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The effects of microlearning-supported flipped classroom on pre-service teachers' learning performance, motivation and engagement

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Abstract

Flipped classroom (FC) has recently attracted researchers' interest in teacher education thanks to its potential for promoting pre-service teachers' (PTs) professional development. However, some of major issues are the lack of interactivity, disengagement, and amotivation of PTs for pre-class activities due to poor online instruction design. This explanatory sequential mixed study explores the effects of the microlearning-supported FC on PTs' learning performance for professional development, motivation, and engagement. A total of 128 PTs participated in this study from a university in Turkey. In the quantitative phase, a quasi-experimental pretest-posttest design was conducted and the treatment lasted for 14 weeks. The PTs were divided into two experimental groups and one control groups using random sampling technique. In first experimental group (m-FC, n = 43), the participants learned with microlearning-supported (by using a-bit sized learning chunks outside the classroom) FC model. In the second experimental group (t-FC, n = 39), the participants learned with traditional FC model. A control group (non-FC, n = 46) was not taught using FC model and teacher-centered approach was adopted in this group. The findings indicated that FC model (in both experimental groups) increased learning performance, intrinsic motivation, emotional, and behavioral engagement compared to a group that was not used to FC. Moreover, m-FC group had better intrinsic motivation and engagement than both t-FC and non-FC groups. Semi-structured interviews showed that two major themes emerged regarding benefits and challenges of microlearning-supported FC. Most of PTs had positive perceptions that it enhances the willingness to participate in pre-class activities. The implications for teacher education, recommendations and directions for further studies were also discussed.

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1 Introduction

Traditionally, teacher-dominated instruction refers to the transfer of knowledge to the students by an instructor. Accordingly, there is not enough time for student-oriented activities in the classroom. Students are also not offered several opportunities to progress at their pace. However, with the rapid developments in information and communication technologies (ICTs), there has been a transformation in learning-teaching paradigms. As a reflection of this, FC approach, one of the current buzzwords with a potential Google (2020) search term, has been a tremendously advocated and popular pedagogy with its technology-based and learner-centered structures in educational settings (Strelan et al., 2020). Broadly speaking, FC, as a popular form of blended learning approach (Staker & Horn, 2012), is an approach that overlaps face-to-face (F2F) and online learning (OL) by reversing the traditional teaching-learning procedures. Specifically, FC differs from other types of blended learning in that the course contents in various media formats are used to learn new concepts or subjects before classroom activities. While FC provides an interactive learning environment in the classroom, the lectures given outside the classroom are designed to help students learn at their own pace regardless of time (Bergmann & Sams, 2012).

Bergmann and Sams (2012) reported that FC is basically what is done at home is done at school (e.g., homework assignments) and what is done at school is done at home (e.g., delivering instructional contents). The students review the course contents during at-home activities and prepare for F2F activities with various contents such as video lectures, quizzes, prescribed readings, and audio recordings. Hence, FC provides them with additional time to apply the newly acquired knowledge in the classroom (Zou et al., 2020). It allows group discussions and problem-based learning activities in which the student has not a passive role in the classroom (Bergmann & Sams, 2012). Thus, in traditional education, it is difficult to equip students with higher order thinking (HOT) skills such as problem-solving, critical thinking, reasoning, creative thinking, self-regulation due to restricted time in school.

As an innovative and flexible learning method (Abeysekera & Dawson, 2015), FC facilitates deep understanding by activating these skills and promoting student engagement (Strelan et al., 2020). The main objective of FC is to improve students' HOT skills underlined in Bloom's Cognitive Taxonomy (analyzing, evaluating, creating) by making students more active in the learning process (Sun et al., 2022). Previous meta-analyses and systematic reviews have confirmed that FC is an effective pedagogy for supporting students and instructors during the teaching-learning process (Akcayir & Akcayir, 2018; Strelan et al., 2020; Wagner et al., 2021). As one of the top trends in e-learning in 2020 (Pandey, 2020), FC increases the effectiveness and transferability of learning for students (Kapp & Defelice, 2019; Wang et al., 2020). Contrary to its benefits, there is a gap in the design of FC learning activities, especially those applied outside the classroom

during the pre-class phase. Jovanović et al. (2019) underlined that pre-class activities are crucial to the success of FC. Lo and Hew (2017) emphasized that the main challenges in the implementation of FC are instructors' workload in designing the course materials and learners' disengagement in learning outside the classroom.

On the other hand, while numerous research has focused on FC within the broad educational arena, there are relatively few empirical studies in a university context (Kim et al., 2021), especially in the discipline of teacher education (Barahona et al., 2022; Han & Røkenes, 2020). FC promotes active learning and peer interaction in teacher education by integrating technology into the classroom (Vaughan, 2015). Few empirical studies in teacher education provided evidence that FC enhances pre-service teachers' (PTs) learning motivation and achievement (Debbag & Yildiz, 2021; Yough et al., 2019). Previous teacher training research indicates that there are challenges with the practical applications and instructional design of FC regarding teachers' professional development. However, its integration with different learning approaches has been sparsely studied and this is still in its infancy for teacher education (Han & Røkenes, 2020). The instructional design of FC seems simple in appearance, that is, in-class (lecture) and out-of-class activities (homework) are inverted. Beyond this simple sequence, if we make an analogy between an iceberg and FC, the invisible parts of the iceberg of FC are pivotal factors in facilitating learning (Kim et al., 2021). Based on previous studies, the key factors for the success of an FC can be mainly listed as follows: well-designed instructional content, good guidance from the instructor, consistency between in-class and out-of-class activities, timely feedback, guiding for self-regulation, and following the course content regularly for pre-class activities (Hung, 2015; Jovanović et al., 2019; Sointu et al., 2022).

Considering that today's learners confront information overload and short-term focusing, recent study focused on microlearning activities in teacher education as a part of instructional design in the out-of-class part of FC to address these gaps. If there is poor student engagement and asynchronous contents are not attractive and engaging enough for the students in an FC, it is difficult to make significant improvements in their learning performance. With its increasing popularity over the last several years in educational contexts (Pandey, 2020; Taylor & Hung, 2022), microlearning directs students to learn with nugget contents by reducing the cognitive load on the working memory and enhancing self-regulation, engagement, and motivation. Essentially, integrating this approach with FC in the educational setting is likely to a solution to overcome challenges of FC model, especially for activities outside of classroom. Microlearning provides an opportunity to blend F2F learning with activities outside the classroom (Dolasinski & Reynolds, 2021). It can be a supportive pedagogical approach for out-of-classroom of FC especially in developing important variables such as motivation and engagement in OL environments. Although microlearning is promising for educational settings, empirical research on its effectiveness is scarce and there is not much supporting and apparent evidence. Accordingly, the current study explored the impacts of the microlearning-based flipped classroom (m-FC) on PTs' learning performance, motivation, and engagement in

the teaching principles and methods course compared to the traditional flipped classroom (t-FC) and traditional instruction (non-FC). The research questions (RQs) of this study were:

RQ1. Do the instructional activities conducted with m-FC, t-FC, and non-FC groups ensure significance difference among the learning performance post-test scores of PTs upon controlling pre-test scores?
RQ2. Do the instructional activities conducted with m-FC, t-FC, and non-FC groups ensure significance difference among the learning motivation post-test scores of PTs upon controlling pre-test scores?
RQ3. Do the instructional activities conducted with m-FC, t-FC, and non-FC groups ensure significance difference among the course engagement post-test scores of PTs upon controlling pre-test scores?
RQ4. What are the perceptions of the PTs in the experimental groups about FC activities?

