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# Unpacking the advantages and challenges of flipped classrooms in initial mathematics teacher education in Vietnam

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**Abstract**
The flipped classroom is an innovative pedagogical approach in which students are introduced to instructional content outside of class and engage in active problem-solving and discussions during in-class sessions. This pedagogical shift empowers students to take greater responsibility for their learning pace, transforming teachers into facilitators. Despite increased interest in flipped classrooms, their implications for mathematics teacher education still need to be clarified. This study employs a Delphi methodology to investigate the advantages and challenges associated with implementing the flipped classroom approach in Vietnam's initial mathematics teacher education. The findings reveal a high consensus among experts regarding the importance of the identified indicators related to the advantages and challenges of flipped classroom in initial mathematics teacher education. Our study also uncovers contextual and institutional constraints, providing insights into unique challenges within the Vietnamese context. This research offers guidance for improving initial mathematics teacher education through flipped classroom model.

**Keywords:** flipped classroom, mathematics teacher education, Delphi methodology, Vietnam

## INTRODUCTION

The flipped classroom is an innovative pedagogical paradigm that has inspired considerable interest due to its potential to reshape teaching and learning dynamics. At its core, the flipped classroom model transforms traditional learning by shifting the acquisition of lesson content to the home environment while reserving classroom time for collaborative problem-solving and interactive discussions (Bergmann & Sams, 2012; Yough et al., 2017). This departure from conventional teaching methodologies engages students more profoundly and empowers teachers to transform into facilitators of learning (Bergmann & Sams, 2012). A remarkable facet of the flipped classroom is its capacity to nurture self-directed learning, empowering students to govern their own learning pace (Lai & Hwang, 2016). Today, the flipped classroom model has been implemented in many different disciplines, schools, and universities worldwide (Hao, 2016).

Evidence from a series of studies suggests that the flipped classroom offers many positive educational outcomes. By reconfiguring the traditional learning sequence, these studies underscore the ability of flipped classrooms to enhance students' mastery of foundational knowledge and essential skills (Elmaadaway, 2018; Ng, 2018; Ng & Lai, 2012; Ng et al., 2013; Voigt et al., 2020). Beyond academic growth, the flipped classroom model enriches face-to-face discussions, stimulating student engagement and fostering satisfaction within the learning environment (Awidi & Paynter, 2019; Zainuddin, 2018).

However, alongside these promising outcomes, the literature highlights several challenges that accompany the implementation of the flipped classroom. Challenges encompass the temporal investment required for redesigning courses to align with the flipped approach (Schlairet et al., 2014). Moreover, students may have difficulty managing their time to follow out-of-class learning (Lai & Hwang, 2016), potentially compounded by deficits in self-regulated learning behaviors (Sun et al., 2017). Fung et al. (2021) conducted a literature review of flipped classrooms in mathematics education.


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**Contribution to the literature**

- Discovering the advantages and challenges faced by pre-service secondary mathematics teachers (PMTs) in university's flipped classroom settings using Delphi method was the most significant contribution of this study.
- Furthermore, this article illuminates the advantages and challenges confronted by mathematics teacher educators in flipped classroom environments.
- This research contributes to the growing body of knowledge concerning the advantages and challenges of the flipped classroom model, with a particular focus on its application in the initial mathematics teacher education in Vietnam.

Results revealed that the effect of flipped classrooms in enhancing students' academic performance is ambiguous. Although the flipped classroom is an effective alternative teaching and learning strategy, the evidence is still insufficient to conclude whether the flipped classroom is better than the traditional approach regarding students' academic performance. This synthesis underscores that flipped classroom, though replete with advantages, does not evade challenges.

Nevertheless, it is noteworthy that the substance of previous research has predominantly examined the implications of the flipped classroom on student learning. This examination, however, needs to encompass the nuances of initial mathematics teacher education, particularly in developing countries. Remarkably, the landscape remains bereft of studies delving into the perceptions and consensus of experts concerning the benefits and challenges of the flipped classroom within this specific domain. Understanding both the advantages and challenges of employing the flipped classroom method in mathematics teacher education will facilitate the effective implementation of this model in practice. This research gap necessitates a study of the viewpoints held by experts regarding the advantages and potential challenges of an effective flipped classroom implementation.

The Vietnamese education system has recently shifted towards the learner-centered education approach, whose central policy is the curriculum 2018. This reform emphasizes learner-based teaching strategies like flipped classrooms, particularly in higher education, heightened by the impact of the COVID-19 pandemic. Despite these efforts, effective implementation of the learner-centered education approach faces challenges, as noted by Ho and Dimmock (2023). The objective of this study is to characterize the advantages and challenges associated with the implementation of the flipped classroom within initial mathematics teacher education in Vietnam. Specifically, we address the following research questions:

1. What are the advantages and challenges of the flipped classroom for PMTs?
2. What are the advantages and challenges of flipped classroom for mathematics teacher educators?

