# Blended learning and the flipped classroom: the potential effect to enhance students' mathematical proficiency and self-efficacy:

## a mixed methods study from Saudi Arabia

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# Abstract

The flipped classroom (FC) is becoming an increasingly popular teaching method in education. However, current FC studies often underutilise conceptual frameworks and pedagogical designs. Moreover, few studies have rigorously evaluated the effectiveness of FC, and even less so in countries where students' level of mathematics achievement is low. The research presented in this thesis contributes to the existing literature by evaluating the effectiveness of the FC approach in Saudi Arabia with relevant theoretical designs based on empirical principles. The study used a mixed methods approach that involved collection and analysis of quantitative and qualitative data. A total of 281 high school students (5 teachers in 4 different schools) participated in the study lasting 9 weeks. The study examined the impact of FC on students' mathematics performance and self-efficacy, as well as the perceptions of both students and teachers towards their experience with the FC. Rigorous statistical analysis (i.e., mixed effect models) were used to analyse the quantitative data while acknowledging the clustered nature of the study. The findings showed that students who received the FC instruction had higher self-efficacy but no significant difference in math proficiency was observed. Students' questionnaires and teacher' interviews indicated that overall, they had positive attitudes regarding the FC implementation. The qualitative analysis suggests that FC could enhance teaching and learning by offering more time for active learning opportunities, interactions and feedback in the classroom session. In addition, video lectures provide easy access and an effective flexible learning environment for students at home. However, teachers indicated that the FC needed a learner to take responsibility for their learning, better technology infrastructure and professional development training to progress FC implementation in practice. Overall, the research provides insights into the potential impact of FC on student learning and teacher practices for teachers, educators and policymakers in Saudi Arabia and other contexts.

**Keywords**: flipped classroom, mathematics, proficiency, self-efficacy, students' and teachers' perceptions

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# Declaration

I declare that this thesis is a presentation of original work, and I am the sole author. All sources are acknowledged as References. This work has not previously been presented for an award at this, or any other, University with the exception of the following:

**Publications and Conferences**

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# Chapter 1 : Introduction and Background

## 1.1 Introduction

The aim of this thesis is to evaluate the potential effect of the flipped classroom (FC) instructional approach on students' mathematical proficiency and self-efficacy in high school settings. This initial chapter provides an overview of the field, to identify the landscape that forms the basis of this study. The first aim is to explain the increasing popularity of the FC approach. The study's context and the components that shape learning in the Saudi context will then be examined. Then the broad aim and objectives of the research are presented, and the study's significance is highlighted. An outline of the thesis structure is also provided.

## 1.2 Background and Rationale

Although educators have often debated the best way to deliver content in the classroom, previous research has called into question the traditional teaching approach, where most of the available time is spent on lectures with very little interaction between students and teachers (Butler, 1992; Omelicheva & Avdeyeva, 2008). This is particularly the case in practical subjects, such as science, technology, engineering, and mathematics (STEM), where more application of knowledge and collaboration with the class is required (Brown et al., 2011). Active learning is suggested as an alternative to lectures, and is an instructional method that engages students with course materials via problem solving, discussions, and better knowledge retention, which improves understanding of the course concepts (Prince, 2004). Unlike lectures, active learning places more responsibility on the student. However, guidance from a teacher remains important. Previous research has demonstrated the positive influence that active learning can have on students' learning, engagement, achievement, and positive attitudes toward learning, compared to lectures (Blasco-Arcas et al., 2013; Hyun et al., 2017). Michael (2006) states that although active learning is beneficial, it does not simply happen; it occurs when the teacher creates a learning environment that facilitates it. This implies that teachers should introduce changes to promote active learning in the classroom. For years, teachers have always said that limited time is available for introducing new teaching strategies and meeting the learning needs of every student alongside the other multiple demands placed upon them

(Davis et al., 2006). The inadequacies of the traditional approach have given rise to new instructional approaches, which include advances in learning technology and new pedagogical models intended to improve the learning performance of students. Additionally, students and teachers now have 24/7 access to knowledge via the internet and video-friendly social media sites. This increase in technology dissemination and usage among both teachers and students encourages more educational instructional approaches that depend on technology to function, such as blended learning in K12 (primary and secondary education), and higher education. For example, blended learning, in which learning can be carried out flexibly and anywhere at any time, in addition to an environment where learning takes place in person combines instructional modalities (or delivery materials) and methods (Horn & Staker, 2012). Blended learning is now widely considered the most effective mode of instruction because of its flexibility and the fact that it provides continuous, timely learning (Porter et al., 2014).

Much research has emphasised the fact that blended learning can support teachers' instructional practices in the classroom by combining online learning and classroom time (Singh, 2021). The design of a blended learning environment involves a number of various blends. One of these is the FC, which has been examined by many researchers in both K12 and higher education (Lo & Hew, 2017). Bishop and Verleger (2013) defined this as an educational method formed of two parts: interactive group learning activities inside the classroom, and direct computer-based individual instruction outside the classroom. The pedagogical model moves from using a traditional teacher-centred approach to the traditional classroom dynamic, which focuses on student-centred learning as part of the lecture takes place outside of the classroom, where this then becomes a pre-learning activity, and classroom time is used for engaging students in active learning activities (Bergmann & Sams, 2012). Because students can watch videos explaining the lecture topic at home, most of the class time is then free for hands-on activities, examples of real-world applications, in-depth discussions, and other collaborative activities, which there is now time to include in the lesson (Roehl et al., 2013). Therefore, the FC does not remove any of the lecture's importance; instead, the lecture is thus converted from an in-person, in-classroom instructional component to an out-of-class homework activity that involves viewing lecture videos (Bergmann & Sams, 2012).

The main reasons for introducing the FC are that it can provide more feedback and interaction in the classroom, active and inquiry-based learning, flexibility, effective use of class time, and (so it is claimed) improves the learning outcomes of students (e.g., Awidi & Paynter, 2019; Bhagat et al., 2016; Chen et al., 2016; Lo et al., 2018). Several experimental studies and researchers have observed or measured positive changes in the academic achievement, and other factors such as satisfaction, motivation, and student creativity (Al-Zahrani, 2015; Guerrero et al., 2015; Lo and Hew, 2017; Lia and Hwang, 2016; Zainuddin & Perera, 2019). In mathematics education, the context of the current study, the potential of the FC has attracted attention as a response to the struggles reportedly faced in high school mathematics classes, where there are issues of poor student performance (Offer & Bos, 2009). In fact, mathematics educators face a major challenge in improving students' performance in mathematics (Gersten et al., 2009). Low mathematics achievement is reported in many contexts around the world and many researchers and educators are working hard to address this issue, suggesting different approaches that might help to overcome this problem. With this in mind, use of the FC in mathematics education has been studied and evaluation of effectiveness and student perceptions are frequently measured outcomes in research. The results across various studies are, however, inconsistent. Some studies have found the FC to have a significant effect on students' mathematical performance (e.g., Bhagat et al. 2016; Lo and Hew, 2017; Lo et al., 2018), while others showed no evidence of effectiveness (e.g., Love et al., 2014; Clark, 2015; Guerrero et al., 2015; Vang, 2017; Yong et al., 2015). Critical evaluation of the previous studies showed that this may be attributed to differences in the design and methodology adopted by different researchers, which will be discussed further in the next chapter. Another issue to be addressed is self-efficacy, since students are required to regulate their behaviour through cognitive methods and develop better ways for efficient learning within appropriate learning environments (Bandura,1989). This means that effective learning strategies need to be incorporated into the learning process to improve the self-efficacy of students. Self-efficacy is a measure of a student's confidence in their ability to perform a task successfully. It affects students' choices and future career (Abele & Spurk, 2009). Self-efficiency is vital for mathematics as research has shown a positive relationship between self-efficacy and mathematical achievement (Hackett & Betz, 1989; Skaalvik et al., 2015). Students often have challenges that demand a considerable commitment to better thinking and addressing problems in academically hard subjects such as mathematics (Pajares, 1996). For motivation and self-regulation, self-efficacy is necessary in such courses. As a result, students in the FC must be self-motivated if they are to watch recorded videos to gain the initial information from the video lectures outside the traditional classroom (Bergmann & Sams, 2012). Therefore, this study explores the affordances of the FC in the Saudi context, using an approach that was developed with regard to the improvement and self-efficacy of high school students' mathematical learning performance, informed by educational conceptual frameworks (Lo et al., 2017).