2 Theoretical framework

2.1 Flipped classroom

Although FC, also known as the inverted classroom, historically traces back to the year 2000 (Lage et al., 2000), its pedagogical popularity has dramatically started to increase since the advent of Bergmann and Sams' efforts (for high school students missing in-class pedagogies) in 2012 (Bergmann & Sams, 2012). FC has been described in different ways by researchers and practitioners. In a general sense, it is defined as learning through asynchronous instructional videos at home and homework assignments, discussions, and group activities at school by using class time more effectively in the learning process (Bishop & Verleger, 2013; Lo & Hew, 2017).

Theoretically, FC is related to student-centered approaches such as constructivism, connectivism, collaborative learning, and technology-based theories (Bishop & Verleger, 2013). From a contemporary perspective, the FC has recently been referred to as the flipped learning mode. The structure of this approach has two stages: F2F and online (out-of-class) activities. Compared to traditional courses, in the typical FC pedagogy, students learn by progressing at their own pace through short instructional videos and other media contents (slides, podcasts, notes, forums, etc.) outside the classroom, mainly emphasizing on lower order cognitive processes (remembering, understanding, applying) to get basic knowledge and understand the main concepts. Before in-class sessions, the instructor uploads the instructional materials to a Learning Management System (LMS). Students acquire the essential main concepts of the subject for classroom activities (Abeysekara & Dawson, 2015). Then, in the classroom, learners perform active learning practices such as problem-based learning tasks, collaborative tasks, and group discussions by using the knowledge they have acquired prior to the class, focusing on HOT skills (analyzing, evaluating, creating) to better construct knowledge under the teacher's guidance (Hsia et al., 2022).

Kim et al. (2021) emphasized four core elements of instructional design for FC: time (after class, before class, during class), space (online vs. offline, pre-class vs. in-class), and activity type (individual vs. collaborative), technology use (technology-enhanced vs. F2F interaction). As a non-profit organization, Flipped Learning Network also proposed the F-L-I-P™ model with four pillars for an effective design of FC environments (Hamdan et al., 2013): (i) flexible environment, (ii) learning culture, (iii) intentional content, and (iv) professional educator. The elements consisting of 11 indicators serve as a framework for researchers and practitioners (Flipped Learning Global Initiative, 2018). The first pillar of this model, *flexible environment*, offers flexibility to students by removing time and place barriers to their learning. The second pillar, *learning culture*, serves for the formation of a student-centered pedagogical ground. The third pillar, *intellectual content*, lays emphasis on offering appropriate course contents for students' cognitive and fast learning. The last one, *professional educator*, assigns teachers a facilitator role in the construction of knowledge by the learners. Moreover, educators observe and evaluate the teaching-learning process and give feedback to students.

Several studies showed that that FC has a profound impact on achievement (Akcayir & Akcayir, 2018; Strelan et al., 2020), motivation (Debbag & Yildiz, 2021), self-regulation skills (Yoon et al., 2021), and student engagement (Bond, 2020; Bond et al., 2020; Cevikbas & Kaiser, 2022) in different educational contexts. As an innovative and active learning approach, the FC model provides several opportunities to enhance self-paced learning, HOT skills (Huang et al., 2021; Strelan et al., 2020). Motivation, interaction, instructional design, and self-regulation skills are pivotal factors that enhance learner engagement in FC (Birgili & Demir, 2022). It has great potential to support active learning, technology utilization, rich learning contents, and flexible learning (Lai et al., 2021).

Contrary to its potential benefits, there are several challenges such as motivational and interactive deficiencies, especially in the activities outside the classroom (Akcayir & Akcayir, 2018; Birgili & Demir, 2022). A major issue in FC is poor instructional design and planning, especially for OL activities. For instance, Fiorella and Mayer (2018) recommended that shortened instructional videos are used as a potential media in FC. A great body of research has reported that the students do not complete the assignments or are not engaged in pre-class learning (Akcayir & Akcayir, 2018; Lo & Hew, 2017). Moreover, there are other issues such as technical problems, the poor readiness of students, lack of physical presence and social interaction, and the time-consuming designing process of the materials. A few studies have reported on the in-class activities that students have difficulty about participating in collaborative group activities. Webb and Doman (2019) asserted that using different digital technologies rather than just video lectures for the pre-class activities is important. Jung et al. (2022) also revealed that FC requires more responsibilities for individual and group learning processes compared to the traditional classroom.

Recently, researchers focused on the effectiveness of integrating FC with different pedagogical approaches or technologies. For instance, Li et al. (2022) indicated that the experimental group used mini-game based FC had higher scores than control group used video based traditional FC in learning performance, flow experience and

concentration. Similarly, Jung et al. (2022) found that self-regulated supported FC model had a positive impact on student performance and HOT skills. A study by Huang et al. (2021) showed that experiential FC mode with spherical video-based virtual reality had a positive impact on learning achievement, decision-making performance, HOT tendency, and engagement compared to conventional FC mode for nursing professional training. Based on these findings, the integration of innovative pedagogies with FC is effective for learning. Considering this potential, the current study focused on the microlearning approach, which includes learning chunks or bites is suitable for the structure of FC.

2.2 Microlearning approach

Microlearning, also called "bite-sized learning", is an approach based on small chunks or units of information and short-term focused learning activities (Reinhardt & Elwood, 2019; Kossen & Ooi, 2021; Kapp & Defelice, 2019) defined it as *"an instructional unit that provides a short engagement in an activity intentionally designed to elicit a specific outcome from the participant"* (p. 11). Based on this definition, the elements of microlearning are an instructional unit, a short engagement, engagement, an activity, an intentional design, eliciting a specific outcome, and the participant (Kapp & Defelice, 2019). Microlearning is a novel educational trend in which an instructor presents the course content by dividing it into easily understandable small learning pieces or nuggets (Horst et al., 2020). That is to say, students learn through several micro contents such as brief video segments, short podcasts, bite-sized flashcards, short-term assignments, mini quizzes, and small paragraphs. These learning chunks can be designed using different media elements such as text, video, and audio. Microlearning becomes more accessible from anywhere and anytime using mobile devices (Nikou & Economides, 2018; Taylor & Hung, 2022) classified the microlearning formats into three types: (i) short, (ii) just-in-time, and (iii) flash lessons. The first category, short lesson, mostly contains short videos (5–10 min) including in demonstrating procedures. The second category, just-in-time lesson refers to short, highly contextualized, and personalized contents that also contains a time contingency. It offers students to be in control of their learning which affects engagement or motivational beliefs. The last category, flash lesson uses text messages specifically and are deployed by mobile technologies.