## LITERATURE REVIEW

### Research on Flipped Classroom

The inception of the flipped classroom concept can be traced back to its initial application by Lage et al. (2000) and its subsequent popularization as an active teaching strategy by Bergmann and Sams (2012). These pioneering scholars introduced the flipped classroom paradigm as a dynamic pedagogical approach, wherein learners assume an active role in their knowledge acquisition process, thereby enhancing the interactive discourse and temporal engagement between students and teachers. The flipped classroom framework aims to equip learners not only with subject-specific knowledge but also with a range of generic skills such as collaboration, critical thinking, information technology proficiency, problem-solving abilities, and self-directed learning skills (Ng, 2018; Ng & Lai, 2012; Ng et al., 2013). In essence, the flipped classroom stresses a learner-centered teaching methodology that fosters comprehensive student involvement in the learning journey.

The flipped classroom model represents a pedagogical approach that restructures the traditional classroom dynamic by reallocating the in-class time typically used for essential knowledge delivery to out-of-class activities focused on knowledge application and homework tasks (Bergmann & Sams, 2012). This restructuring enables educators to engage students in more active learning experiences, including the practical application of learned knowledge through projects, discussions, problem-solving, and collaborative endeavors (Missildine et al., 2013). The out-of-class learning component primarily addresses lower-level cognitive processes related to knowledge recall and comprehension (Mason et al., 2013).

Extensive research on the flipped classroom approach consistently reports positive outcomes in terms of students' academic performance, skill development, and motivation (Cevikbas & Kaiser, 2020, 2023; Kong, 2015; McLaughlin et al., 2014; Murillo-Zamorano et al., 2019; Ng, 2018). According to McLaughlin et al. (2014), the flipped classroom methodology fosters a deeper understanding of subject matter and concepts, with students expressing that the

acquired knowledge and skills hold value for their future works. In the context of higher education, Murillo-Zamorano et al. (2019) affirm that flipped classrooms have a positive impact on students' knowledge acquisition, skill development, and engagement. Cevikbas and Kaiser (2023) undertook a thorough examination of studies concerning the adoption of flipped mathematics instruction during the pandemic and beyond. Their findings indicate that the flipped classroom approach holds great promise in enhancing mathematics teaching and learning, yet it also poses notable challenges. In essence, to ensure the resilience of mathematics education in times of crisis, lessons from the pandemic must be considered.

The advantages and challenges associated with the flipped classroom approach for both students and instructors have been investigated by Akcayir and Akcayir (2018). The most reported advantage of the flipped classroom model is its potential to enhance student learning performance. Researchers have also identified various other benefits, including increased learning motivation, positive student attitudes, and the development of critical skills. However, the model also presents specific challenges, as highlighted by Pinnelli et al. (2016). These include concerns about the quality of out-of-class resources, students' classroom preparation, and their technological competencies for effective engagement with the flipped classroom approach.

A pivotal aspect emphasized by Pinnelli et al. (2016) underscores the role of the flipped classroom in democratizing knowledge dissemination. The flipped classroom transcends temporal and spatial constraints by allowing students to access instructional content at their own convenience. This flexibility empowers students to engage with lecture materials from any location and any time before in-person class interactions. As a result, during classroom sessions, students are free to participate actively in discussions, express their viewpoints, and collaboratively share knowledge.

A systematic review of the literature conducted by Akcayir and Akcayir (2018) identified several challenges associated with the flipped classroom model, primarily linked to out-of-class activities. Notably, the quality of resources for out-of-class activities, inadequate student preparation, interaction tools, and technological competencies are potential barriers to implementing the flipped classroom effectively. In mathematics, the work of Fung et al. (2021) emphasizes that the effect of flipped classrooms in enhancing students' academic performance and perception is still an issue. Using a systematic review, these authors assert that the evidence is still not strong enough to conclude whether a flipped classroom is better than a traditional one regarding students' academic performance and perception.

While significant progress has been made in comprehending the advantages and challenges of the flipped classroom method, certain aspects still lack clarity, notably the influence of this approach on students' academic performance (Fung et al., 2021). There is a call for additional research into the implementation of the flipped classroom, paying attention to contextual and subject-specific factors to gain a deeper understanding of both the benefits and challenges associated with this instructional model. Han et al. (2024) suggest that future studies should address various subject disciplines, including participants from several teacher education programs, and examine the long-term effects of implementing flipped classrooms.

