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Transforming Teaching with ICT Using the Flipped Classroom Approach: Dealing with COVID-19 Pandemic

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Abstract: During the COVID-19 pandemic, educators changed their pedagogic practices, developed new teaching sequences, and blended learning approaches such as the flipped classroom. Claims have been made that the flipped classroom influences student motivation, enhances active engagement and class participation, and improves academic performance. Three teacher educators were invited to develop flipped instructional materials for chemistry teacher education. The materials included course plans, online videos, tasks, teaching, and online and face-to-face instruction learning sequences. This study examined opportunities and barriers to using the flipped classroom approach for chemistry teaching. Teacher educators were interviewed before and after running the course using the developed instructional materials. The interviews were then analyzed to identify the teachers' rationale, the opportunities, and the challenges of using the flipped classroom. Teacher educators found that integrating technology into their classrooms can enhance their ICT skills and that of their students. Educators believed flipped instructions could promote student-centered learning where students take responsibility for their learning, where and when it is most convenient. The teacher educators perceived that the approach helped students take an active role in their learning and enhance their participation. They also felt that it improved academic performance. Teacher educators also noted that their workload was reduced, and they had more time to interact with students. Some barriers and challenges were recognized as well. In the interviews, teacher educators described how ICT competencies and inadequate ICT infrastructures, such as poor internet connectivity and lack of ICT equipment, limited the use of the flipped classroom approach. The study provides suggestions for future research that can contribute to understanding the practical application of the flipped classroom approach.



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1. Introduction

The COVID-19 pandemic has resulted in changes in educators' pedagogic practices as schools and universities have struggled to provide good teaching and learning opportunities for teachers and students [1]. One response to this change was the increased emphasis on ICT usage [2]. In Ghana, a government policy on ICT for Accelerated Development (ICT4AD) outlined a framework to facilitate the utilization of ICT for "all students to acquire basic ICT skills to learn" [3]. This policy focused on making ICT a teaching and learning tool for e-learning for future transformation [4,5]. However, the policy failed to achieve its goals due to a lack of institutional support [6,7], inefficiency in the ICT policy design [8–10], teachers' lack of ICT competencies [11,12], and inadequate ICT infrastructure [13–15].

During the pandemic, there was an explosion in blended learning opportunities as online options increased steadily, and there was a need to use face-to-face time more efficiently [16,17]. A flipped classroom approach is a reformed blended learning approach

to engage and facilitate students learning using technology [18]. Many tertiary institutions have encouraged their faculty to continue developing the flipped classroom approach, making educators to use new digital technologies to change classroom practices [19].

Flipped classroom involves students viewing video materials before class and engaging in active face-to-face discussions in the classroom [20,21]. According to [18,22], the flipped classroom is a teaching reform that enables educators to change their teaching using technology. To [23], the flipped classroom approach involves “the use of technology to provide audio-visual learning materials to students to prepare for a class time” (p. 17). Students’ pre-existing knowledge makes face-to-face learning more active, increasing learning quality [24]. Students’ pre-class learning help improve the quality and quantity of teacher-student interaction in class [25]. In the flipped classroom, educators guide students to engage in interactive activities in a collaborative learning environment and apply knowledge from content learned [26].

The researcher (first author) and teacher educators designed a teaching and learning model comprising face-to-face and online sessions to suit a blended learning approach. With the COVID-19 disruptions on education, there was less teacher-student contact time, few learning opportunities, and changes in pedagogical practices, but the same assessments (e.g., assignments, tests, and exams). The introduction of online learning resulted in teachers and students becoming overburdened due to the lack of ICT infrastructure and competencies to use digital tools. Since flipped teaching is a new approach in Ghana, face-to-face and online sessions enabled teacher educators to support their students’ learning through engagement, discussion, and motivation. The findings and implications of this study can serve as a guide for teachers when implementing the flipped classroom approach.

2. Related Literature

The flipped classroom is a technology-driven pedagogical approach to providing student learning opportunities [27,28]. According to the constructivist theory, the flipped classroom allows educators to shift learning from a teacher-centered approach toward a more student-centered one [29]. Instructional videos engage students in independent out-of-class and in-class collaborative learning [30]. The instructor guides students to participate in learning, apply knowledge gained from concepts, and equip learners with 21st-century skills. Students become more familiar with new knowledge and participate in class activities through student collaboration to improve their creativity, critical thinking, and problem-solving skills [31,32].