Microlearning makes learning more attractive for today's students by reducing the volume of information (Kossen & Ooi, 2021). It is frequently mentioned together with the concepts of e-learning, mobile learning, and informal learning activities. According to Revised Bloom's Taxonomy, this approach is appropriate for the domains of remembering, understanding, and applying (Kapp & Defelice, 2019). Therefore, the integration of microlearning with the out-of-class process of the FC model seems applicable for achieving better learning outcomes. Previous research has provided evidence that microlearning increases student engagement (Manning et al., 2021), self-regulation skills (Shamir-Inbal & Ina Blau, 2020), learning performance (Nikou & Economides, 2018), and motivation (Sozmen et al., 2021) and reduces the information overload (Kossen & Ooi, 2021) in open and distance

learning (ODL) environments. For instance, Sozmen et al. (2021) found that the microlearning approach increases the effectiveness of learning and motivation for medical students. In essence, microlearning has the potential for an effective teaching-learning process in online and hybrid (flipped classroom, etc.) learning environments. In short, small and short-term materials offer several opportunities for learners and instructors to enhance engagement and presence in OL regardless of place and time (just-in-time). In microlearning, the information can be easily delivered via mobile and web-based technologies.

Although the advantages of microlearning have been widely known, it also has several challenges such as the difficulty of ensuring deep learning and HOT skills. Poorly designed microlearning contents may be ineffective for learning. Moreover, fragmented microlearning contents can cause distractions by forcing the learners to concentrate on different pieces at one time (Zhang et al., 2018). These issues can be minimized by systematically integrating different learning approaches into the microlearning approach (Stohr et al., 2019). More importantly, this integration can be promising for better learning as it benefits from the strengths of both sides.

As mentioned before, microlearning is an approach suitable for the nature of blended learning or distance education. The major issues are the lack of interactivity, disengagement, and amotivation in OL environments. Microlearning may be a potential approach to reduce these challenges in the out-of-class process of FC. Therefore, this research focused the effectiveness of microlearning-supported FC not only on learning performance but also on motivation and engagement variables.

2.3 Student engagement and motivation

Student engagement which means a learner's active involvement in the learning process is a key factor for the success of the FC model (Jung et al., 2022). This term refers to the energy and effort dedicated by learners to learn accompanied by curiosity, attention, optimism, and passion to learn more during the learning and teaching process (Bond et al., 2020). Its three main structures are (i) cognitive, (ii) emotional, and (iii) behavioral engagement (Fredricks et al., 2004). Cognitive engagement is related to mental and motivational efforts (e.g., critical thinking, reflection, self-regulation, and deep learning) during learning processes (Christenson et al., 2012). Emotional engagement focuses on positive (e.g., enthusiasm, interest, and enjoyment) and negative feelings (e.g., sadness, frustration). Pekrun and Perry (2014) highlighted that whereas positive activating emotions contribute the learning performance positively, negative activating emotions have a negative effect on academic outcomes. Behavioral engagement refers to effort, action, homework completion, attention, and positive conduct. Bond (2020) suggests a bioecological model on the engagement of student which includes the integration of microsystem elements with the three structures mentioned above. This microsystem reflects the learning environment where FC is used with the student being at the center interacting with the technology, peers, teacher, learning activities, and the environment.

More importantly, in order to improve learning performance, FC needs active learner engagement (Cevikbas & Kaiser, 2022; Lai et al., 2021). The student

engagement in the FCs is affected by student, curriculum, teacher, technology, student, peer, and family components. FC studies dwelling on engagement in PTs are needed (Yough et al., 2019). In the recent study, the researcher adapted the concept of engagement from Fredricks et al.'s (2004) conceptualization. It is confused with the motivation concept, which is an internal or external force that directs student behaviors (Fredricks et al., 2004). Motivation is one of the antecedents of student engagement and positive academic outcomes (Bond et al., 2020). According to Abeysekera and Dawson (2015), it is difficult to discuss motivation in the scope of innovative pedagogies without student engagement. The widely accepted definition of motivation is a process that initiates, manages, and maintains behavior. Self-Determination Theory (SDT), which has influenced a large body of empirical educational research, suggests a general frame for motivational orientations as follows: amotivation (absence of will for doing an activity), intrinsic, and extrinsic motivation (Ryan & Deci, 2000). While students with high intrinsic motivation tend to perform better in the classroom and learn by enjoying, extrinsically motivated students need external regulations such as reward, punishment, and praise to perform a certain goal or task (Niemiec & Ryan, 2009).

Universally, SDT is based on three basic psychological needs: efficacy, autonomy, and relatedness for the motivational continuum (Ryan & Deci, 2017). The first of these needs, autonomy, is related to the learner's control of his/her behavior and capability to make his/her own decisions. The second need, competence, addresses to having sufficient skills to accomplish a task. The third one, relatedness, means that people need to interact with and connect to other people or be accepted by others. SDT is important for students' motivation because it addresses both social-cultural contexts and their experiences (Ryan & Niemiec, 2009). SDT has been seen as a suitable theory for the FC approach (Abeysekera & Dawson, 2015). Technology-based and student-centered approaches (e.g., FC) have the potential to enhance learning performance, student engagement, and motivation in teacher education. Accordingly, the recent study focused on these variables which are equally important and interrelated for educational research.

3 Methodology

3.1 Research design

The study followed explanatory-sequential mixed design (Creswell & Plano Clark, 2018) as a mixed method paradigm. Quantitative (to answer RQ1, RQ2, and RQ3) and qualitative data (to answer RQ4) were collected sequentially. In the quantitative phase, a quasi-experimental pretest-posttest design was carried out. Following this, the experiment was examined in depth analysis by semi-structured interviews.

3.2 Participants

A total of 128 PTs (80 female, 48 male) taking the Teaching Principles and Methods course participated from a large sized university in Turkey voluntarily. The PTs were on average 19.78 years old (within the range of 19 and 24 years, $SD = 1.14$). Random sampling was utilized to select groups. There were two experimental groups (m-FC: PTs who adopted microlearning based flipped classroom method, t-FC: PTs who learned with traditional FC method) and one control group (non-FC: PTs who learned with traditional instruction method) in this study. The participants were sophomores enrolled in the department of Math Teaching (m-FC, $n = 43$), Turkish Teaching (t-FC, $n = 39$), Psychological Counseling and Guidance (non-FC, $n = 46$) in the faculty of education. Moreover, the follow-up interviews were conducted with 8 PTs (6 females, 2 males) in the m-FC group and with 6 PTs (3 females, 2 males) in the t-FC group. PTs in experimental groups were proficient in using their smartphones.

3.3 Experimental procedure

This long-running study lasted for 14 weeks in the second semester of the 2020–2021 academic year. Prior to the experiment, the recent study was approved by the research ethics committee and consent was obtained from the PTs in all groups. Before the implementation, the pre-tests were used to investigate whether the three groups had the same knowledge, motivation, and engagement level. Initially, FC groups were informed about the intervention process. Online teaching activities during the COVID-19 process were supportive for both the adaptation of students and reducing the effect of novelty.