## Flipped Classroom in Initial Teacher Education

The flipped classroom methodology holds significant promise in teacher education by exemplifying pedagogical approaches that foster active and collaborative learning paradigms (Vaughan, 2015). Despite its potential, the implementation of flipped classrooms within teacher education contexts has been the subject of limited empirical investigation (Yough et al., 2017). Using a flipped teaching model in a pre-service teacher education course, Vaughan (2015) highlights that students engaged in flipped classrooms exhibit heightened ownership of their learning, an increased tendency for creativity during instructional activities, and an enhanced capacity to apply acquired knowledge. This distinction was substantiated through a comparative analysis by Fraga and Harmon (2014), revealing that pre-service teachers in flipped classroom environments reported high confidence levels in specific pedagogical facets and a greater inclination to engage in discussions within the learning environment when compared with their peers in traditional classroom setups.

Further examination encompassed pre-service teachers' perceptions of flipped classrooms and their increased use of technology. For instance, Hao and Lee (2016) investigated pre-service teachers' concerns during the phases of transitioning to a flipped classroom model. The study surveyed 502 pre-service teachers' concerns about teaching with flipped learning instruction in a teacher education university in Taiwan. The outcomes revealed that concerns associated with considering the consequences to students learning and refocusing practices were moderately correlated with self-efficacy in instructional strategies, classroom management, and student engagement. Similarly, Unruh et al. (2016) conducted a survey encompassing six educators, examining their use of technology, instructional efficacy, technological comfort, and attitudes toward technology. The survey and interview data were collected from a matched sample of in-service teachers representing both flipped and traditional class models from a large suburban southeastern Texas school district. The findings elucidated those educators adopting the flipped classroom model attained significantly higher scores

across all metrics than those adhering to conventional teaching methods. The authors suggested that technology in flipped classrooms must be supportive, increasing perseverance in the learning process.

In a recent study, Han et al. (2024) investigated how pre-service teachers perceive the flipped classroom. They collected data through surveys and focus group interviews with pre-service teachers specializing in English as a foreign language in Norway. The findings revealed that most participants viewed the flipped classroom as an effective teaching method, particularly because it optimizes class time. Additionally, the study identified five challenges associated with the flipped classroom: accountability for pre-service teachers' preparation, different student teachers' preparation, delayed question responses, increased workload for student teachers, and high demand for teacher educators. The authors also proposed that the flipped classroom could serve as a valuable pedagogical approach during pandemics or other critical situations, where remote teaching becomes an alternative to traditional in-person instruction.

Yough et al. (2017) used a quasi-experimental design to examine differences in motivation and objective learning outcomes between traditional and flipped sections of a foundational educational course. Evidently, pre-service teachers in the traditional section demonstrated superior scores in intrinsic and identified regulatory aspects of motivation. Conversely, students within the flipped sections achieved notably higher scores across several dimensions of objective learning outcomes. Consequently, while the flipped classroom model has been frequently associated with enhancing student motivation, the findings of Yough et al. (2017) disputed this notion, emphasizing that a mere shift in instructional approach is insufficient. The authors contended that a purposeful and deliberate refinement of the design and implementation of the flipped classroom is imperative to support student motivation effectively.

Ng (2018) took a more specific stance by investigating the effectiveness of the flipped classroom paradigm, aligned with the principles of self-regulated learning, in enhancing constructive learning outcomes for seventy-three university students enrolled in a teacher education program. All the participants had completed their secondary school education and had no full-time work experience. The findings endorsed the efficacy of flipped classroom activities, demonstrating a highly favorable response from students. Diverse pedagogical, instructional, and evaluative strategies were employed, aligning with the seven fundamental principles of promoting and nurturing students' self-regulated learning.

Despite these insightful investigations, a discernible gap remains in the scholarly inquiry of flipped classrooms within the domain of teacher education, particularly within the context of initial mathematics teacher preparation. While some researchers have examined the potential advantages and challenges of implementing the flipped classroom methodology for teaching mathematics in university settings, there is a lack of research that delves into the perceptions and experiences of experts within the field, particularly in the context of developing countries. Clarifying the challenges of the flipped classroom approach will help mathematics teacher educators make informed decisions about implementing flipped classrooms in their teaching practice.

## RESEARCH METHODOLOGY

This research employed the Delphi method to establish a consensus among subject matter experts concerning the benefits and challenges associated with implementing the flipped classroom approach within the context of initial mathematics teacher education in Vietnam. The Delphi technique, introduced by Goodman (1987), is a qualitative method designed to facilitate group decision-making and discourse without necessitating physical meetings. This method facilitates the convergence of expert opinions on specific principles or knowledge domains by administering iterative surveys until consensus is reached (Hasson et al., 2000; Manizade & Mason, 2011). By incorporating multiple rounds of survey revisions and feedback mechanisms, experts can refine their judgments considering the collective perspectives of the group (Clark, 2006; Dressel et al., 2007). This methodology has found applications across various domains, including mathematics education (Manizade & Mason, 2011) and technology competency (Fong et al., 2013).