### 1.3 Context of Study

The present study takes place in Saudi Arabia, where low achievement in mathematics is a serious concern (Bakr Khoshaim & Ali, 2015). From an international perspective, Saudi Arabia ranks below average on international assessments as compared to other nations in recent years. In the most recent Trends International Mathematics and Science Study (TIMSS, 2015), the average mathematics attainment of Saudi Arabian fourth graders (383 points) and eighth graders (368 points) was substantially lower than the average score of 500 (SD = 100). By comparison, in the US, where most rigorous evaluations of the FC have been conducted, fourth and eighth-grade students scored, on average, 539 and 518, respectively. In fact, Saudi Arabia's eighth graders had the lowest performance of all the participating countries. Saudi Arabia's low performance is not only observed on the TIMSS. In the last iteration of the Programme for International Student Assessment PISA (2018), Saudi Arabia mathematics achievement ranked 74th out of the 79 countries tested (373 points compared to 478 in the US; mean: 500, SD: 100) (OECD, 2018).

Those results suggest that Saudi students are still attaining poorly in high school mathematics, despite the efforts of educational leaders to improve the maths curricula in both middle and high schools. Mathematics is more than ever a central part of life. It is crucial to enable students to make informed decisions and become productive citizens. Nevertheless, despite its importance, students often struggle to understand many of the basic mathematical concepts taught in school, such as arithmetic, fractions and algebra (Gersten et al., 2009). Since most learners are not able to develop a firm maths foundation, a large number of such students graduate from Saudi high school unprepared for university or employment (Bakr Khoshaim & Ali, 2015). Most higher education institutions in Saudi Arabia consider an applicant's mathematical skills before admission, which causes students to struggle during the first year at university, which may result in stress, demotivation, and even depression (Bakr Khoshaim & Ali, 2015). This data suggests that students in Saudi Arabia may require higher quality high school mathematics instruction than that currently provided. In addition, researchers and practitioners have suggested that the difficulty of learning mathematics may, at least in part, be attributable to the teaching methods used by teachers (Alsaleh et al., 2019).

This highlights the ideological issues with the Saudi educational system. Rote learning and memorisation usually forms the basis of the pedagogical approach in Saudi schools. Knowledge is transmitted from teachers to students rather than created through independent thinking (Rugh, 2002). Usually, the work of students is dependent upon guidelines and learning from teachers and is primarily guided by the teacher. Independent problem-solving strategies and creative group work are encouraged less frequently than in Western learning environments (Allamnakhram, 2013; Prokop, 2003). In mathematics education in the Saudi context, the lecture format is still by far the most common teaching method, despite much research suggesting that alternative teaching strategies (e.g., active learning, cooperative learning, learning through projects, FC) are delivering greater benefit (Dodeen et al., 2012).

Another issue identified in the Saudi education system is the rigid curriculum. Saudi schools have received criticism over the curriculum's content, especially in mathematics. Teachers reported an intensive curriculum to be covered in limited time (Al-Seghayer, 2014). Moreover, Saudi Arabian teachers are constrained by teaching policies promoting particular pedagogies and ideas, with limited teacher participation in curriculum development (Al-Seghayer, 2014; Sywelem & Witte, 2013). Because the traditional teaching style is well established, instilled in the teaching philosophy are the qualities of dependence, passivity, respect for authority, and an unquestioning attitude (Allamnakhram, 2013). This approach does not accord with developments in education, which seek to enable students to search for sources of information and be responsible for their own learning by integrating technology into education to make it more interesting (Elmaadaway, 2018). Hamdan Alghamdi (2013) and Dodeen et al. (2012) conducted analysis of the reforms that focused on only a few aspects of the education system. They argued that there was a need for greater effort to address teaching styles and classroom instruction theories, especially in light of their influence on student outcomes.

In response to this issue and the low student achievement referred to earlier, Saudi educationists have increasingly called into question the traditional approach (Alebaikan & Troudi, 2010). Interest has grown in reforming mathematics instruction in line with the revolution in the field of educational technology, and a new teaching approach may be a possible way to address this demand. The Ministry of Education has recognized the need for reforms in teaching practices to meet the needs of the 21st century and satisfy the demands of the contemporary knowledge economy (Nurunnabi, 2017). Therefore, the Saudi government has espoused a commitment to the exploitation of technology in education (AL-Zahrani, 2015) and attached importance to this, as well as to developing students' higher-order thinking skills such as creativity and problem solving, within Vision 2030, a plan for reforms across several sectors, including education (Nurunnabi, 2017). Previous research has revealed an increase in the number of educators in Saudi Arabia who have implemented modern teaching methods and experiments with FC have already been conducted in higher education contexts (e.g., Al-Zahrani, 2015; Albalawi, 2018; Alali, 2020; Elmaadaway, 2018; Sajid et al., 2016; ALRowais, 2014; Jdaitawi, 2019) and in language learning courses (Al-Ghamdi & Al-Bargi, 2017; Alsowat, 2016; Al-Harbi & Alshumaimeri, 2016; Oraif, 2018). Those studies revealed beneficial impact on students' engagement, motivation, skill performance and creativity. For example, Al-Zahrani (2015) introduced the FC in an e-learning university course and found evidence that the FC may play an important role in the promotion of higher education students' creativity. In addition, Elmaadaway (2018) found that undergraduate students who were enrolled in an electronic course design class perceived classroom engagement as significantly higher in the flipped group, and participants reported a preference for the flipped approach over other teaching methods. Furthermore, Jdaitawi (2019) found significant improvement in students' self-regulation and social connectedness in the flipped group compared to students in the traditional group. The only study found that measured the effectiveness of the FC in university maths courses found a significant difference in students' performance, favouring flipped instruction (Albalawi, 2018). However, only two studies have been found that were conducted in high schools in the Saudi context (Al-Harbi & Alshumaimeri, 2016; Albahuoth, 2020). While Albahuoth (2020) found significant differences between the flipped group and control group when examining the effectiveness of the FC in developing 11th graders' grammatical competences in the Arabic language, Al-Harbi and Alshumaimeri (2016) found no significant effect of FC in improving English grammar among the Saudi high school students.

Implementing the FC in the Saudi context has not been without some challenges. While the previous studies revealed promising results of the effectiveness of the FC in the Saudi context, they also revealed some challenges associated with the approach. In Al-Zahrani's study (2015), the participating students noticed various challenges in implementing the FC. Some of these problems were connected to the FC strategy's utilization of technology, considering that the FC is a technology-driven approach and that its success depends on the technical competence of teachers implementing it (Lo & Hew, 2017). Elmaadaway (2018) also revealed complications linked to the technical problems encountered by students while watching online video materials or applying skills in lessons. Further, students may not be prepared for this strategy (Al-Zahrani, 2015). This is because the FC requires more effort than traditional instruction and students need to be independent and take responsibility for their own learning, a feature most Saudi students are not familiar with. Therefore, students need time, preparation and support to adjust to the new approach. In addition, lack of support and training for teachers may be a challenge. Studies have suggested that Saudi Arabian teachers often lack the training to implement technological learning resources (Albugami & Ahmed, 2015). Not surprisingly, despite the high popularity of the FC in Western countries, few Saudi Arabian teachers are familiar with the method, and teachers who have attempted to implement the FC did not receive adequate funding and technological resources (Alzahrani, 2019).