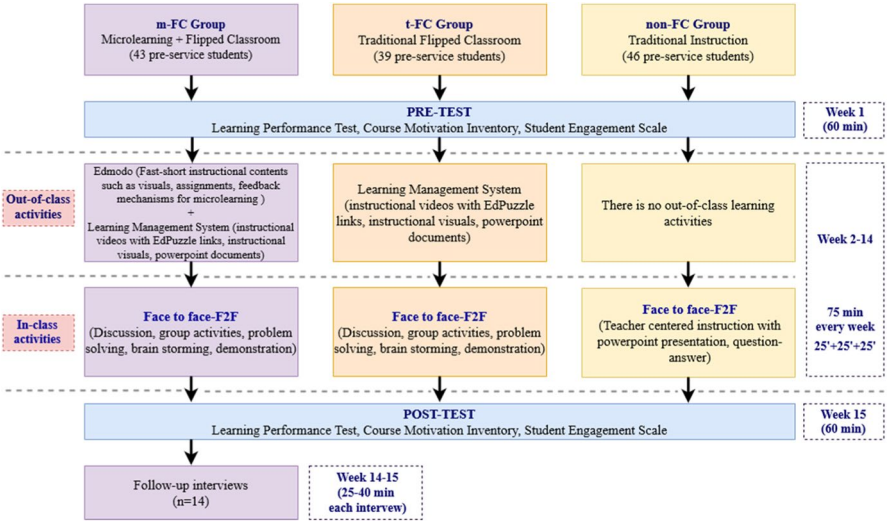

Fig. 1 Diagram of the experimental procedure

Table 1 The weekly subjects of course

Week	Subject
#Week1	Pre-tests
#Week2	Basic concepts (education, learning, instruction, teaching, etc.)
#Week3	Curriculum and planning in the learning-teaching process
#Week4	Instruction principles
#Week5	Instruction approach and theories-1 (Expository method of teaching, meaningful learning, discovery learning, inquiry-based learning)
#Week6	Instruction approach and theories-2 (Multiple intelligence theory, constructivism, cooperative learning)
#Week7	Mastery learning model, model of school learning, Gagne's model of instruction design, Glasser's model
#Week8	Problem-based learning, project-based learning, 5E instructional model, brain-based learning
#Week9	Question-answer, problem-solving, direct instruction, Socrates technique, metaphor
#Week10	Brainstorming, group discussion techniques, drama, role-playing, micro-teaching, Jigsaw
#Week11	Six thinking hats, six action shoes, producing an idea, mind mapping, diagonal, ball bearing
#Week12	Station, speech ring, aquarium, snowball, game-based learning, scaffolding, Ishikawa, V diagram
#Week13	Simulation, programmed learning, computer-based instruction, individualized instruction
#Week14	Case method, demonstration, field trips, card matching, bazaar, bingo
#Week15	Post-tests

The same procedure was followed for both FC groups. The only difference was that the instructor used bit-sized contents by sharing them on the Edmodo app in the m-FC group. An LMS platform was used to share out-of-class learning contents in both FC groups. Figure 1 illustrates the experimental procedure. At the end of the experiment, post-tests were performed. After that, follow-up interviews were conducted with 14 PTs in both FC groups. The PTs were interviewed from June 12, 2022, to July 21, 2022.

The implementation was carried out in the scope of a compulsory course titled "Teaching Principles and Methods" offered at education faculties in Turkey because of its importance for PTs' professional development. The purpose of this course is to provide PTs with the necessary knowledge and skills in terms of teaching principles, techniques, and methods in the learning-teaching process, curriculum development process, and planning. This course is suitable for the FC model thanks to its nature of combining theory and practice in teacher education. The same instructor, with 15 years of seniority, taught in all three groups of this study with the same course syllabus. Before the implementation, the instructor was informed about the FC approach and its instructional design. Table 1 shows the weekly subjects of the course in the groups throughout the implementation process.

On the other hand, the non-FC group practiced the traditional (instructor-based) instruction mode. The instructor taught using question-answer and PowerPoint slides techniques in the classroom. The students usually completed homework after

class. The PTs in the non-FC group were subjected to the same subjects and concepts with both FC groups.

3.3.1 Out-of-class learning activities for the FC groups

An LMS platform was used to share the out-of-class instructional materials in the FC groups on a weekly basis (See Fig. 2). The platform offers the video-watching and document-clicking analytics of every PT in both FC groups. A total of 41 instructional videos were created by using Adobe Premiere software for this study. The average duration of the videos was 5.89 min (Min = 2.03 min, Max = 12.32 min, *SS* = 2.65). The different video types, recommended by Fidan and Debbag (2023), were used to improve the effectiveness of learning in the FC environments. All videos had the instructor's own narration. Figure 3 shows sample screenshots of these videos.

EdPuzzle app was used to make it easier to follow the videos and increase the interaction (see Fig. 4). Unlike a traditional video editor, EdPuzzle enables users to add several interactive features such as questions or notes to the specific parts of videos and video-cropping. Thanks to this feature, several notes and short questions were added to certain points of the videos to enhance the interaction.

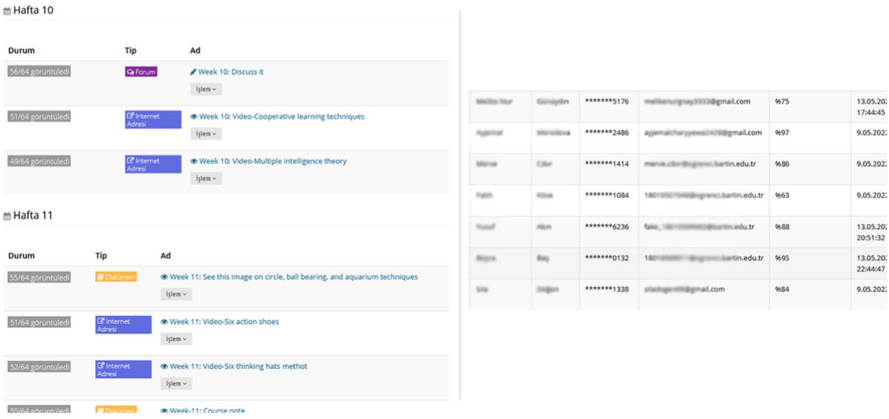

Fig. 2 A screenshot of the document activities following rates on LMS in both FC groups (out-of-class)

Fig. 3 Examples of instructional video types used for FC groups

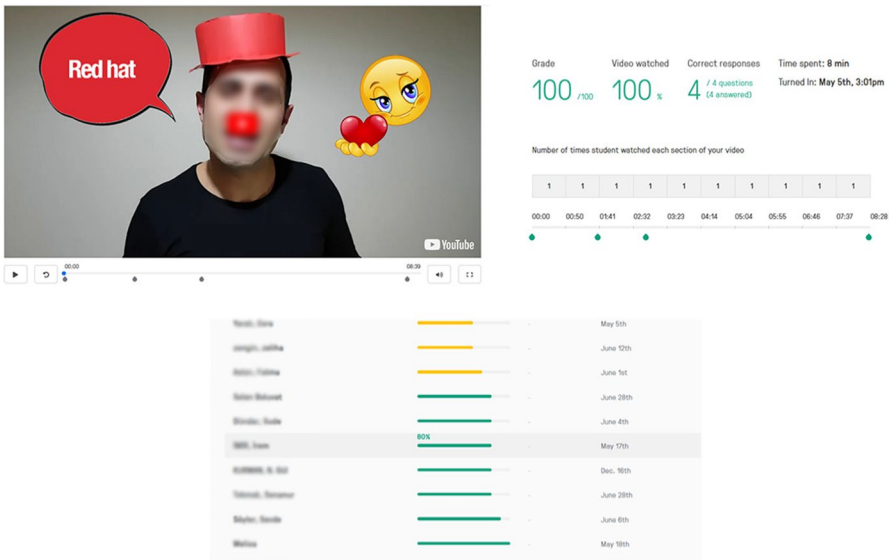

Fig. 4 An example screen of video watching rates by using Edmodo in both FC groups (out-of-class)

The PTs could also pause and resume the instructional videos at any time. EdPuzzle video links were shared for both FC groups on the LMS per week. Unlike the t-FC group, all PTs in the m-FC group used their mobile devices to access the microlearning contents (short-term video segments, fast-answer questions, informative visual posts, fast-completion assignments, and polls). Firstly, they installed the Edmodo app on their devices to follow these contents, accomplish tasks, and interact with each other (commenting, liking, voting, etc.).