### Pre-Delphi Construction of Potential Indicators

To put the foundation for the Delphi process, an exhaustive review of existing literature concerning the use of flipped classrooms in initial teacher education was conducted. This study focused on identifying the advantages and challenges inherent in employing the flipped classroom model in initial mathematics teacher education settings. From this review, potential indicators relevant to the advantages and challenges of the flipped classroom model were discerned. These indicators served as the building blocks for the initial survey designed for expert participants.

### Study Participants

The selection of expert participants adhered to specific criteria: participants needed to be mathematics teacher educators who possessed practical experience in using flipped classrooms to teach mathematics at the university level. The study comprised a panel of thirteen Vietnamese experts.

**Table 1.** Summary of experts' characteristics

| Age | Years of teaching experience | Years of flipped classroom experience | Discipline | Teacher education institution |
|---|---|---|---|---|
| 33-36 (5) | 5-10 (3) | 1-3 (3) | Mathematics | Hue University of Education (5), Tay Nguyen University (1), Quy Nhon University (1), Da Nang University of Education (2), Ho Chi Minh City University of Education (2), & Other institutions (2) |
| 37-40 (7) | 11-15 (5) | 4-6 (5) | | |
| More than 40 (1) | 16-20 (5) | 7-10 (5) | | |

Note. Number in each parenthesis is corresponding number of experts

### Data Collection & Analysis

In the initial round (round 1), a set of indicators grounded in the literature review was extracted, encompassing both the advantages and challenges of the flipped classroom model in initial teacher education. To refine these indicators, a series of face-to-face meetings were conducted with an expert. The resulting preliminary indicator set comprised 20 indicators aligned with the advantages of flipped classrooms for PMTs, five indicators related to the challenges faced by PMTs, six indicators associated with the advantages for mathematics teacher educators, and five indicators regarding the challenges encountered by mathematics teacher educators. Subsequently, this indicator set was deployed via Google Forms to the panel of 13 Vietnamese experts. **Table 1** shows a summary of experts' characteristics.

In the subsequent round (round 2), the experts evaluated all indicators, assessing their importance through a 5-point Likert scale: (1) strongly disagree, (2) disagree, (3) partly agree, (4) agree, and (5) strongly agree. Experts were also allowed to propose modifications to the indicators to more precisely address the nuances of advantages and challenges posed by the flipped classroom approach. Moreover, experts could give supplementary comments on the indicators. The collected responses were processed and quantitatively analyzed. The median value of the group's responses served as the benchmark for determining the degree of importance attributed to each indicator. This importance was categorized into high (median value of four and above) and medium (median value below four). The degree of consensus was gauged using the quartile deviation, categorized into three levels: high, medium, and no consensus. A high consensus was indicated if the quartile deviation was 0.5 or less, medium consensus lay between 0.5 and one, and no consensus was evidenced if the quartile deviation exceeded one. The qualitative assessment of experts' opinions further contributed to the construction of indicators, elucidating their significance and consensus. In instances, where indicators demonstrated high importance and consensus levels, they were utilized to formulate a comprehensive set of indicators detailing the benefits and challenges of the flipped classroom approach.

For the subsequent round (round 3), we interviewed three experts to reaffirm the indicators that achieved high consensus with high importance in round 2. We also interviewed these experts for indicators that achieved a medium or no consensus to seek further explanations. Insights gathered from interviews with these experts were qualitatively analyzed. Furthermore, prior to formulating the survey distributed during round 2, the consensus achieved in round 1 was evaluated. The attainment of consensus in round 2 signified the successful groundwork posed in round 1. This validation of reliability is aligned with the guidelines by Fish and Busby (2005).

## FINDINGS

### Advantages & Challenges of Flipped Classroom for Pre-Service Secondary Mathematics Teachers

In this section, we analyze the advantages and challenges of the flipped classroom model for PMTs. The outcome of this analysis, indicating high significance and consensus of specific indicator statements concerning the advantages of flipped classrooms, is presented in **Table 2**.

#### *Advantages*

The indicators identified in **Table 2**, which achieved both substantial importance and consensus, shed light on the advantageous aspects of flipped classrooms concerning the enhancement of students' knowledge. These indicators achieved a median value of four or higher and a quartile deviation value of less than or equal to 0.5.