Another essential characteristic of the flipped classroom approach is its flexibility, allowing students to control their learning. Students can watch pre-class instructional videos and read lecture notes at their own pace before class. Educators are thus able to plan and organize class time differently to maximize support for students’ learning. Face-to-face time is used for teacher-student interactions where students receive feedback, and their misconceptions can be corrected [33]. During in-class sessions, students develop a conceptual understanding from active participation and develop their collaborative learning skills [34].

Challenges and barriers have also been encountered when implementing the flipped classroom approach. Educators may be conservative and hesitant to use the flipped classroom approach since it involves adjusting pedagogic practices [35]. They may also lack skills and technological competencies to deliver instruction [36,37], or the ICT infrastructure may be poor [38,39].

Several studies have recognized that the flipped classroom approach effectively optimizes learning among higher education chemistry students [40–43]. Considering the importance of chemistry education in the national curriculum, society, and the relevance of the field to the chemical industry for a sustainable future generation, more research is therefore needed. Studies on the flipped classroom approach have focused mainly on chemistry student teachers’ learning [44–47]. Research on chemistry educators’ experience using flipped classroom approach has not been researched as much as in some other sciences.

This study investigates how teacher educators tried changing their traditional teaching to adopt flipped instruction. The following research questions guided the study:

1. What is the rationale for integrating flipped teaching?
2. What are the advantages of integrating flipped teaching?
3. What challenges are encountered in implementing flipped teaching, and how can they be resolved?

3. Conceptual Framework for Pedagogical Practice

This study is focused on the premise of ICT as an agent of change. We adopted the UNESCO ICT framework, which is a set of competencies teachers need to integrate ICT into their classroom. The framework helps to enhance the use of ICT in teacher training policies to strengthen students' ability to become more collaborative, creative, and problem-solving learners.

ICT integration and educational tasks are essential to support educators in setting up online lessons. Educators need to master ICT skills and become competent to create an enabling environment that enhances and transforms learning. Trainers and tutors must be familiar with ICT approaches and new competencies for teaching and learning. As indicated by [48], educators' innovative behaviors are affected by their traits, attitudes, self-efficacies, and school climate. These factors impact their ICT professional development and efficacy.

Many trainers are incorporating ICT to focus on a rethink of teacher training and capability development models. There are stages of development in education that can be used effectively with the ICT Framework for Teachers (ICT-CFT), developed by UNESCO, explaining how ICT competency policies and standards should be integrated into classroom activities. These factors help educators make choices on ICT through emerging ICT knowledge, using and applying the knowledge to transform classroom practices. Based on the conceptual model, for teacher educators to adopt ICT effectively in their classroom, they require adequate information on ICT, improved instructional skills, and support to specialize in ICT use [49] (see as Figure 1). They also need support in school practices, such as making the timetable, developing the school curriculum, and updating facilities available in the school [50].

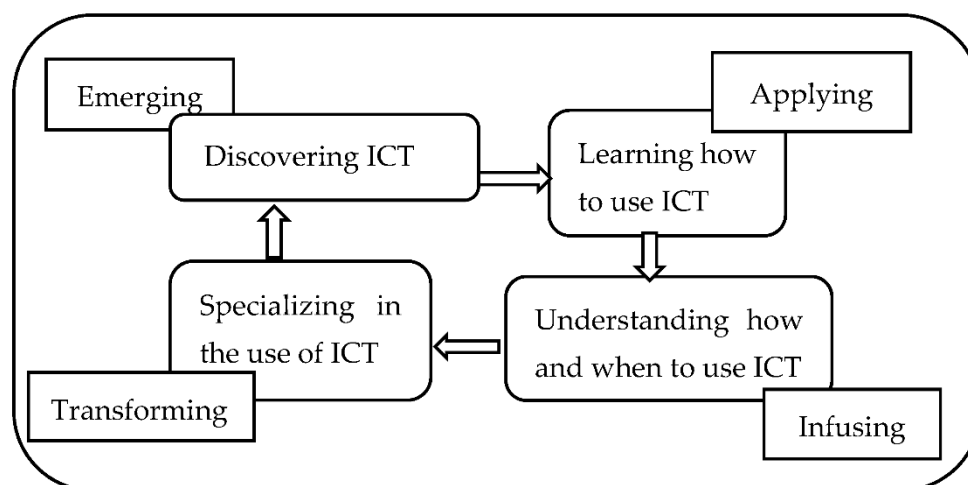


Figure 1. Adopted from UNESCO ICT competency framework for teaching [49].