Based on the above discussion, the FC is still an emerging teaching approach in K12 schools in the Saudi context. There is a need for more research on the use of FC pedagogy and how it may contribute to the improvement of students' learning experience through measuring different aspects such as motivation, self-efficacy, achievement, interaction and engagement with the content, and students' and teachers' perceptions of using such an approach. No research has been found that evaluated the effectiveness of the FC approach on students' mathematical proficiency and self-efficacy in high school settings. Therefore, this research responds to this need and is intended to fill this gap in the Saudi context. Evaluating whether the FC is beneficial and feasible in improving mathematic proficiency and self-efficacy is a question that will be explored in the present study.

## 1.4 The Aim of the Study

This study aims to investigate the potential effect of the FC on students' mathematical proficiency and self-efficacy in high schools in Saudi Arabia, by investigating whether there are significant differences in maths proficiency and self-efficacy between two groups of students: students who learn in the flipped class model and students who learn in the traditional model. In addition, this study also examines students' perceptions of their experience of this new teaching approach, as well as the teachers' perceptions and their experience of the flipped class model and the challenges associated with this approach.

Therefore, to achieve the main objectives, the following questions were posed:

- RQ1. How does mathematical proficiency compare between students who learn mathematics with the flipped class model and students who learn mathematics with the traditional class model?
- RQ2. How does mathematical self-efficacy compare between students who learn mathematics with the flipped class model and students who learn mathematics with the traditional class model?
- RQ3. What are the participating students' perceptions toward their experience in learning mathematics with the flipped class model?
- RQ4. What are the participating teachers' perceptions toward their experience in teaching mathematics with the implementation of the flipped class model and the difficulties associated with this approach?

## 1.5 Significance of the Study

The FC has become an increasingly popular way of teaching mathematics, both in K12 and higher education settings (Lo et al., 2017). The existing evidence is promising, but highly variable: some studies show that the FC produces large gains in achievement (e.g., Lo & Hew, 2017; Bhagat et al., 2016), while others show minimal or non-existent gain (e.g., Clark, 2015; Love et al., 2014; Overmyer, 2014; Petrillo 2016; Ziegelmeier & Topaz 2015). One possible suggestion is the variation in the FC designs and methodology adopted by different researchers, especially as most of those studies were not based on a theoretical framework or empirical principles to guided their implementation (Kim et al., 2014; Song et al. ,2017; O'Flaherty & Phillips, 2015; Lo et al., 2017). For example, O'Flaherty and Phillips (2015) pointed out that the current FC studies underutilize conceptual frameworks and pedagogical designs and they call for more powerful evidence in the evaluation of student outcomes in a FC. A need has been asserted for empirically based principles, rather than mere teacher intuition, to guide the design and implementation of flipped courses (Lo et al., 2017). There was a lack of consistency in reporting of the studies into FC designs in the past, and there are variations in the designs and methodologies used (for more details, see section 2.10.4). Therefore, this study tried to fill this gap in the literature by designing a FC intervention based on design principles created by Lo et al. (2017), all of which were established on the basis of relevant empirical evidence. In this way, this study makes a theoretical contribution to FC research in mathematics education.

The literature suggested that further study of the FC should be done in secondary education because a large proportion of previous and current studies concentrated on higher education. In Lo et al.'s (2017) review, over 60 mathematics education empirical studies were examined, though only four of them (Bhagat et al., 2016; Clark, 2015; DeSantis et al., 2015; Kirvan et al., 2015), in high school mathematics classes, specifically compared the FC to traditional learning based on lectures. For this reason, it is not clear if the FC will work with high school students. High school students differ from higher education students; they have less autonomy, they are younger, less motivated and their time is structured by others. Because the FC depends mainly on the student and the teacher acts as the guide in the learning process, high school students need certain skills to succeed, such as being independent learners. University education is very much about independent learning, and being very self-motivated. In addition, there is a dearth of research that looks at the potential effect of the FC approach in enhancing students' mathematical self-efficacy. Measuring students' self-efficacy is very important because of the strong connection it has with achievement and other important academic outcomes such as students' motivation and the increased interest in STEM subjects (e.g., Winne & Hadwin, 2012).

In addition, it is not clear in the literature whether the FC could improve mathematics proficiency in high school in Saudi Arabia, since, as stated earlier, no research has been found that measures its impact on high school mathematics proficiency and self-efficacy. Moreover, investigating the FC in the Saudi Arabian context may result in different findings from those reported elsewhere, and this may be attributed to the distinctiveness of Saudi when compared to other nations, specifically, gender segregation in all Saudi schools. Since most past studies considering the impact of the FC on students' mathematical proficiency were done in mixed-gender classes, this study may lead to different results because the classroom culture is likely to be very different. The literature shows that there is a difference between mixed and single-sex classes, especially in terms of engagement, interaction, communication, and achievement level (Marsh & Rowe, 1996; Strange et al., 2003; Pahlke et al., 2014).

Furthermore, there is limited research into teacher perceptions of the instructional effectiveness of the FC approach and the impact it has on student learning, as well as on detailed descriptions on the model's classroom implementation. Teachers' perceptions are likely to influence the adoption of the FC in schools; it is thus critical to investigate this question. Consideration should be given to their opinions to increase the understanding of the strengths and weaknesses of this teaching approach, which could lead to improvements. This research could provide new information concerning teachers' perceptions regarding the FC in mathematics classrooms, which could help to inform policy-making by the Ministry of Education in Saudi Arabia so encouraging more teachers to consider this teaching approach and how to get the most benefit from it. In addition, this study aims to provide insight into the feasibility of this new instructional strategy and its suitability in the Saudi environment. This is in keeping with the vision of the Ministry of Education, which emphasises the dissemination of digital knowledge and building a modern education based on information technology, by enabling teachers and students with digital and learning tools that enhance teaching and learning (Ministry of Education, 2015). The study is relevant due to the high level of innovation in the education sector, since technological innovation affects not only teaching but also the whole economy.

## 1.6 Structure of the Thesis

This chapter has introduced the thesis and its main concerns, the rationale, and the research questions and objectives for engaging with the topic of this thesis. The remainder of the thesis is organised as follows: Chapter Two provides an overview of the existing FC literature, beginning with the general field of blended learning; this is followed by a description of a specific approach, namely, the FC, and then a historical overview of the field. An extensive review is then conducted of the advantages and disadvantages of the FC in mathematics education and its relationship with mathematics proficiency and self-efficacy. This examination of the literature provides a foundation for the current research, and also highlights and addresses the persistent gaps in the literature. Chapter Three presents the theoretical framework and detailed descriptions of the principles used to guide the design of the study. Chapter Four describes the research methodology, including the rationale and philosophical underpinnings of the research and methodologies used. It also describes the data collection and data analysis processes and issues of ethics, reliability, and validity. Chapters Five and Six present the findings of the study. Chapter Five reports the quantitative findings, including a statistical analysis of the mathematics proficiency and self-efficacy data using both descriptive and inferential statistics. Chapter Six presents the perceptions of students and teachers concerning the approach presented and evaluates the implementation process. Chapter Seven presents a discussion of the study findings and the research questions addressed, and connects the findings to the existing literature and the theoretical framework that guides this study. The final chapter is the conclusion, which draws conclusions from the research questions, highlights the contributions of this research, and provides implications for future research on implementation in other contexts.