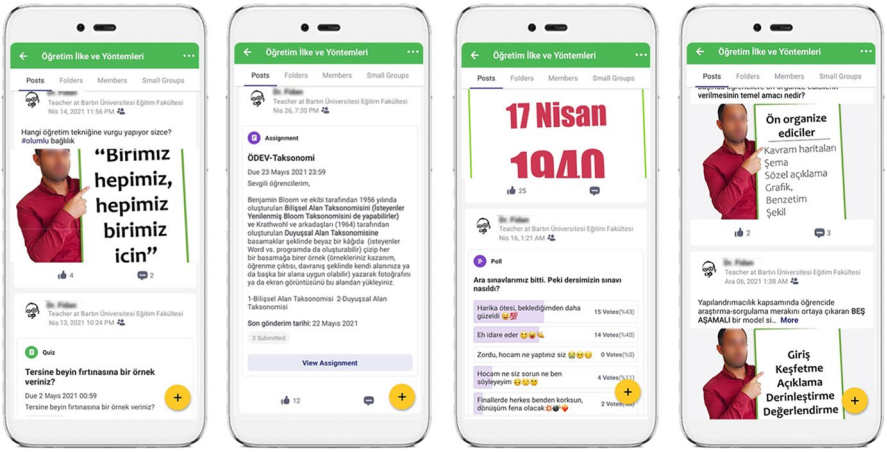

Fig. 5 Mobile screenshots of microlearning contents as out-of-class activities in m-FC group

Fig. 6 Students responded by commenting for a microlearning content in m-FC group

Edmodo, one of the most popular educational social network sites (Unal & Uzun, 2021) with its structure similar to that of Facebook and others, offers to create assignments or quizzes, share videos, pictures, polls, and documents, and manage these activities through a social learning management system. As a safe and free media, Edmodo is a potential environment for feedback, discussions, and group works within educational contexts (Fig. 5).

When an instructor shared the instructional microcontents, reminder messages or instant notifications were sent to PTs' mobile devices for their access. Accordingly, they were informed about the weekly posts. Some visual posts had the instructor's human embodiment, image, and highlights. Figure 2 shows the Edmodo screenshots of the microlearning contents. They consist of learning chunks (short questions, informative images, or case-based videos) that students can comment under the posts. These contents were designed by using Adobe Premiere, Photoshop, and Illustrator software programs. Mayer's (2009) Cognitive Theory of Multimedia Learning principles and Sweller's (2011) Cognitive Load Theory guided us in designing the videos and images for both FC groups. Then, the PTs commented on a microlearning contents, liked, and responded to each other's answers. Figure 6 shows a sample screenshot on commenting the PTs for a microlearning content.

3.3.2 In-class learning activities for the FC groups

During the in-class learning process, the PTs participated in learner-centered activities such as problem-based activities, collaborative tasks, discussions, and brainstorming. The course was conducted in three sessions per week and lasted for 75 min in total. In-class learning activities were identical in both FC groups.

Fig. 7 Examples from in-class student-centered activities

At the beginning of the F2F course in the class, the instructor gave feedback about the out-of-class activities and asked reminder and corrective questions on main concepts or topics in 10 min. For instance, FC groups watched a video including the six thinking hats technique shared on LMS before coming to the classroom. They discussed an issue using this technique after coming to the classroom. They brought a lot of equipment (cartons, scissors, colored pens, etc.) to practice some techniques in the classroom. Almost all of the activities were held in groups. Several roles such as speaker, timer, and group leader were distributed among the group members during group work. Moreover, each group had a name for itself. The instructor had a guiding role during in-class activities. In another example, the instructor confronted the PTs with a problem situation in the teaching profession. Each group discussed the problem within themselves and presented to the other groups their proposals for the solution to the problem in the classroom. Figure 7 shows some examples from the in-class group activities.

3.4 Instrument

Learning performance A pre-test and post-test were used to determine the PTs' knowledge level about Teaching Principles and Methods course (see Table 1 for

QUESTION-5

To complete a story, Mr. Ince (teacher) determined three corners for language teaching in the classroom. While the first corner is the area of determining the main idea of the story, the second corner is the area of rewriting the story. The third corner is also the area of creating a poster about the story. The students in the classroom were divided into three groups. Then, they completed their tasks by teamwork in every corner.

Which instruction technique did the teacher use for language teaching?

A) Station ✓ B) Attention groups C) Cornering D) Producing an idea E) Jigsaw

Fig. 8 A sample question from the learning performance test

subjects). It is one of the pivotal courses for their professional development. The test consisted of 20 multiple-choice and 5 fill-in-the-blank questions, with total score of 100. Two experts' opinions were taken for content validity of the test. A pilot study was performed on 84 PTs, regardless of the sample of this study. Pilot test consisted of 36 items (27 multiple choices, 9 fill-in-the-blank questions). Because of poor reliability, 11 of them were removed from the test. The item difficulty indexes of test ranged from 0.23 to 0.78. The difficulty index of overall test was calculated as 0.52. The item distinctiveness indexes of test ranged from 0.35 to 0.58. The distinctiveness index of overall test was calculated as 0.47. The internal consistency value (KR-20) was 0.88. Figure 8 shows a sample multiple-choice question.

Learning motivation Motivated Strategies for Learning Questionnaire (MSLQ) was conducted to investigate the course motivation level. Turkish version of this questionnaire was adapted by Buyukozturk et al. (2004) to measure both learning strategies and motivation. The original version, a well-validated instrument, was developed by Pintrich et al. (1993). In this study, 17 items with 7-likert type (ranged from 1-"not at all true of me" to 7-"very true of me") from three MSLQ subscales were used in this study: intrinsic motivation (4 items, sample item: "In this course, I prefer course material that arouses my curiosity, even if it is difficult to learn"), extrinsic motivation (4 items, sample item: "If I can, I want to get better grades in this course than most of the other students"), and self-efficacy (9 items, sample item: "I'm confident I can do an excellent job on the assignments and tests in this course"). The Cronbach's alpha values of these subscales were calculated as .88, .86 and .90, respectively. These findings showed that internal consistency of all scales was sufficient (> .70).

