the facilitation of active learning, faster feedback, and the adjustment of instruction based on individual student needs [37],[38]. This confirms that strong pedagogical competence is essential to successfully implementing this model in higher education.

H. Strengthening Lecturers' Instructional Competence and Learning Design

One important finding is that the use of the flipped classroom model expands lecturers' ability to design more creative and student-centred learning [37], [39]. Lecturers no longer rely solely on verbal explanations but have begun to develop multimodal approaches such as animated videos, digital demonstrations, simulations, and interactive modules to explain technical concepts. The integration of technology makes it easier for lecturers to implement project-based learning strategies, case studies, and workplace simulations, which are relevant

in vocational education. With pre-learning materials, students enter the classroom with adequate basic knowledge so that classroom discussions are more in-depth and analysis-based [7], [40]. Lecturers also reported that the use of digital systems helped them conduct formative assessments more effectively, particularly through automatic quizzes, digital rubrics, and student error analysis. This shows that the flipped classroom not only changes the structure of learning but also improves the quality of assessment.

Conclusion

This study shows that the implementation of the flipped classroom model with the support of a digital learning platform is effective in improving the pedagogical competence and learning management skills of lecturers in the Faculty of Engineering. This model enables lecturers to make optimal use of digital materials before face-to-face meetings, so that classroom activities can focus on in-depth discussions, guidance on the application of concepts, and the resolution of more complex learning problems. The results of the paired sample t-test show a significant difference between initial abilities and abilities after training, while the one-sample t-test confirms that the final achievements of lecturers are above the competency standards set in the intervention. The moderate N-Gain value indicates that the improvement in lecturers' abilities is consistent and evenly distributed across various aspects of model mastery. The integration of digital platforms contributed significantly to improving lecturers' abilities in designing content, developing learning media, utilising online learning resources, and compiling digital evaluation instruments. In addition to improving classroom management efficiency, the use of digital platforms also strengthened lecturers' abilities to provide quick feedback, monitor student learning activities, and adapt teaching strategies more responsively to 21st-century learning needs. The application of the digital platform-based flipped classroom model has a positive impact on lecturers' readiness to adopt innovative learning approaches, improve the quality of learning interactions, and strengthen the integration of technology in vocational teaching practices. This model is recommended for wider application as a strategy for lecturer professional development in supporting the transformation of vocational education in the digital era.

Limitation and Suggestions

A key limitation of this study is the use of a one-group pretest–posttest design without a control group. The small sample size and the fact that the participants were drawn from a single faculty also constitute limitations of this study.

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Conflict of Interest

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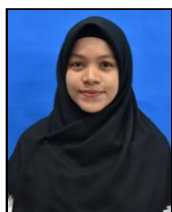
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