## 1.7 Chapter Summary

This chapter has outlined the background to the research, including its aims and objectives and the research problem being addressed. The scope and significance of the research were also discussed. The next chapter presents a critical review of the current literature relating to current gaps in knowledge and how this study may contribute to the development of education and the FC in the mathematics field.

# Chapter 2 : The Flipped Classroom (FC) Approach

In this chapter, a review of the blended learning concept is conducted, before a description is provided of a particular type of blended learning, termed the FC, the basis of this study. The FC is defined and the benefits and challenges of implementing it are discussed, as well as key elements in the design of the FC. At the end of this chapter, the application of a flipped maths class is described, demonstrating the application of the FC and identifying the gap in the existing literature, which this study proposes to help fill.

## 2.1 Blended Learning (BL)

Worldwide education programmes have evolved exponentially with new technology. The use of e-learning technology enables education programmes to be adapted according to the needs and capabilities of each student, which can have a positive effect on performance and academic achievement (Januszewski & Molenda, 2008). However, because of the low socialisation level and the few support benefits of traditional learning methods and techniques, purely online courses were criticized (Arkorful & Abaidoo, 2015). For this reason, research has been conducted on the combination of traditional learning and e-learning, resulting in the development of the concept of BL in order to achieve a more effective learning process and meet the needs of each individual. A recent study by Thai et al. (2020) found that when compared to the e-learning environment, studying in BL conditions results in better learning performance. This result highlights the potential usefulness of a face-to-face lecture preceding an online debate. Incorporating technology into traditional teaching has received much attention and has been the subject of extensive research. BL is deemed to be one of the most effective and widely used modes of instruction used by education organisations, based on its perceived effectiveness in delivering flexible, timely, and continuous education (Graham, 2006; Porter et al., 2014; Güzer & Caner, 2014). The recent crisis in education due to the Covid-19 pandemic has demonstrated the upside of a BL approach to education. BL is one of the many proposed models for the future of the technology-assisted classroom (Myung et al., 2020).

BL is instruction provided in two different formats –face to face and technology-mediated (Güzer & Caner, 2014). However, while the concept of BL is longstanding, researchers and scholars still do not agree on what actually constitutes BL. Various definitions of blended learning exist, which may be attributed to the substantial variations in the specific design and structure of these (Graham, 2006). In the literature, terms such as blended, hybrid, mixed mode, and flexible are used to refer to the combination of different instructional methods in a course (Graham, 2006).

Graham (2006) proposes a simple definition, “Blended learning systems combine face-to-face instruction with computer-mediated instruction” (p.5). The key principle underlying the blended learning approach is provided by this definition, which is the combination of two models: face-to-face learning and online learning, with the emphasis on the central role of computer-based technology in blended learning. BL is defined according to Horn and Staker (2012) as "any time a student learns at least in part at a supervised brick-and-mortar location away from home and at least in part through online delivery, with some element of student control over time, place, path, and/or pace” (p.3). This type of learning offers a flexible and convenient learning environment for both teachers and students, and helps students to develop self-directed learning skills, digital literacy and the ability to control their learning pace and learn remotely. Additionally, Boelens et al. (2018) propose a definition which emphasises the personalisation characteristic of BL as “an instructional approach that combines online and face-to-face instructional activities, to create more flexible modes of education, and personalised learning trajectories” (p.199). Hence, besides the idea of flexibility in place and time, BL offers students the chance to receive personally tailored teaching.

Learning activities in the BL environment can be either synchronous or asynchronous (Bonk & Graham, 2012), a concept which is crucial in BL. The in-person component refers to synchronous learning. Several students engage in the learning process concurrently during face-to-face learning activities. This can be done via different channels, including online chat, webcast, virtual lesson and chat (Yamagata-Lynch, 2014). This sort of learning allows for a high degree of socialisation that can influence student understanding and achievement (Bower et al., 2015). However, synchronous is less convenient than asynchronous learning. Moreover, synchronous learning restricts the versatility of students, as they are unable to access information and guidance from anywhere at their convenience (Yamagata-Lynch, 2014). Conversely, asynchronous learning can be viewed as a method of teaching that makes information sharing easy with various online learning tools and media, regardless of time and location constraints (Güzer & Caner, 2014). Asynchronous learning can, for example, happen via videos, podcasts, online discussion boards and emails, in the mixed learning domain (Bower et al., 2015). As an alternative to a synchronous learning approach, asynchronous learning, which is frequently promoted through media like e-mail and panels, promotes relations between learners and teachers, even when participants cannot be online at the same time. It is therefore a core element of scalable e-learning (Arkorful & Abaidoo, 2015). Nevertheless, asynchronous learning is usually seen as having significant limitations, due to inadequate internet connections, expensive technical maintenance, and a lack of assistance from educational providers (Hrastinski, 2019).

Following the above-mentioned influential definitions, several BL models were proposed. Models of BL usually focus on physical or surface-level aspects, rather than pedagogical or psychological factors (Graham, 2006). The literature has identified the following different models of BL programmes in the K-12 sector (Staker & Horn, 2012). 1) The flex model, in which the content is mainly online, and each student has an individual, customised schedule. Teachers provide in-person support as required via activities including individual training, group projects, and small-group instruction. 2) The rotation model, in which students rotate between learning activities, including online learning. Other activities include individual tutoring, group projects, and full-class instruction. 3) The enriched-virtual model, in which students divide their attendance between a campus and online remote learning. 4) The self-blend model, in which students supplement their traditional courses by taking other, online courses (Staker & Horn, 2012).

The concept of BL involves technology that does not have to replace traditional learning, but can add an extra aspect to the learning experience. BL also helps to ensure that mutual support arrangements, both online and offline, can adopt aspects of e-learning and vice versa (Güzer & Caner, 2014). According to Collis and Moonen (2001), the importance of versatile approaches to teaching and learning is not simply based on the use of digital technology, but rather on the value of a flexible approach to learning and teaching. Friesen’s (2012) definition of BL is the most relevant to the current study: BL involves combining Internet and digital media with established classroom forms that require the physical co-presence of teacher and students. In the light of all the above meanings, BL may differ in terms of its ability to produce and extend significant variations in design in BL. Therefore, the current study adopts the definition of Friesen (2012), as it is appropriate for the context of this research. For example, for the purposes of this study, BL is a pedagogical approach that uses technology to enhance learning; that merges effective online learning tools through Moodle that facilitate interaction with the online materials and face-to-face learning. This decreases the amount of time spent on traditional learning and promotes collaboration between students to improve their mathematical skills.