In total, we found 11 indicators related to the advantages of the flipped classroom for PMTs. These indicators were clustered under three distinct categories:

1. PMTs' knowledge,
2. PMTs' skills, and
3. PMTs' attitudes.

Based on the indicators in **Table 2**, the findings indicated that consensus is emphasized on PMTs' skills and attitudes when participating in a flipped classroom. The data presented in **Table 2** clearly illustrates the consensus among experts regarding the beneficial effects of the flipped classroom approach on the skills and attitudes of PMTs. Specifically, this pedagogical method is seen to enhance several key skills, as follows:

**Table 2.** Indicators of advantages of flipped classroom for PMTs

| Codes | Indicators | Median | Q1 | Q3 | IQR | QD |
|---|---|---|---|---|---|---|
| PMTs' knowledge | | | | | | |
| K1 | PMTs acquire more profound knowledge because they have more favorable conditions to search for learning materials & more diverse resources. | 4.50 | 4.00 | 5.00 | 1.00 | 0.50 |
| K2 | PMTs can study at their own pace with flexible times. | 5.00 | 4.00 | 5.00 | 1.00 | 0.50 |
| PMTs' skills | | | | | | |
| S1 | Promote teamwork & collaborative skills | 4.00 | 4.00 | 5.00 | 1.00 | 0.50 |
| S2 | Promote communication & discussion skills | 4.00 | 4.00 | 5.00 | 1.00 | 0.50 |
| S3 | Promote ICT skills | 4.50 | 4.00 | 5.00 | 1.00 | 0.50 |
| S4 | Promote problem-solving & posing skills | 4.00 | 3.25 | 4.00 | 0.75 | 0.38 |
| S5 | Promote self-study skills | 5.00 | 4.00 | 5.00 | 1.00 | 0.50 |
| PMTs' attitudes | | | | | | |
| A1 | Promote PMTs' self-confidence in learning activities | 4.00 | 3.25 | 4.00 | 0.75 | 0.38 |
| A2 | Promote PMTs' engagement in learning activities | 4.00 | 3.25 | 4.00 | 0.75 | 0.38 |
| A3 | Promote PMTs' readiness to participate in learning activities | 4.00 | 3.00 | 4.00 | 1.00 | 0.50 |
| A4 | Promote PMTs' creative attitude | 4.00 | 3.00 | 4.00 | 1.00 | 0.50 |

**Table 3.** Indicators of challenges of flipped classroom for PMTs

| Codes | Indicators | Median | Q1 | Q3 | IQR | QD |
|---|---|---|---|---|---|---|
| C1 | PMTs do not have a self-learning awareness & a motivation to learn. | 4.00 | 4.00 | 5.00 | 1.00 | 0.50 |
| C2 | PMTs do not have enough technological facilities to learn (Internet, laptop, etc.). | 3.00 | 3.00 | 4.00 | 1.00 | 0.50 |
| C3 | PMTs have difficulties in communicating with instructors in out-of-class activities. | 4.00 | 4.00 | 5.00 | 1.00 | 0.50 |

1. **Teamwork and collaborative skills:** The flipped classroom fosters the development of PMTs' abilities to work effectively within a team and engage in collaborative activities.
2. **Communication and discussion skills:** PMTs are observed to enhance their communication and discussion skills because of the flipped classroom approach, facilitating better interaction and dialogue.
3. **Information & communication technology (ICT) skills:** The use of ICT tools and resources in the flipped classroom setting equips PMTs with essential digital skills, augmenting their proficiency in this domain.
4. **Problem-solving and posing skills:** The flipped classroom promotes PMTs' capabilities in both problem-solving and the formulation of mathematical questions, contributing to their overall problem-solving skills.
5. **Self-study skills:** Through this approach, PMTs acquire and improve their self-study skills, encouraging independent learning and research.

Experts strongly agreed on two PMTs' knowledge-related indicators, while four others achieved a moderate consensus. These four indicators were, as follows:

1. PMTs have better learning outcomes,
2. PMTs have a deeper understanding of the lesson,
3. PMTs have a better problem-solving performance, and
4. PMTs learn better because it is easy to discuss and give feedback to instructors.

This consensus distribution highlights the ongoing uncertainty regarding the flipped classroom's holistic impact on PMTs' knowledge.

### *Challenges*

Regarding the challenges, **Table 3** encapsulates items that achieved high or moderate importance levels and a substantial consensus among experts regarding the obstacles associated with flipped classrooms for PMTs. These items attained a median value of four or higher while maintaining a quartile deviation value below or equal to 0.5.

Our investigation revealed a strong consensus among the panel of experts concerning three primary challenges in the context of flipped classrooms. The first challenge pertains to the self-learning awareness and motivation of PMTs. The second challenge involves the availability of technological facilities, which is problematic in developing countries like Vietnam. The third challenge lies in the complexity of fostering effective mathematical communication with instructors during out-of-class activities. These challenges underscore the importance of adequate technological infrastructure for successful flipped classroom adoption in teacher training, particularly in the context of initial teacher education programs in developing countries. The third challenge underlines the unique considerations related to mathematics education when implementing the flipped classroom approach in teacher training.