Student engagement Two questionnaires were adapted to Turkish: emotional engagement scale by developed (Jamaludin & Osman, 2014) and behavioral engagement scale by developed (Lai et al., 2021). Emotional engagement scale consisted of 5 items and used 7-point Likert type, from 1: Strongly disagree

to 7: Strongly agree (a sample item: "I enjoy learning new things in online course"). Its theoretical framework is based on Reeves (2013). The Cronbach's alpha value for emotional engagement was 0.84. To ensure the validity and reliability, items were translated to Turkish language by taking experts' opinions (n = 4) and conducted a pilot study on 98 PTs. Confirmatory Factor Analysis results showed that the structure of model was satisfactory ($\chi 2 / (df) = 2.80$, $CFI = 0.95$, $TLI = 0.94$, AGFI = 0.87, $RMSEA = 0.056$, $SRMR = 0.048$), indicating good fit indexes of the scale (Tabachnick & Fidell, 2007). Behavioral engagement scale consisted of six items. These items were readapted for both experimental and control groups. It presents the involvement in activities (e.g., discussion, answering question), learning efforts, paying attention, observed behaviors for in-class and pre-class activities. The Cronbach's alpha value for emotional engagement was 0.81.

Follow-up interviews Semi-structured interviews were performed to investigate the PTs' perceptions of the experimental process in depth (e.g., Edmodo and LMS use outside the classroom, instructional contents, and student-centered activities in the class) in the FC groups. Each interview lasted between 22 and 45 min ($M = 32.44$ min, $SD = 6.74$). It contained 6 open-ended questions which mainly covered the experimental process consisting of in-class (practice-oriented activities) and pre-class (microlearning and LMS materials) FC activities. These questions were asked in all the interviews in Turkish. The semi-structured interview questions were as follows:

1. How did the instructional contents on Edmodo contribute to you? Please, give details about its benefits (For the m-FC group).
2. What do you think about the educational usability of Edmodo? Please, share your experience. (For the m-FC group).
3. Which challenges did you encounter while using Edmodo? Please, give details about its difficulties. (For the m-FC group).
4. What do you think about the FC model used in the experimental process which combines in-class and pre-class activities? (For both the m-FC group and t-FC group).
5. What do you think about in-class activities? What kind of skills did you acquire through these activities and how did they contribute to your learning?) (For both the m-FC group and the t-FC group).
6. What were the advantages and limitations of the course contents on the Learning Management System? (For both the m-FC group and t-FC group).

3.5 Data analysis

To test whether there was a difference in students' learning performances between the flipped classes and conventional classes, a Univariate Analysis of Covariance (ANCOVA) test was conducted. Before ANCOVA test, the normality distribution of

data was controlled by skewness and kurtosis values. The age, gender, and pre-tests were evaluated on post-tests as covariate variables. For effect size of F tests, partial eta squared ($\acute{\eta}2$) was reported.

With respect to qualitative data collection, each interview session was conducted in good times on Zoom and audio-recorded. Then, the data obtained were transcribed verbatim fully. Thematic analysis framework (Braun et al., 2019) was used to analyze the interview data in this study. Firstly, interview data coded by reviewing and entitled by gathering similar codes under themes. To ensure reliability, two academics also coded the qualitative data and categorized the codes. The inter-coder reliability was adequate (Cohen's $k = 0.89$). Qualitative findings were supported by direct quotations from the participants.

4 Findings

4.1 Quantitative results

4.1.1 Preliminary analysis

Firstly, prior to ANCOVA and paired sample t tests, pre- and post-test values were checked for normality. As the skewness (ranged from −0.21 to 0.39) and kurtosis (ranged from −14 to 0.42) values were between +2 and −2 (Kline, 2015) for all variables, the normality distribution condition was acceptable. In addition to, the Shapiro Wilk coefficient was tested whether the data were normally distributed or not, showing satisfactory of normality ($p > .05$) for all variables. Then, the regression coefficient homogeneity tests were checked for ANCOVA. The results showed that this assumption was confirmed for all variables ($p > .05$).

Table 2 Descriptive statistics

Variables	m-FC ($n = 43$)		t-FC ($n = 39$)		non-FC ($n = 46$)	
	Pre-test M^a (*SD*)	Post-test M^a (*SD*)	Pre-test M^a (*SD*)	Post-test M^a (*SD*)	Pre-test M^a (*SD*)	Post-test M^a (*SD*)
Learning performance	37.20 (7.50)	81.18 (10.56)	38.97 (10.71)	78.20 (9.89)	36.30 (8.65)	70.86 (11.44)
Intrinsic motivation	4.18 (0.87)	6.32 (0.83)	4.14 (0.67)	5.86 (0.57)	4.23 (0.85)	4.87 (0.70)
Extrinsic motivation	4.16 (0.64)	3.33 (1.02)	4.24 (0.89)	3.72 (1.29)	4.02 (0.72)	4.23 (0.67)
Self-efficacy	3.83 (0.53)	5.83 (0.72)	3.66 (0.92)	5.40 (1.02)	3.90 (0.64)	4.75 (1.25)
Behavioral engagement	3.47 (0.65)	6.51 (0.88)	3.62 (1.24)	4.95 (0.85)	3.68 (0.75)	3.90 (0.63)
Emotional engagement	3.99 (0.96)	6.39 (0.80)	3.64 (0.92)	5.62 (0.80)	3.96 (0.94)	4.26 (1.05)

[a]The scales are in 7-point Likert type for all variables, excluding the learning performance

Before experimental process, a series of ANOVA was performed to investigate the equivalence between groups. No significant differences were found between pre-test scores of all variables ($p > .05$). The findings implied that the groups are equivalent and homogenous. Table 2 shows descriptive statistics of pre- and post-tests. A series of ANCOVA of post-test scores was performed to evaluate these findings more reliable by controlling pre-test scores of all variables (covariates).

Learning performance As illustrated in Table 3, the ANCOVA results showed that there was statistically a significant difference between both FC groups and non-FC group in terms of learning performance ($F = 9.98$, $p < .05$) with a medium effect ($\acute{\eta}2 = 0.13$). m-FC (Adj. $M = 81.47$) and t-FC (Adj. $M = 77.81$) groups had adjusted post-test means higher than non-FC group (Adj. $M = 71.14$). However, there was no significant difference between m-FC and t-FC groups ($p > .05$). The findings implied that the PTs who learned with FC groups had better learning performance than those who learned with the traditional instruction.

Learning motivation As demonstrated in Table 3, it was found that there was statistically a significant difference between both FC groups and non-FC group in terms of intrinsic motivation ($F = 47.63$, $p < .05$) with a large effect ($\acute{\eta}2 = 0.43$). m-FC (Adj. $M = 6.32$) and t-FC (Adj. $M = 5.86$) groups had intrinsic motivation post-test means higher than non-FC group (Adj. $M = 4.87$). Importantly, the PTs in the m-FC group had also intrinsic motivation scores significantly higher than the PTs in the t-FC

Table 3 ANCOVA results of the post-tests

Variables	m-FC ($n = 43$)		t-FC ($n = 39$)		non-FC ($n = 46$)		F	$\acute{\eta}2$	Post-hoc[b]
	Adj. M^a	SE	Adj. M^a	SE	Adj. M^a	SE			
Learning performance	81.47	0.16	77.81	0.18	71.14	0.16	9.98*	0.13	1 > 3 2 > 3
Intrinsic motivation	6.32	0.10	5.86	0.11	4.87	0.10	47.63*	0.43	1 > 2 2 > 3 1 > 3
Extrinsic motivation	3.31	0.13	3.66	0.14	4.30	0.13	13.53*	0.16	1 < 3 2 < 3
Self-efficacy	5.82	0.15	5.48	0.16	4.69	0.15	14.29*	0.18	1 > 3
Behavioral engagement	6.49	0.24	4.87	0.24	3.90	0.23	29.65*	0.32	1 > 2 2 > 3 1 > 3
Emotional engagement	6.35	0.13	5.70	0.14	4.26	0.13	67.68*	0.52	1 > 2 2 > 3 1 > 3

* $p < .05$, m-FC:1, t-FC:2, non-FC:3

[a]The scales are in 7-point Likert type for all variables, excluding the learning performance

[b]Bonferroni post hoc test were chosen for multiple comparisons

group ($p < .05$). It is inferred that microlearning supported FC activities improve the PTs' intrinsic motivation.