## 2.2 Flipped classroom (FC) and Blended learning (BL)

As noted in the previous section, Staker and Horn (2012) identified four basic learning models. According to Staker and Horn (2012) "the rotation model has four sub-categories, including (1) the lab-rotation model, (2) the station-rotation model, (3), the individual-rotation model and (4) the FC model" (p.8) (see figure 2.1). Of these four, the most frequently used is the flipped-classroom model, in which "students rotate on a fixed schedule between face-to-face teacher-guided practice (or projects) on campus during the standard school day and online delivery of content and instruction of the same subject from a remote location (often home) after school" (Staker & Horn, 2012, p. 10). Since the FC offers at least part of the instruction in a practical learning setting and another segment of the instruction is done online, many educators and researchers regard FC as a type of blended learning (Bergmann & Sams, 2012; Herreid & Schiller, 2013; Slomanson, 2014). The modern transformations in web-based technology have enabled classroom teachers to blend the best aspects of synchronous face-to-face studying with the flexibility of asynchronous online teaching (Yamagata-Lynch, 2014). A growing number of teachers are moving to blended instruction, since they consider this format to facilitate the best chance to concentrate on high-value events like project-based instruction and critical thinking (McLean et al., 2016; van Alten et al., 2019). Flipping the lecture delivery's location essentially varies the learning setting, freeing face-to-face class time for exploiting active methods of learning proven to enhance the retention of significant concepts and to increase student satisfaction (Roehl et al., 2013; Akçayır & Akçayır, 2018). Staker and Horn (2012) explained that in the FC, instruction and context are primarily delivered online. This differs from a scenario in which students simply do their homework online, which is how other blended learning models are used. Although there are similarities, the FC and BL cannot be equated.

The application of technology in providing low-level fact-based information to learners at home to fully exploit face-to-face time for active schooling is the guiding principle behind flipped instruction (Bergmann & Sams, 2012).

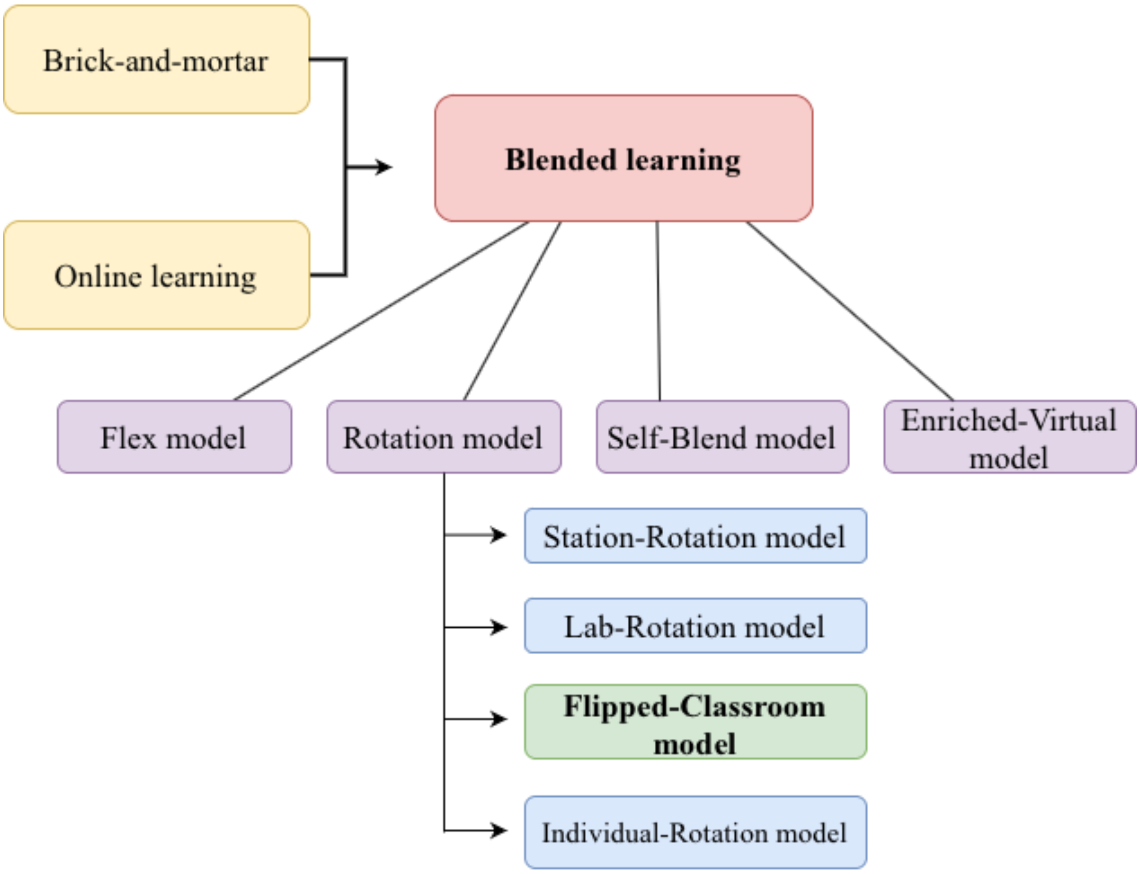


Figure 2-1 Blended learning models and implementation types from (Staker & Horn, 2012)

### 2.3 The history of the FC

What we now think of as the FC rests on ideas that have been around for a while. These ideas include: cognitive load; and removing from classrooms the more basic elements of teaching in order that the learning actually carried on there can be more in-depth. As far back as the 1850s, students at West Point were taught using the Thayer Method (Shell, 2002). The essence of that way of teaching was for reading and other activities to be removed from the classroom to provide a basis for students to learn collaboratively when in class. It was expected that students would arrive in class with a good grounding in that day's concepts, and then collaborate with each other in the solution of problems and the manipulation of information so that a new and deeper understanding could be reached (Shell, 2002). At the end of the 20th century and beginning of the 21st, the method attracted greater interest as a result of the search by teachers for ways to transfer into the classroom's more structured environment those activities previously largely conducted outside it, including critical thinking and project-based learning, without sacrificing more basic thinking abilities (Lage et al, 2000).

Professor Erik Mazur in Harvard University, in 1996, is considered the first to have recorded a FC with his physics classroom (Bergmann & Sams, 2012). Mazur argued against the application of lectures with passive students in the classroom. He utilized an approach identified as Peer instruction. He requested that his students prepare themselves for class by studying specific resources so that they are actively engaged in the peer learning process (Baker, 2000). Since then, a wide range of scholars have played a key role in the evolution of the FC. For example, Baker (2000) used an online platform to deliver lectures to his students and made use of class time for problem-solving activities through group discussions. In the same period, Lage et al. (2000) had their classroom inverted, issuing students with recorded lectures, reading materials and PowerPoint slides to read outside the classroom. The indoor learning activities centred on group practices and activities. Technology changed the application of FCs. An "inverted", or flipped, economic course run by Lage et al. (2000) made use of the technology then available (as all such programmes must), but greater access to technology made for greater use of FCs. In 2006, Salman Kahn's non-profit website was designed with the aim of providing free videos on almost all academic topics so as to enhance teaching. Key developers of the model were Bergmann and Sams, two Woodland Park, Colorado, teachers. In 2003, they brought flipped teaching to the fore educationally. Finding it difficult to deliver the content of courses to absent students, they made screencasts and videos and posted them online (Bergmann & Sams, 2012). First to benefit were the absent students but it was not long before other students were using the online resources as a way of reviewing concepts and strengthening their understanding. This led the two teachers to see the FC as a way to change the way they managed class time (Tucker, 2012). In the beginning, the teaching method was to turn classroom instruction into a vodcast (video podcast). Their subject was chemistry and they presented both content and problems (to which they also showed the solutions) by using video screencasts and screen captures. Learning as they went along, they looked for ways to anticipate and include the information and examples that would be most needed, in order that students in the classroom would be very well prepared to participate in the learning process (Bergmann & Sams, 2012). Interestingly, they did not use the term FC, but dubbed it "pre-broad casting". This eventually became known as the FC, and became a very popular technique. Bergmann and Sams (2012) are amongst the foremost advocates of flipped instruction; they write books and host conferences on flipped instruction and the benefits that arise when technology is integrated into a FC. In sum, while a flipped or inverted approach has been in successful use for several years, it is a technology that has made possible the successful FC models now being seen in practice. The Flipped Learning Global Initiative (FLGI), the latest project of Berrgman and his partners, is a global alliance of educators, administrators, technologists, providers of professional development and educational leaders from 49 countries (FLGI, 2020). FLGI aims to meet the global need for cross-border collaboration in three areas: research curation and dissemination, the development of best practice for flipped learning, and the selection and implementation of technologies (FLGI, 2020).