In conclusion, our findings highlight the advantages and challenges inherent in the flipped classroom model for PMTs. These insights provide a multifaceted perspective on the potential benefits as well as the

**Table 4.** Indicators of advantages of flipped classroom for mathematics teacher educators

| Codes | Indicators | Median | Q1 | Q3 | IQR | QD |
|---|---|---|---|---|---|---|
| AL1 | Feel free to support PMTs' learning | 4.00 | 4.00 | 5.00 | 1.00 | 0.50 |
| AL2 | Be more active in teaching | 4.00 | 4.00 | 5.00 | 1.00 | 0.50 |
| AL3 | ICT skills are enhanced. | 4.00 | 4.00 | 5.00 | 1.00 | 0.50 |
| AL4 | Pedagogical skills are enhanced. | 4.00 | 4.00 | 4.75 | 0.75 | 0.38 |
| AL5 | Classroom data is managed in a better way. | 4.00 | 3.00 | 4.00 | 1.00 | 0.50 |

**Table 5.** Indicators of challenges of flipped classroom for mathematics teacher educators

| Codes | Indicators | Median | Q1 | Q3 | IQR | QD |
|---|---|---|---|---|---|---|
| CL1 | It takes more time to prepare lessons compared to traditional teaching approaches. | 5.00 | 4.00 | 5.00 | 1.00 | 0.50 |
| CL2 | It takes much mental power to prepare lessons compared to traditional teaching methods. | 5.00 | 4.00 | 5.00 | 1.00 | 0.50 |
| CL3 | It requires proficient use of technology tools compared to traditional teaching approaches. | 4.00 | 4.00 | 5.00 | 1.00 | 0.50 |

difficulties associated with adopting the flipped classroom approach within initial mathematics teacher education in Vietnam.

## Advantages & Challenges of Flipped Classroom for Mathematics Teacher Educators

### *Advantages*

In this section, we present the key findings derived from expert consensus on the advantages and challenges of the flipped classroom for mathematics teacher educators. **Table 4** outlines the specific items that achieved substantial importance levels, coupled with a high degree of consensus, underscoring the benefits of the flipped classroom for mathematics teacher educators. Notably, these items attained a median rating of four or higher, demonstrating a high degree of agreement among respondents. Furthermore, the quartile deviation, a measure of dispersion, was consistently 0.5 or less, accentuating the convergence of opinions within the expert panel.

The consensus among experts highlights some key advantages of the flipped classroom in the context of initial mathematics teacher education. Firstly, this approach promotes a sense of instructional freedom among mathematics teacher educators, enabling them to provide more tailored support for PMTs, while taking on a more proactive role in teaching. Moreover, it facilitates the streamlined management of classroom data, enhancing efficiency and convenience in the teaching process. Additionally, the flipped classroom is instrumental in encouraging the technology skills of mathematics teacher educators. These advancements in technology skills enable them to harness technology more effectively in their teaching. Furthermore, their pedagogical skills are enhanced, resulting in more refined and effective teaching strategies.

Within the domain of advantages, all five indicators presented in **Table 4** collectively contribute to an augmented consensus about the pedagogical abilities and classroom management skills of mathematics teacher educators. These indicators collectively underscore a robust agreement on the transformative potential of the flipped classroom model. Importantly, none of the indicators assessed during the initial survey round achieved a moderate consensus, affirming the flipped classroom's prominent role in enhancing teaching methodologies for mathematics teacher educators.

### *Challenges*

Turning our attention to challenges inherent in the flipped classroom paradigm, **Table 5** outlines the indicator statements that acquired considerable importance ratings, accompanied by a substantial consensus level. As observed with advantages, these items attained a median score of four or higher, with a quartile deviation was 0.5 or less, signifying a harmonized perspective among the experts.

Of note, three challenges enumerated in **Table 5** achieved a robust consensus among the expert panel. These main challenges are, as follows:

(1) taking more time to prepare lessons compared to traditional teaching approaches,

(2) taking much mental power to prepare lessons compared to traditional teaching approaches, and

(3) requiring proficient use of technology tools compared to traditional teaching approaches.

These three indicators prominently revolve around the allocation of time, cognitive resources, and proficiency in information and communication technologies, requisites that mathematics teacher educators must navigate when adopting the flipped classroom approach. These challenges resonate as shared obstacles encountered by teacher educators across disciplines when embracing the flipped paradigm.