4. Materials and Methods

The study is based on an educational design research framework [51]. The framework focuses on finding effective solutions to challenges faced by educational researchers. Three teacher educators collaborated with the researcher (the first author) and co-designed and

developed a pre-service chemistry teacher education course utilizing flipped classroom approach. Teacher–researcher partnerships can be used to investigate and seek solutions to problems of educational practice at different levels of education [52,53]. The participants taught the same chemistry course at three colleges of education in southern Ghana. The study took place over eight weeks during the 2020/2021 academic year. This study focuses on the participating teacher educators' experiences adopting the flipped classroom as a pedagogical approach. The data collected for this study include semi-structured interviews and classroom observations. This is a qualitative study with the intent to understand how participants interpret their experiences [54].

4.1. Interview Settings

To better understand the teacher educators' stories, one-on-one interviews were conducted twice on their perceived motivation for changing classroom practices. The interviews were conducted and recorded on Zoom and WhatsApp. The interviews were semi-structured and guided by open-ended questions. Using open-ended and non-judgmental questions allowed the narratives or themes to emerge [55]. An identifiable theme was used as the starting point to explore the teacher educators' views on transforming their classroom practices. Through follow-up questions, the participants discussed essential issues in a flipped classroom. Each discussion with the participants lasted for 45 to 60 min. The class observation was conducted in each class to understand how teacher-student interactions and student collaborating activities occurred during the delivery of the lessons. The second interview was taken after the intervention and followed the issues discussed in the first interview. The participants were asked to describe their classroom practices and why they changed them.

4.2. Data Analysis

The themes that emerged from the narrative interviews were identified and used to report the teacher educators' experiences and practice in a reflective process [56]. The data were sorted and coded into ten themes through thematic analysis to connect the responses to the research questions [57]. The initial coding involved open coding, extracted from interviews and grouped into main codes. The first coding was based on the teacher educators' experience transforming their face-to-face teaching, the purpose of the transformation, benefits, and challenges. The second round of open coding was based on the experiences in using flipped classroom. The data from the planning meetings, training, implementation, assessment, and interviews were analyzed. The analysis enabled the researchers to understand the phenomenon and elicit teacher educators' way of practice from a socially significant identity using language, actions, beliefs, and values. To better understand the nature of flipped classroom experiences, benefits, and challenges, themes were further formulated from the second codes to make explicit connections. The relationships between themes were identified with constant comparisons and cross-case analyses.

5. Results

The key ideas from the results identified as a theme for rationalizing the use of flipped classrooms were educational technology, advantages of flipped classrooms for teachers and students, and challenges of developing and using flipped classrooms. Each theme supported coded categories, and sample quotes are summarized in Table 1 below.

5.1. Shift in Classroom Practice Using Educational Technology

Educators believed the time had come to adopt 21st-century teaching strategies to support their students' learning. Educational technologies should replace the didactic pedagogic approach with student-centered learning strategies. One participant stated, "I see flipped classroom as a turning point to shift our teaching and learning practices towards a student-centered approach and allow students to construct their knowledge". In addition, educators believe using flipped classrooms can enable students to take responsibility for

their learning instead of depending on their teachers. One educator noted, “The COVID-19 has caused us to change our teaching and learning practices, and flipping our class is a suitable option for students to learn on their own instead of relying on teachers”.

Table 1. Summary of themes and example quotes based on the research questions.

Research Questions	Themes	Example Quotes
What is the rationale for integrating flipped teaching?	Student-centered learning strategies can have a greater role in designing lesson plans	<i>I see flipped classroom as a turning point to shift our teaching and learning practices toward a student-centered approach and allow students to construct their knowledge.</i>
	Educators and student teachers can improve their skills and competencies in ICT	<i>I believe in-service and pre-service teachers can use the flipped approach to improve their skills and competencies in using new digital technologies and ICT.</i>
What are the advantages of integrating flipped teaching and learning?	Reduces the teacher’s workload	<i>Flipped instructions help reduce my workload since most of the initial preparations of writing lecture notes and explaining to students are now replaced with videos.</i>
	Creates an avenue for teacher-student interactions	<i>Flipped classroom creates opportunities for face-to-face connection time with students to discuss their problems, which helps boost students’ understanding of the concept.</i>
	Enhances peer collaboration among students	<i>Flipped classroom allows students to collaborate with peers, share their learning experiences, and encourage creativity and personal knowledge.</i>
	Encourages students to take more responsibility for their learning	<i>Students work independently on pre-class tasks giving them more control over their learning, especially after watching videos, constructing new knowledge enhancing their understanding of the content learned.</i>
	Enhances conceptual understanding and improves critical thinking and problem-solving skills	<i>Students’ active engagement helped build conceptual knowledge and develop problem-solving skills.</i>
What are the challenges encountered in implementing flipped teaching and learning?	Students’ lack of access to the internet and digital tools	<i>Some students did not have access to digital tools or the internet to watch the videos and join online classes.</i>
	Educators’ lack of technology competencies	<i>The videos of expanded structural formulas of some organic compounds are not precisely as I wanted, and drawing them with a computer was challenging.</i>
	Students’ lack of technological skills	<i>Some students had difficulty using the online applications tools and learning platforms, making it difficult to interact effectively with students during online discussions.</i>