## 2.4 The FC model

Much recent attention has been paid to the FC instruction model (Lo & Hew 2017; Thai et al., 2017). Some researchers such as Tucker (2012) argue that the FC concept has been used in education for some time, however, given the development of internet infrastructure and multimedia production, and greater numbers of people having access to technology, this educational model has been brought to the forefront (Sun et al., 2018). A key part of FCs is exposure to content prior to in-person teaching, whereby students can first practise and examine their skills. They can then practise to clarify content and obtain feedback and their skills can be used to increase their knowledge with other students and teachers in the classroom (Akçayır & Akçayır, 2018). The FC is also referred to as "inverted instruction" or "inverted classroom" (Bergmann & Sams 2012).

The FC was originally defined by Lage et al. (2000) as the situation where "events that have traditionally taken place inside the classroom now take place outside the classroom and vice versa" (p.32). Although this definition encapsulates the reasoning for the utilisation of the words *flipped* or *inverted*, it nevertheless gives an insufficient representation of the practice that researchers call "the FC" (Bishop & Verleger, 2013). Such an explanation would suggest that this "FC" signifies nothing more than a reordering of classroom practice and at-home activities; nevertheless, in practical terms, it involves more than this (Tucker, 2012). Therefore, the term FC is most frequently used to refer to courses that utilise activities incorporating asynchronous web-based video lectures with quizzes or closed-ended problems. Consequently, the FC is a curriculum extension and not simply a reorganisation of the activities performed. Accordingly, Bishop and Verleger (2013) provide a precise definition of the FC as "an educational technique that consists of two parts: interactive group learning activities inside the classroom, and direct computer-based individual instruction outside the classroom" (p.5). Their description is explicit with regard to the necessity of utilising educational multimedia presentations as an outside-of-class learning element and excluding plans that do not utilise video presentations. By adopting the definition of Bishop and Verleger (2013), it is possible to differentiate the FC approach from certain traditional lesson preparation strategies, such as the expectation that students would do some prescribed reading on their own in advance of the lesson. Such reading assignments, however, do not involve the provision of instruction, such as explanation by the teacher of the ideas in the text (Bishop & Verleger, 2013).

The approach described above includes the use of educational video presentation, which allows teachers to impart new knowledge to their students and to explain the topic by providing examples, in advance of the lesson. Consequently, more classroom time can be allocated to group learning projects and to students' solutions to practical problems, with the help of peers as well as of the teacher (Bergmann & Sams, 2012). For this reason, the application of multimedia elements such as educational video presentation, screencast, Khan Academy, YouTube, and podcast, for learning outside of the classroom and regular (rather than optional) face-to-face meetings in the classroom are assumed to be the two required facets of the FC model (Bishop & Verleger, 2013). Although this provide a more specific structure, there is still considerable potential for variation in the way information is provided outside of the classroom by computer, and in the nature and organization of collaborative group learning projects in class (Bishop & Verleger, 2013). In the current study, Bishop and Verleger's (2013) definition of the FC is adopted, using videos and online environment to promote student interaction and the materials before the class time.

This model aims at optimising face-to-face time for teachers to communicate with students in a personal way (Bergmann & Sams, 2012; Staker & Horn, 2012). The FC is becoming a popular approach; recent reports from Horizon New Media Consortium have recognised that FCs are a critical development in education technology (Johnson et al., 2016). These reports describe the evolving role of academics and stress that they may be expected to use various teaching models, including the FC.

## 2.5 Components of the FC

### *2.5.1 Pre-class activities*

At the heart of the FC is the need to complete pre-class activities. While as noted previously, the FC involve more than more re-ordering of activities, it is nonetheless true that the FC reverses traditional classroom standards, allowing students to prepare for classes before they take part and demonstrate what has been learned in face-to- face classes (Betihavas et al., 2016). The most popular pre-class activity in the flipped approach is using video lectures, which have proven to be effective at preparing students well before class time. Nouri (2016) explored students' experiences of using video as a learning tool in the FC and found that it had a strong correlation with effective learning, increased learning, and perceived increased motivation. In addition, he found that students appreciated video as they could pause, rewind and fast-forward the content, which helped their learning. They also agreed that combining non-traditional and video lectures was useful, as well as being able to watch lectures in a flexible manner (Nouri, 2016).

The pre-class activities should be an introductory guide to address lower levels of Bloom's taxonomy, such as knowledge acquisition and comprehension, while class time is used to tackle higher levels of Bloom's taxonomy such as creativity, analysing, evaluating and application, with the help of teachers and peers (Morton & Colbert-Getz, 2017). Care should be taken in the design, length, and intensity of the videos to ensure that the presented content is retained by the students and to prevent the students skipping the pre-class activities. Some studies have demonstrated that watching videos can be boring, time consuming and passive, and students cannot focus on watching them (Schultz et al., 2014). To overcome these problems, it could be helpful to limit each lesson's pre-class activities to 15-20 minutes and focus on more basic skills that do not contain very complex materials. These techniques will prevent the disengagement of students from video lectures. Therefore, pre-class activities should be relevant to the in-class activities (O'Flaherty & Phillips, 2015). Compared to conventional classes, students completing the pre-class tasks are more interested in class (Lo & Hew, 2017). Moreover, depending on students' success in those activities, teachers can develop appropriate classroom learning experiences (Betihavas et al., 2016). Teachers may also create an online platform for discussion so that the learning environment can be extended outside of the classroom to enable students to ask questions and debate with peers. Teachers can look for ways to involve students in advance of lessons and facilitate pre-class activities by offering a quiz to test their understanding of the materials in advance of or during the course (Bergmann & Sams, 2012). Computerized feedback from these online exercises enable students to follow up on their own progress, so that they can deliberately review video lectures in order to gain a deeper understanding (Lo et al., 2017).

### *2.5.2 Student-centred classroom*

A student-centred classroom, or student-centred learning environment, is one in which the instructional focus shifts from the teacher to the students, the objective being to develop students who have autonomy and independence by placing the learning responsibility onto them (Leow, 2015). That description contrasts with the traditional teacher-centred classroom. Many student-centred learning advocates argue that it is one of the most efficient ways to help students develop the skills needed to solve problems independently and learn throughout their lifetime. One of the problems faced by the current educational model is that it does not adapt to all students' specific learning needs. Not all students learn in the same manner. As a consequence, there is no universal approach to education, as suggested by traditional teaching models; rather, learning needs to be customised to the students' needs, to facilitate a student-centred environment (Leow, 2015).

Research on student-centred instruction emphasises that students should play an active role in the learning process rather than be passive recipients of teacher information, demonstrating results consistent with the development of 21st century skills, including critical thinking, creativity, innovation, information literacy and problem-solving skills (Lo & Hew, 2017). The FC is an approach that facilitates student-centred environments.