Additionally, two indicators attained a high consensus with moderate importance. The first indicator highlights the potential mismatch between the flipped classroom and the nuances of teaching university-level mathematics. The second indicator underscores the unease experienced by mathematics teacher educators when tasked with the transition from traditional teaching methods to the flipped approach. These two

indicators spotlight domain-specific intricacies and apprehensions that emerge when integrating the flipped classroom model into university-level mathematics education. The consensus within the expert panel echoes a collective recognition of the challenges associated with implementing the flipped classroom approach within university mathematics education.

### Qualitative Insights

To enhance the rigor and clarity of our qualitative analysis, we interviewed three experts among thirteen participating in this research. These three experts (denoted as Mrs. MTE1, Mrs. MTE2, and Mr. MTE3, respectively) were chosen based on their expertise in the subject matter, and their perspectives served to validate and augment the indicators that emerged as having both high consensus and significance during round 2 of our analysis.

During these interviews, an agreement was observed among the experts regarding the indicators that achieved high consensus and importance. This not only reinforced the credibility of these indicators but also added depth to our understanding of their relevance within the context of our study. Furthermore, we sought to delve deeper into indicators that achieved only moderate or lacked consensus. These exploratory discussions aimed to uncover nuanced explanations for these indicators.

For instance, Mrs. MTE1 articulated her viewpoint on the advantages of the flipped classroom model. This mathematics teacher educator found five such indicators of the advantages of the flipped classroom for mathematics teacher educators consistent with their teaching practice. Among these, the flexibility for teaching and learning to transcend temporal and spatial boundaries was highlighted. Additionally, the expert underscored how the flipped classroom approach motivated teacher educators to innovate their pedagogical techniques, fostering the development of higher order thinking and problem-solving skills and enhancing students' communication abilities. This expert drew a connection between the flipped classroom model and the evolving education setting, particularly after the COVID-19 pandemic.

> "I find five such indicators of the advantages of the flipped classroom for mathematics teachers' educators consistent with practice. In addition, teaching and learning can take place anytime, anywhere. Teachers are motivated to innovate teaching methods and promote higher-order thinking, problem-solving, and students' communication skills. In particular, the flipped classroom model aligns with the trend of teaching in universities after the COVID-19 pandemic" (Mrs. MTE1).

Conversely, Mrs. MTE2 shared her perspective on the challenges inherent in the flipped classroom model. This expert elucidated that such three distinct indicators involving the challenges of flipped classrooms for mathematics teacher educators are reasonable, drawing from her own experiences with traditional teaching methods. The expert highlighted the prevailing inclination among mathematics teacher educators to adopt a conventional lecture-style format for teaching mathematics to larger groups. Consequently, transitioning to the active learning paradigm of the flipped classroom presented a challenge for mathematics educators.

> "Three indicators of such flipped classroom challenges are reasonable and consistent with my own experience with the flipped classroom model. In addition, most mathematics teacher educators are used to teacher-centered traditional mathematics teaching methods in a traditional classroom with many students. Therefore, transitioning to an active teaching model like a flipped classroom is also challenging for mathematics teacher educators" (Mrs. MTE2).

Another expert, Mr. MTE3, echoed the sentiment that the advantages and challenges associated with the flipped classroom model were comprehensive. He attested that he frequently encountered these issues while implementing this model to PMT education.

> "The advantages and challenges of the flipped classroom model like yours are quite exhaustive. These are generally the problems that I often encounter when implementing this model in training prospective mathematics teachers" (Mr. MTE3).

In summary, our qualitative analysis, enriched by the insights of these three expert interviews, provides a refined understanding of the indicators that achieved consensus and significance, as well as the nuanced perspectives surrounding indicators that received moderate or no consensus. These analyses validate the credibility of our findings and illuminate the complex interplay between flipped classroom model, pedagogical practices, and the evolving educational landscape.

## DISCUSSION

The primary aim of this study involves the discernment and elucidation of the advantages and challenges inherent in implementing the flipped classroom approach within the initial mathematics teacher education in Vietnam. To address this inquiry, the Delphi method was used to facilitate the aggregation of expert opinions and reach a consensus on the salient dimensions of the implications arising from the flipped classroom paradigm.

Upon the end of round 1, we identified twenty indicators encapsulating the advantageous facets, juxtaposed with four indicators spotlighting the challenges of the flipped classroom model for PMTs. Regarding the advantages and challenges of the flipped classroom for mathematics teacher educators, a discernible assemblage of ten indicators emerged, shedding light on both advantages (five indicators) and challenges (five indicators).