Teacher educators believe the emergence of new technologies has shaped the 21st-century classroom. Therefore, implementing a flipped classroom approach can help improve educators’ ICT competencies and students’ ICT skills. One participant explained, “I believe in-service and pre-service teachers can take advantage of the flipped approach to improve their skills and competencies in using new digital technologies and ICT”. Another educator believed the use of ICT can improve their skills in teaching and said, “the availability of ICT facilities is a challenge for teachers to upgrade their skills to use ICT to assist students in gaining technological experiences”.

5.2. Advantages of Flipped Classroom

Educators mentioned several ways the flipped classroom enhanced their work and students' learning. Flipping the class help to reduce the teacher's workload. Videos can reduce the time spent preparing lecture notes, dictating, and explaining the concepts to students. One participant said, *"flipped instructions help reduce my workload since most of the initial preparations of writing lecture notes and explaining to students are now replaced with videos"*. Another participant emphasized videos helped reduce the talk time and explained that *"students watch the videos to have a basic understanding of the concepts at home and in class, we use discussions and interactions to practice the video content"*. In agreement with the time factor in flipped instructions, one educator believed that *"once the students watch videos at home, it saves some time for the in-class activities to discuss what they watched and make sure they do not form varied concepts"*.

Educators felt that a flipped classroom enabled them to use varied approaches to engage students to construct knowledge guided by the teacher. An educator indicated the flipped classroom created an avenue for teacher-student interactions and explained: *"flipped classroom creates opportunities for face-to-face connection time with students to discuss their problems, which help boost students' understanding of the concept"*.

Flipped classroom enhanced collaboration among students. One educator said, *"the in-class activities involved several activities including group discussion among students which enhance their understanding of the content and conceptual knowledge construction"*. Another educator agreed that active engagement and collaboration enabled students to construct more knowledge and explained that the *"flipped classroom allows students to collaborate with peers, share their learning experiences, and encourage creativity and personal knowledge"*.

Educators emphasized that flipped classroom is more flexible than the lecture approach. They felt the flexible nature of the model allows students to revise learning materials and do tasks at their own convenient time. One educator stated, *"students work independently on pre-class tasks giving them more control over their learning especially after watching videos, construct new knowledge enhancing their understanding of content learned"*.

Finally, educators felt engaging students in flipped classroom activities involving deep thinking enhances conceptual understanding and improves critical thinking and problem-solving skills. One teacher educator noted, *"student's active engagement helped build conceptual knowledge and develop problem-solving skills"*. Another educator explained that flipped classroom enhances students' skills of responding to higher-order questions, indicating *"the way students asked and responded to questions shows their critical thinking skills have improved"*.

5.3. Barriers and Challenges of a Flipped Classroom

Teacher educators mentioned some barriers and challenges while developing and using the flipped classroom. Educators reported access to the internet and digital tools, technological competence, and skills affected their teaching, students' preparation, and class participation. Network connectivity in certain areas and homes was poor, making it difficult for students to access learning materials. One educator explained, *"some students did not have access to digital tools or the internet to watch the videos and join online classes. This hinders students' preparation for in-class activities, so I had to record the lessons for them to play back later. Sometimes I have to group students based on their access to digital tools and the internet"*. Another educator added, *"students do not have smartphones or computers or laptops to do the assigned tasks. To ensure no student is left behind, I usually allow them to watch the videos in class with my mobile Wi-Fi or open an ICT lab for students to use"*.