The focus in flipped learning is not on instruction, but on learning experience and students' direct exploration of their own knowledge (Bergmann & Sams, 2012). The FC bridges the learner-centred environment and allows deeper learning. The face-to-face components of FC are focused on real, creative, experiential, project-based, knowledge-based, self-actualizing and investigation-based activities in the classroom (Jensen et al., 2015). This approach enables students in real-life situations to apply and evaluate previously studied ideas and material in accordance with high-level learning at the top of Bloom's taxonomy. Keengwe (2014) maintained that in the FC, students are increasingly autonomous in learning and teachers are facilitators. Learning is active and problem-based, with the role of the teacher being to enable students to think critically on subjects and obtain a stronger grasp of concepts (Roach, 2014). The FC offers learners chances of skill development in order to solve problems and work with peers and teachers. Cronhjort et al. (2018) found that students thought that studying in the FC increase the chances of engaging more with their colleagues and teachers. This could be because teachers have more time with students in the FC and stronger relationships are created among the students.

### *2.5.3 Active learning during class time*

In a standard lesson, it is crucial that the teacher decides what to do with in-class time in order to create a meaningful learning environment for students. The replacement of passive learning (reading) with active learning techniques is at the heart of the success of the FC. Many researchers have suggested that the successes of the FC can be attributed to the nature of class activities rather than video lectures, which is why learning and teaching practices in the classroom are often considered the most important component of flipped learning (Chen et al., 2016). Active learning recognises that people learn best from experience; that students learn little by sitting in the class listening to teachers, memorising pre-packaged assignments, and rehearsing answers. Active learning operates on the principle that students learn more by engaging in a learning activity than when they are passive recipients of information presented to them. The students will talk about the learning, write on the subject, link it to past experiences and apply it to their daily life (Bergmann & Sams, 2012; Keengwe, 2014). Accordingly, Freeman et al. (2014) performed a meta-analysis of 225 papers that reported data comparing the performance of students in undergraduate (STEM) courses using active learning in standard teaching for examination scores or failure rates. They observed that active learning has a greater impact on being able to master higher versus lower-level cognitive skills. Furthermore, substantial evidence has shown that active teaching strategies have a beneficial effect on test results and lowering failure rates (Miller & Metz, 2014). In the FC environment, as the lecture comes out of the classroom, students have more time, make mistakes, and engage in disorganised learning. Students are therefore active participants in the classroom activities and become more responsible for their learning outside the classroom. This approach also helps the lower achieving students, who often struggle to learn in traditional classrooms, but have a chance to succeed when there are varied learning activities. Research has indicated the importance of active learning, especially in raising learner and minority success rates (Miller & Metz, 2014; Freeman et al., 2014). Students have more time to take part in a dynamic learning experience and actively participate in their own learning when the lecture no longer takes place in the classroom. In the FC, videos are assigned as homework, therefore students have greater learning autonomy, since they can watch the content at their own convenience and as many times as they want, which boosts their understanding of the materials presented.

The main advantage of videos is to allow struggling students to view the video lectures repeatedly, pausing to understand concepts when necessary. With the aid of video pre-class activity, teachers have more time in class to organise discussions as an entire class or in smaller groups (Bergmann & Sams, 2012; Bishop & Verleger, 2013). Discussions of pre-class work, problem-solving, games, and other engaging collaborative activities are some of the active learning strategies used in the FC approach (Jensen et al., 2015). Pre-class work must be completed by students to gain an understanding of basic concepts of the course in order to free up class time for such activities. With preparation for the lesson completed before class, the teacher can use his or her time to apply that knowledge in greater depth with activities such as discussions, debates or problem solving (Roehl et al., 2013; Keengwe, 2014). Through these techniques, students can explore topics in order to develop a better understanding of the material, such as by synthesis and application. By interacting with the teacher in class, students can also gain clarity on difficult topics, an aspect that is lost in a typical lecture (Lo et al., 2018; Wilson et al., 2013). Love et al. (2014) utilised the FC to enhance active learning with a problem-based approach. They found that students in the FC were more successful in exams than those in traditional classrooms, throughout the course. Active learning techniques were implemented in a related study conducted by Roehl et al. (2013) and test results between two types of lessons were compared. Students in the FC were more involved, and reflected more on their education and were better able to make practical use of their knowledge and skills than conventional learners (Roehl et al., 2013). These studies confirm that flipped learning improves active learning strategies. Increased time spent working with students enables teachers to review concepts in small groups or with individual students.

### *2.5.4 The role of the teacher in the FC*

The teacher's role is vital in the FC model, since the model relies on the teacher establishing an inquiry-based teaching environment where in-person learning time moves from being teacher-centred towards the student-centred spaces, placing the emphasis on the students instead of the teacher (Bergmann & Sams, 2012). Flipped educators support the shift to a student-centred classroom and argue that the teacher's transition from sage on the stage to guide on the side is a crucial stage of this process (Baker, 2000; Bergmann & Sams, 2012). In the FC, teachers act as the facilitator, observing and supporting students in their learning (Keengwe, 2014). In this environment, teachers do less teaching and more of the design of collaborative activities and, therefore, students must take more responsibility for their own learning. It is the student's obligation to acquire basic concepts outside of the classroom; the teacher can then help the student toward a greater comprehension of the topics and clear up any misconceptions. (Altemueller & Lindquist, 2017). In the FC, the teacher goes beyond distribution of information, since, in such a limited approach, there is no room for self-directed learning. Rather, the teacher concentrates on educational experiences that encourage students to establish self-reliant learning patterns (Sun et al., 2018). The smooth transition from the traditional approach to the flipped one is the responsibility of teachers. It is advised that teachers move to the flipped approach gradually, to avoid students' reluctance, because developing independent learning skills in the flipped environment takes time, effort, and guidance (Chen et al., 2014). Therefore, familiarising students with the new approach first, and well-prepared and designed in-class and out-of-class activities are the key elements to success.

In designing a suitable educational resource to guarantee the quality of in-class activities and web-based instruction, courses must be appropriately designed, and the relevant resources put into place (Bergmann & Sams, 2012). Consequently, the FC model additionally depends on teachers being purposeful about the resources that they choose and therefore depends upon consideration of which topics are to be taught directly to the students and which content students should be permitted to access individually, away from the classroom environment (Keengwe, 2014). This is to be seen when a teacher emphasises strategies for enabling students to access material individually, devises suitable resources to engage students (most commonly videos), and differentiates content so that individual students find it accessible and relevant. When planning what used to be lessons (but now constitutes the learning process), teachers should look for videos and tutorials that will be both effective and appropriate, the content of which students can understand and are able to watch online (Keengwe, 2014). There is also a need for teachers to consider activities to accompany the videos and tutorials, that require students to write down the ideas presented or to answer questions so that when they come into the classroom, they bring with them the basics they have learned. A major task for teachers is finding and creating classroom activities that build on online learning to make possible collaborative problem solving and learning. In a study conducted by Wanner and Palmer (2015) to investigate teachers' attitudes towards implementing the FC, most of the respondents stressed how important it was to understand the subject and plan the course to make it possible for students to learn, and for teachers to plan and structure the course with flipping in mind. Nevertheless, whilst some teachers might aim to establish a student-centred classroom, others do not have the skills or knowledge to do this in practice. Equally, insufficient content often results in an environment becoming teacher-centred; even if this is not what the teacher was striving for (Kirvan et al., 2015). The input of the teacher is magnified within a flipped learning culture, as each teacher should have an awareness of the specific learning requirements of individual students as their engagement with the students grows on a daily basis (Bergmann & Sams, 2012). This consequently increases the demand for teachers who are qualified, experienced and dedicated. "Although video can be leveraged to deliver direct instruction, it does not, and cannot, replace the teacher as the facilitator of learning" (Bergman & Sams, 2012) (P.3). In the flipped method, teachers need time to adjust to the new learning techniques; however, many believe that the costs are outweighed by the benefits (Akçayır & Akçayır, 2018; O'Flaherty & Phillips, 2015).