As we investigated the result of round 2, a subset of fourteen indicators emerged, marked by a confluence of significance and a consensus threshold of 70%. Notably, it is interesting to note that, among these fourteen indicators, there are twelve indicators involving PMTs' skills and attitudes, and only two involving PMTs' knowledge. This trend underscores the transformative potential that the flipped classroom model has over PMTs' skills and attitudes. This assertion aligns with the observations presented by Murillo-Zamorano et al. (2019), who expounded on the constructive influence of the flipped classroom on university students' competencies, cognitive aptitudes, and overall engagement. This result also shares with the findings of Fraga and Harmon (2014) that pre-service teachers in flipped classroom environments reported high confidence levels in pedagogical skills and a greater inclination to engage in classroom discussion.

However, it is important to emphasize an aspect of our findings pertaining to four specific indicators associated with PMTs' knowledge. These indicators achieved a moderate consensus level among our expert panel. This consensus echoes prior research findings, such as those by Fung et al. (2021), which have demonstrated that the impact of flipped classrooms on students' academic performance and perceptions remains uncertain. The consistent ambiguity in these findings emphasizes the need for further investigations into the extent of the flipped classroom's influence on the academic achievements of university students, as previously suggested by Akcayir and Akcayir (2018). Additional research efforts are necessary to comprehensively elucidate the implications of the flipped classroom model in higher education settings.

Challenges of flipped classrooms were no less noteworthy, with the collective viewpoint of the expert panel converging strongly on obstacles encompassing PMTs' self-learning awareness, the availability of technological facilities, and the dynamics of mathematical interactions during out-of-class activities. Significantly, a particularly distinctive challenge arose in the context of mathematics education. The expert panel underscored the difficulty of one-to-one mathematical interactions between teacher educators and PMTs in out-of-class environments, mainly related to the content and complexity of mathematical symbols during the interaction. Pinnelli et al. (2016) highlighted the issue of ensuring the quality of out-of-class resources for a successful implementation of the flipped classroom model. Our research further accentuates this challenge by pinpointing obstacles related to the quality of interactions during these out-of-class activities. Specifically, given the nature of mathematics lessons, which often involve complex formal symbols, these obstacles become particularly evident and are widely acknowledged by the experts in our study. Additionally, Pinnelli et al. (2016) mentioned students' technological proficiency as difficult for effective engagement with flipped classrooms. This challenge also received a high level of consensus among the experts in our research. They emphasized the limitations posed by technological infrastructures, especially in the Vietnamese context, which complicates the implementation of flipped classrooms for teaching and learning.

Our research reveals that Vietnamese mathematics teacher educators face several challenges when implementing the flipped classroom model. These include the time required for course preparation, the mental effort needed to adapt lessons, the necessity of technological proficiency, and the discomfort of shifting from traditional teaching methods. This aligns with Ho and Dimmock's (2023) observation that despite recent reforms favoring learner-centered education, Vietnamese educators still essentially control the content, pace of learning, and classroom activities. Transitioning to learner-centered approaches like the flipped classroom requires gradual adjustment and support through professional development to enhance teachers' understanding and skills.

## CONCLUSIONS

In conclusion, our study has provided empirical evidence to evaluate the advantages and challenges inherently associated with adopting the flipped classroom paradigm within the Vietnamese context of initial mathematics teacher education. This result shares common advantages and challenges of the flipped classroom, as suggested by Akcayir and Akcayir (2018), and highlights the advantages and challenges that are specific to mathematics and the Vietnamese context.

Our research has discerned distinct indicators about the benefits and challenges associated with the adoption of the flipped classroom approach within initial mathematics teacher education. We have systematically categorized these advantages and challenges into two main categories: those affecting PMTs and those affecting mathematics teacher educators. The findings of our study constitute an addition to the existing body of knowledge surrounding the advantages and challenges of the flipped classroom model, particularly within the context of training prospective mathematics teachers.

Our study offers recommendations for integrating flipped classrooms into initial mathematics teacher education in Vietnam. Firstly, mathematics teacher

educators should allocate sufficient time for course preparation and transitioning to a flipped classroom structure. Additionally, the availability and proficiency in utilizing technology tools should be ensured. Secondly, emphasis should be placed on enhancing self-directed learning among pre-service teachers and fostering interactive dynamics during out-of-class activities.

Methodologically, the selection of the Delphi method has served as an appropriate choice in achieving our research objectives, specifically in the careful measurement of indicators and the attainment of consensus thresholds. However, it is imperative to acknowledge certain limitations. Although well-qualified, the panel of appointed Delphi experts remains finite, potentially influencing the comprehensiveness of the insights gained. Moreover, using three-round surveys may not be sufficient and needs further exploration, especially concerning indicators that attained a moderate consensus level. Future research could potentially bridge these gaps and offer a more holistic understanding of the advantages and challenges of the flipped classroom in initial mathematics teacher education in Vietnam.

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