Educators explained that their technology competencies were challenging when developing flipped instructions. One educator said, *"I find it difficult to monitor and communicate with students during group work to assess their level of engagement and participation. However, students were encouraged to contact me by email anytime for assistance"*. Another participant expressed difficulty drawing structures of organic compounds using the computer. Usually, educators relied on already made videos on the internet but could not emphasize the

examples. This view was explained by saying, “the videos of expanded structural formulas of some organic compounds are not exactly as I wanted, and drawing them with a computer was challenging. I relied on the ICT tutor for some training”.

Another educator expressed that students’ lack of skills in using the learning platforms made it difficult to interact with them as frequently as needed. The educator commented, “some students had difficulty using the online applications tools and learning platforms, making it difficult to interact effectively with students during online discussions”.

6. Discussion

This study aimed to examine teacher educators’ views of using flipped classroom approach to deliver chemistry lessons. The study focused on teacher educators’ rationale, perceived advantages, and challenges to understand better how educators adopted and used the flipped classroom. The overall findings of this study showed that teacher educators had positive views about the flipped classroom helping to change their pedagogical practice.

6.1. The Rationale for Implementing Flipped Classroom Approach

Teacher educators could use the flipped classroom to shift their classroom practice toward student-centered learning using ICT. Teacher educators felt it was time to embrace change in their classroom practices by engaging students to construct their knowledge. The flipped classroom is a student-centered approach for facilitating students’ collaboration and discussions for deeper learning [29]. Previous studies have argued that teachers’ desire to use the flipped classroom is based on implementing student-centered learning [58–60]. Teacher educators mentioned the relevance of engaging students using ICT in different instructional scenarios. Educators must incorporate different pedagogical strategies in the classroom to foster student active engagement and participation, such as think-pair-share and scaffolding [61]. Teacher educators believed that flipped instructions allowed students to use instructional applications for real-world technological competence and learning skills [62–64]. Training students to use ICT can foster in-service and pre-service teachers’ competence and skills in the use of ICT.

6.2. Advantages of Using a Flipped Classroom Approach

Using videos can reduce teachers’ workload and time spent preparing and delivering lectures to students. The flipped classroom approach helped teacher educators reduce the time used to prepare materials and explain to students, and extra time is given to students who spend less time taking notes during lessons. Teacher educators felt that watching a lesson at their convenience and re-watching portions they had problems understanding tend to aid students’ understanding. Previous studies have affirmed that arguments on videos serve as a guide and sustain students’ attention pre-class.

Teacher educators used the flipped classroom approach to create effective classroom interactions with students. Moving some aspects of the learning process out of class created extra time for active learning activities and teacher-led class discussions. Through the teacher-student interactions, it was possible to identify students’ challenges for possible feedback. Flipped lessons engage students, enabling better learning with maximum teacher-student interaction and scaffolding through constant teacher feedback and motivation [18,32].

The flipped classroom approach created an opportunity to free class time for students’ collaboration to foster deeper engagement with the content. The extra time created enabled teachers to engage students in activities to determine their level of learning and to plan problem-based activities in the classroom. This allowed students to participate in both in-class and out-of-class engagement actively. The findings revealed that the flipped classroom approach promoted student participation in active engagement and facilitated teacher contact time with students to increase understanding. Other studies have also found that a flipped classroom increases students’ participation, self-confidence, active engagement, and collaboration [30,63].

The flipped classroom approach provides a flexible learning environment that allows students to select their learning time and place during the pre-class session [65]. This allows students to control and become responsible for their learning. Flipped pre-class activities allow students to take an active role and take control of their learning [66–68]. Students can pause, rewind, and review the learning materials to enhance remembering and understanding of essential knowledge [69–71].

Our findings show that students engaged in higher-order learning activities during the in-class session, facilitating their conceptual knowledge and learning skills. Through the flipped classroom approach, teacher educators engage students in active learning activities to develop confidence and a deeper understanding of concepts [18,72,73]. When students gain a comprehensive understanding of a concept, it creates positive learning experiences so they can relate what is learned to different contexts [33].

6.3. Challenges and Barriers When Implementing a Flipped Classroom

Despite teacher educators' positive views about the flipped classroom approach, they also faced some challenges and barriers when using the approach. Teachers frequently faced difficulties with poor network connectivity. The cost of internet data bundles was also prohibitive. Previous studies have reported teachers facing challenges of a lack of ICT resources such as computers, access to the internet, poor network connections, no electricity, and the high cost of data bundles which hinder the use of blended learning [13]. Students who cannot afford data bundles and ICT equipment become disengaged in out-of-class activities and skip pre-class tasks [74]. This makes flipped classroom approach less valuable to students and poses difficult tasks for teachers to find alternative ways for students to access pre-lesson materials to prepare for in-class activities [75].