With respect to extrinsic motivation, findings from ANCOVA indicated that there was a significant difference between both FC groups and non-FC group, ($F = 13.53$, $p < .05$) with medium effect ($\acute{\eta}2 = 0.16$). m-FC (Adj. $M = 3.31$) and t-FC (Adj. $M = 3.66$) groups had extrinsic motivation post-test means lower than non-FC group (Adj. $M = 4.30$). The results indicated that while FC mode increases intrinsic motivation, it has the effect of decreasing extrinsic motivation. Moreover, it was found that m-FC had significantly better self-efficacy level than non-FC groups ($F = 14.29$, $p < .05$). However, there was not a significant difference between FC groups ($p > .05$).

Student engagement As shown in Table 3, a significant difference was found between both FC groups and non-FC group in terms of behavioral engagement ($F = 29.65$, $p < .05$) with a large effect ($\acute{\eta}2 = 0.32$). Specifically, m-FC (Adj. $M = 6.49$) and t-FC (Adj. $M = 4.87$) groups had behavioral engagement post-test means higher than non-FC group (Adj. $M = 3.90$). More importantly, the mean of m-FC group was significantly high compared to the mean of t-FC group in terms of behavioral engagement.

With respect to emotional engagement, the findings showed that there was statistically a significant difference between both FC groups and non-FC group ($F = 67.68$, $p < .05$) with a large effect ($\acute{\eta}2 = 0.52$). In other words, the PTs' emotional and behavioral engagement levels in the m-FC significantly increased after experimental process compared to other groups. Moreover, the PTs who learned with traditional flipped mode had better engagement than those learned without FC model.

4.2 Qualitative results

The researcher interviewed the PTs in both FC groups about the experimental process. Firstly, the PTs in the m-FC group mostly expressed positive opinions on microlearning activities. Their opinions were grouped under two categories: benefits and challenges of the m-FC. Table 4 shows the categories and codes with quotes from PTs' opinions. These findings are related to the pre-class microlearning contents of the course shared on Edmodo.

Secondly, the PTs in both FC groups had positive opinions about both the out-of-class (learning contents on LMS) and in-class activities of the FC models. Most of them reported that the content shared on LMS (especially instructional videos) was effective for their learning. One PT from the m-FC group highlighted the accessibility of the system from anywhere, the effectiveness of learning with visuals, autonomous learning, and the elimination of time restrictions for learning saying *"I learn the course subjects wherever and whenever I want. It offers autonomy for learning and provides an environment for effective and permanent learning… The videos are really catchy… The questions integrated into EdPuzzle*

Table 4 Qualitative results

Categories and codes	Quotes
Benefits of m-FC • Providing permanence in learning • Supporting discussion • Supporting learning at any time • Facilitating learning with visual chunks • Increasing curiosity and interest • Supporting social learning and interaction • Enhancing techno-pedagogical skills • Increasing professional skills. • Increasing language skills • Following the bite-sized learning contents periodically • Reducing cognitive load • Encouraging learning with fun • Enabling students to progress at their own pace. • Obtaining foreknowledge for in-class activities.	*PT8: "Using Edmodo was very enjoyable. It is just like Facebook and Instagram. The images and videos shared on it were of very high quality. It was colorful and eye-pleasing. They were also not tiring. There were no long texts. The shortness of the posts made it easy for me to learn. Having coded expressions (like KEBAB) increases the permanence of learning. My interest in the course increased thanks to short notes. Before the course, I learned the basic subjects by researching them with increased curiosity… Edmodo is not much time-consuming, it provides an effective learning environment without boring learners and overloading information…"* *PT11: "The posts were pretty good. Sharing the summary of lengthy subjects was very helpful in terms of readability and comprehensibility. Its accessibility from anywhere at any time allowed us to reach the information whenever we wanted. It helped me to get brief information about the subject tirelessly and curiously before the class. Edmodo is easier and more practical than LMS. LMS is more formal and standard, but Edmodo is warmer. It is the educational version of Facebook. I will also use it when I become a teacher…"* *PT15: "Edmodo helped me to directly have information about the course content. The content and visuals shared before the lesson provided us with a short preparation period prior to the F2F sessions. The fact that our instructor created his/her own content and seeing him/her in the materials attracted me to learn more. When I receive a notification from Edmodo, it instantly calls my attention and I feel curious about what to learn during the week… It has become a routine for me…"*
Challenges of m-FC • Technical issues • Lack of language support • Extra workload • Being Tiring	*PT3: "There is an internet quota in my dormitory and I cannot check the posts regularly."* *PT5: "I was not able to follow the posts because of the quota of my internet. I checked them all when I had the access to the internet. I occasionally had language problems. Even though it included Turkish language support, some functional buttons were written in English."* *PT12: "…Sometimes it seems like a workload at home. I feel obliged to do the assignments on Edmodo. I also have assignments for other courses. They all sometimes become tiring outside the school hours."*

reinforced my learning and I revised the subjects." Moreover, some PTs expressed positive opinions on its guidance for classroom activities. For example, PT5 from the t-FC group mentioned this with the following statements: *"It helped us to have some prior information for the in-class activities. Home assignments should be short but to the point and they should not be boring for us. The materials shared on LMS supported us in learning and studying by being an additional resource for our exams"*. Most of the PTs in both FC groups ($n=9$) had positive opinions on in-class active learning practices, especially collaborative activities. PT9 from the t-FC group explained as follows:

> *"The group works carried out in the classroom were very helpful for the longer-term retention of the methods and techniques. Simulations, games, and*

brainstorming activities contributed to my learning. It is better for us to be active in the classroom as students rather than the instructor's direct lecturing. Thus, classes are not boring but enjoyable."

Comparatively, most students (n = 9) from the m-FC group also stated that Edmodo was more useful and warmer for learning than the LMS. In addition to the LMS, they mainly prefer complemental interactive applications without too many additional applications. PT5 stated his/her opinion about this issue as follows:

"It's nice that all materials are shared regularly on the LMS. I can study the video and course document I want to on the system. However, the posts shared by our instructor in Edmodo seem warmer to me. The reason for this is that the content is not boring, we can make comments on the posts. It looks like Instagram. Every Sunday, our instructor shares posts here… I receive a notification message and automatically check it out. I wonder what my teacher will share next week. LMS seems more formal and exam-oriented. Edmodo posts are more permanent, I don't forget the images there stick in my mind."