Effective use of the flipped classroom approach demands adequate knowledge and skills of ICT use in teaching. Preparing learning materials, engaging students in online discussions, and monitoring students' progress requires at least basic ICT skills and commitment from educators. In addition, ICT literacy and competency are also challenging for educators when using flipped classroom approach. Teacher educators claimed they lacked the skills and ICT competence to create videos and other learning materials. They relied on videos from YouTube and other online video materials, which sometimes are not well aligned with the lessons taught. Previous studies have reported a lack of literacy skills and competency in technology for learning as a drawback to the flipped classroom [76–79].

Providing adequate and prompt feedback to students is essential to the flipped classroom approach as it helps reduce students' frustrations [80]. In this study, teacher educators found it challenging to communicate, interact, monitor students' online activities, and provide timely feedback due to large class sizes. For teachers to be competent in using educational technologies in their classroom, the authors of [81] argued for instructional support in the form of professional development training on computer-enhanced teachings. These barriers imply that educators and students need technical training to use the flipped classroom approach effectively.

7. Implications for Classroom Teaching

In fostering the needs of the 21st-century learner, educators must incorporate technology to motivate students to learn. Researchers have defined the rationale for changing classroom practices to include a role for instructors and students taking responsibility. In achieving such transformation, there is the need to plan instructions focusing on how students gain essential learning skills. Integrating ICT could enhance students' collaboration and communication skills in the 21st-century learning environment. The rapid growth of ICT has enabled students to become more active in learning activities by engaging in tasks in online learning settings. Therefore, teacher educators should motivate students to increase ICT use [82]. Teacher educators should make provisions for students who cannot access pre-class activities to better prepare so that no one is left behind.

Some researchers have underscored mobile technologies as an inexpensive and robust way of delivering online learning when internet connectivity is a problem [83]. In addition, e-learning centers or mobile Wi-Fi equipment can be established in colleges to deliver blended learning smoothly. Institutions can liaise with internet service providers to provide internet bundles or high broadband internets for students and teacher educators at an affordable price. The institutions or policymakers could also distribute ICT equipment such as android phones, tablets, and laptops customized for learning to educators and students at subsidized prices [13].

The flipped classroom approach can be helpful to teacher educators who must be technologically literate to monitor students' participation and interactions which are essential components for effective learning. Teacher educators need support to upgrade their ICT skills and competencies to guide students in using ICT and the flipped approach [28].

8. Limitations

The study participants were limited to three teacher educators. The small size limited the generalization of the study results. To support the conclusions with empirical evidence, the researchers recommend future research with a large sample and other subject areas to ascertain the perceived usefulness and challenges of implementing flipped classrooms in teacher training colleges.

In future research, the issues of inadequate resources, e.g., ICT tools and poor internet connectivity, which impacted preparation, participation, classroom observation, and interviews, should be considered. In addition, a follow-up study is recommended to examine students' achievements and views on the flipped classroom's approach benefits and challenges to support the existing empirical evidence.

9. Conclusions

This study highlighted how teacher educators use flipped classroom approach to engage students to achieve desired learning outcomes. The findings highlight the need to change teacher educators' classroom practices during disruptions and uncertainties to bring about continuity in teaching and learning. Teacher educators must change their classroom practices as stipulated by the curriculum and policies. Despite having issues with internet facilities and technological skills, teacher educators' acceptance of flipped classrooms is high. Teacher educators cited lack of internet facilities, poor network connections, cost of data bundles, and lack of ICT tools as significant barriers to using the flipped classroom.

Adopting flipped classroom approach in developing countries can be beneficial but demands adequate ICT infrastructure, teacher commitment, and professional development training for educators to design and use this approach. Teacher educators' ability to design flipped courses depends on their ICT literacy and competence to enhance students' participation by addressing and responding to students' needs. Institutions can hire experts to train teacher educators to upgrade their skills in ICT to deliver online lessons effectively. These interventions and teacher professional development programs can be a practical approach to building teacher educators' capacity to utilize flipped classroom. In summary, educational practitioners must rethink the teacher training curriculum and capability development models for developing teachers to use ICT.

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