On the other hand, some of the PTs had several opinions about technical problems and poorly- designed materials. One student from the m-FC group made a comment saying that *"I could not access the system regularly every week and check the uploaded materials because I had no internet connection… There were times I had to come to the class without any preparation… The quality of some videos was bad… However, I think the content of them is generally of good quality.*"

5 Discussion

The results of this study indicated that both the microlearning-supported FC model and the traditional FC model had positive effects on the learning performance, motivation, and engagement of the PTs. Specifically, the PTs who were taught through the FC approach had higher learning achievement and motivation compared to the non-FC group. These findings are consistent with the results in previous studies on teacher education (Debbag & Yildiz, 2021; Schwichow et al., 2022) indicating that the FC model could increase academic achievement in the course. Microlearning contents of FC, namely video lectures, encouraged PTs to gain prior knowledge for the course by offering a flexible and active environment (Strelan et al., 2020). Even if the empirical studies on microlearning are scarce, the findings of this study indicated that the m-FC better improved learning motivation than both the t-FC instruction and traditional instruction, which was in line with previous studies (Debbag & Yildiz, 2021; Yough et al., 2019). This result can be associated with the design of out-of-class microlearning activities which allowed self-paced learning, feedback mechanisms, enriched interactive bite-sized materials (small and sweet, but investigative chunks), accessibility from anywhere anytime, and the social media mood. These are limited in traditional learning environments. The harder the subjects covered in the traditional instruction are, the greater the need for scaffolding support

becomes. With the support of teachers and peers, difficulties can be reduced in the classroom (Kossen & Ooi, 2021). Because of the difficulty of learning through OL, microlearning may be a potential pedagogy to reduce this challenge. There is a concern that microlearning may seem a barrier to deep learning. For this, microlearning contents or tasks should be not only in the form of small and sweet chunks but also balanced, thought-activating, investigative, disputable, and useful.

Further findings indicated that microlearning contents helped students develop an intrinsic interest in the assignments and critically discuss the concepts by reducing extrinsic motivation. While one-way video lectures in the pre-class stage mainly addressed to student-content interaction, microlearning contents provided an attractive environment with several opportunities to enhance learners' critical thinking, student-student interaction, collaborative learning, and the comprehension of new concepts or subjects. Moreover, PTs' learning efforts were more self-directed in the m-FC model than in the instructor-centered model in both pre-class and in-class stages. Yin et al. (2021) similarly found that microlearning-based chatbot learning model had a positive impact on intrinsic motivation compared to the traditional learning in a basic computer course. From the perspective of SDT, students with higher intrinsic motivation will learn more autonomously because they enjoy the learning activities more. Another reason for the development of intrinsic motivation in learners may also be peer feedback given by commenting on the contents. According to Ryan and Deci (2017), students were more intrinsically motivated when they were engaged in group activities and interacted with each other.

In particular, these results on engagement exceeded the researchers' expectations and the m-FC model showed promising results for teacher education compared to the t-FC group. More specifically, although the implementation period was relatively long (14 weeks), PTs learned the subjects by participating actively in the interactive activities without getting bored. In this study, the traditional FC model also successfully promoted students' engagement. From a theoretical perspective, cognitive, behavioral, and emotional components are outstanding pillars of engagement (Fredricks et al., 2004). The effect of the m-FC was most notable on emotional engagement, followed by behavioral engagement. The PTs in the m-FC group were satisfied with the microlearning contents and pre-class activities encouraged students to enjoy the course. This was mainly because these contents directly included the instructor's own images, had sympathetic content and motivating feedback, and were not time-consuming. Recent studies by Zheng et al. (2020) and Wang et al. (2022) which investigated FC and self-regulation also showed that the effective assistance or guidance of both teachers and peers promoted student learning by enhancing self-efficacy, motivation, and self-regulation.

Most of the instructional videos used in both FC groups had also the instructor's image and guiding questions. In particular, the behavioral engagement of learners is critical for the success of FC (Lai et al., 2021). The improvement in engagement may partly be due to Edmodo's interactive features such as commenting, short questionnaires, reaction plugins, sharing posts, assignments, feedback, and gamification components. It should be noted that sharing micro contents weekly (like Instagram, and Facebook) is an important factor that increases students' engagement. Similarly, Bond (2020) suggested that collaborative technologies such as Edmodo and Google

Classroom were closely associated with student engagement. Förster et al. (2022) emphasized that watching the pre-class videos timely or following the contents are key determinants for the success of FC. Similarly, a study by Jovanović et al. (2019) demonstrated that studying regularly develops the time management skills of students in OL and affects the success of FC positively. In this context, microlearning offers an opportunity for time-constrained university students by providing an attractive and engaging learning environment.

Qualitative data from the interviews demonstrated that the PTs had broadly positive perceptions regarding the classroom activities of FC. On the other hand, importantly, learners of the m-FC group acknowledged greater motivation for and engagement in pre-class activities than the t-FC group. This might be due to the fact that the integration of microlearning activities into the FC model requires PTs to have a more active role outside the classroom reducing the cognitive load and to work together on group practices in the classroom. Concerning the challenges that PTs face in the m-FC model, it was underlined that their main concern was mostly about the workload of course besides technical problems. Course-based activities can be time-consuming and boring for students, especially outside the classroom. Although microlearning activities provide sufficient support for their intrinsic motivational orientations and online course engagement, more fun and adaptive learning activities such as gamification and personalized scenarios may strengthen the flow and interaction in the course.

6 Conclusion

Unlike previous studies on FC, this study focused on the effectiveness of the integration of microlearning into this approach on learning performance, motivation, and student engagement in teacher education. The data obtained from the PTs' opinions provide substantial support for using microlearning to increase the behavioral and emotional engagement of students and enhance their intrinsic motivation. The qualitative findings suggest that microlearning contents facilitate learning with visual chunks and reduce cognitive load. Moreover, PTs were more interested in the course as the online platform was similar to a social media environment.

The recent study has several educational implications for researchers, educators, and policymakers. First, it can be seen that bite-sized learning materials have the potential to enhance learning motivation and student engagement, especially with the out-of-class activities of FC. Traditionally, instructional activities on LMS can be perceived as a more formal learning environment for the PTs. Actually, it can be said that they prefer a social learning environment (like Instagram) which includes fun, friendly, and interactive visual-based microlearning contents. Practitioners are advised to integrate interactive tools and applications into the LMS platforms. Hence, instructors should be trained in designing microlearning materials. As the quality of instructional design and the interaction in OL gets lower, the levels of behavioral engagement and, consequently, motivation decrease. An LMS platform can be designed with interesting features that increase learner engagement

by including elements such as gamification, deductive feedback, contest, scheduled tasks, artificial intelligence-supported adaptive components, and a social network module. Periodically, instructor can share bite-sized contents that motivate learners and strengthen their confidence through a social learning application like Edmodo.

As for the limitations of the current study, while the sample of this empirical study was relatively large, the generalizability of the findings is limited. It is recommended that further studies may be replicated on samples from different institutions. Future studies can examine using microlearning in the FC approach in relation to the variables such as cognitive load, cognitive engagement, and self-regulation skills. This study guides meaningfully the integration of microlearning with FC in teacher education. However, it is noteworthy to investigate comparatively the integration of different instructional strategies and emerging technologies into the FC model. Moreover, in the future, researchers should conduct modeling or correlational studies on the variables affecting FC. It is also notable that learning contents created through microlearning, scenario-based learning, game-based learning, or gamification techniques which increase the flow and interaction can be included as pre-class activities as well as the conventional learning materials (video lectures, slides, etc.).

Data availability Data will be available on reasonable request.

Declarations

Conflict of interest The author has no conflicts of interest to declare.

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