## 2.6 Potential benefits of the FC

The literature has established many beneficial effects of the FC on teachers and students. The researched outcome variables are related to the learning environment (Strayer, 2012) and students' perceptions and performance (e.g., Awidi & Paynter, 2019; Chen et al., 2016; Lopes & Soares, 2018). Research has also been conducted into various courses, such as medical science (Rotellar & Cain, 2016), engineering (Mason et al., 2013), languages (Chen Hsieh et al., 2017) and, more important for the present study, mathematics (e.g., Bhagat et al., 2016; Lai & Hwang, 2016; Love et al., 2014). The latest meta-analysis of 198 studies from a wide variety of disciplines has shown that FCs have a moderately positive impact on student success (g = 0.50) - an impact that is important in practical terms to students (Strelan et al., 2020).

Proponents of the FC model generally contend it has a range of benefits over traditional classroom models. According to Akçayır and Akçayır's (2018) extensive review, several advantages were identified, including learner outcomes, pedagogical contributions, dispositions and interaction. Other advantages mentioned by other researchers include making students more accountable for their own learning (Clark, 2015), supporting personalized learning and more efficient and appropriate use of class time and flexible technology (Wanner & Palmer, 2015). These benefits are reviewed extensively below.

### *2.6.1 Improved learning outcomes*

The FC offers benefits with regard to the learning outcomes of students, such as their motivation, engagement, and satisfaction. Of the studies reviewed by Akçayır and Akçayır (2018), 52% showed that using the FC model resulted in an increase in the learning performance of students when measured using standardised tests, course grades and the Grade Point Average (GPA). Thus, an important advantage of this model is that learning performance is improved, an essential component of a successful education. This may be because of active learning strategies offered by the FC, as the use of active learning strategies can explain how flipped learning improves learning performance amongst students (Keengwe, 2014). Active methods of learning tend to be more student-oriented than traditional methods of learning since students not only need to hear but also to learn, write, talk and engage in problem-based activities (Freeman, et al., 2014). Furthermore, due to the prior exposure to basic concepts before the class, the facilitator can concentrate attention on the critical part of the lesson, application and problem solving during the course time to improve the learning of students. Evaluative input from peers and teachers also provides incentives in the classroom for progress in learning and the exploration of concepts (Wanner & Palmer, 2015). Bhagat et al. (2016) state that students who were taught with the FC model demonstrated improved performance and less cognitive stress compared with those who were taught with a conventional classroom model. Lo and Hew (2017), in their review, found that the flipped class approach had no negative impact on K-12 student learning. At best, this approach can improve the overall performance of students significantly more than that of students taught in the conventional classroom.

### *2.6.2 Enhanced student satisfaction and engagement*

Another advantage identified in the literature is that the FC boosts the satisfaction and degree of commitment of the student in the course, both of which are key parts of education. Abeysekera and Dawson (2015) found that flipped approaches could enhance the motivation of students and help them manage their cognitive load. They also claimed that the FC learning environments would probably meet student demands for skills and autonomy, and therefore promote greater intrinsic motivation (Abeysekera & Dawson, 2015). In terms of students' satisfaction, many researchers have discovered that students were mostly satisfied with the FC approach (e.g., Schultz et al. 2014; Clark 2015; Bhagat et al. 2016). Lo and Hew (2017) state that one of the benefits of the FC approach is that it contributes to higher satisfaction with courses. Students who watched video lectures before class were, for example, better prepared for class activities, and found it easier than reading text-based materials (Roach, 2014). According to Lopes and Soares (2018), students expressed a preference for flipped instruction, as it gave them more options than only listening to lectures in a range of educational activities – such as real word application and project-based learning. Chen et al. (2014) successfully used the FC and found that there were improvements to attendance and study habits and an increase in student satisfaction. Similar results were found by McLaughlin et al. (2013), who discovered increases in student learning, attendance, and positive perceptions.

Additionally, it was found that the FC enhanced student engagement by ensuring that students were active, interaction increased in the FC model, while there were also fewer distractions (Gross et al., 2015; Murillo-Zamorano et al.,2019). Research has shown that the FC improves interaction between student and teacher, contributing to successful education (Muir & Geiger, 2016). If students feel a sense of satisfaction and high-class engagement, they will be able to foster a sense of safety, security and identity (Bandura, 1997). The active classroom may contribute to better preparation for classroom students by enhancing data retention and use (Jensen et al., 2015). Ziegelmeier and Topaz (2015) noted that students taught using the FC model interacted, showed their motivation, collaborated, and shared knowledge so that they understood concepts, providing teachers with more time to move around the classroom and help others.

### *2.6.3 Increased interaction opportunities*

Additionally, the FC may encourage more interaction between teachers and students, since FCs allow extra time in class for this. However, in the traditional teaching approach teachers only deliver the course content via lectures, causing interactions to remain at a low level. The FC approach facilitates different modes of interactions: student-teacher interaction, student-student interaction, and student-content interaction. Firstly, students access the online platform and interact with the materials in an online format. They then attend class to collaborate, interact, learn, and receive support from their peers or groups members. The students also interact with the teacher for further elaboration on the course materials and to obtain feedback. One reason why student-teacher interaction increases is because the teacher's function in this approach moves from a content presenter to a teaching coach (Bergmann & Sams, 2012). Kim et al. (2014) therefore emphasised that teachers are depicted as facilitating staff in the FC approach, thus enhancing a personal discussion and interaction between teachers and students. The FC provides the teacher with an improved chance to more closely work with learners and provide them with input, encouragement, and clarification in their problem-solving work (Tsai et al., 2015). According to O'Flaherty and Phillips (2015), the interactivity created in the FC enhances and develops the ability of students to work in groups. Furthermore, Strayer (2012) discovered that FC students are more cooperative and more willing to work in groups, compared with students in the conventional classroom.

### *2.6.4 A flexible learning environment*

Another positive feature of the FC is that is creates greater adaptability and flexibility when combined with other active learning methodologies (Wanner & Palmer, 2015).

Lessons and content become more accessible with the flipping approach, by making video lectures available online anywhere, as many FCs use multimedia resources for instruction in the course before the class. Students can potentially learn anywhere and anytime (Thai et al., 2020), and this allows greater ownership of learning as it accommodates students' preferred learning styles (Sun et al., 2018). Similarly, Muir (2020) stated that students in his study appreciated the ability to pause, rewind and revisit lectures using the flipped approach. This affordance caters specifically for the autonomy and competence requirements of students (Ryan and Deci 2000). Bhagat et al. (2016) further clarified that a smooth approach to the classroom could help low achievers who are now able to revisit materials and get more attention from their teachers in class time to enhance their comprehension. Steed (2012) believes that this ability has improved learner behaviour in class, as students who understand a subject are less likely to misbehave. The FC has also demonstrated its flexibility in situations where students or teachers who are forced to miss class due to illness or emergencies can catch up quickly (Bergmann & Sams, 2012). The greater flexibility in delivery and evaluation leads to greater participation of students as partners in independent learning journeys.

### *2.6.5 Encouraging self-regulating learners.*

Other benefits identified by several researchers include helping students to develop as self-regulating learners who reflect, participate and control their own process of learning, leading them to be independent learners (Sajid et al., 2016). The FC is an active instructional design requiring regular participation by students. It has higher educational regulatory requirements than traditional designs (Sun et al, 2018, Lai & Hwang, 2016). Students in the FC are responsible for their learning, because the model's nature focuses more on the approach adopted by students instead of the teachers' approach. Students in the FC take responsibility for their learning, and the speed at which they learn, by accessing content at a time and location before class that works for them (Sajid et al., 2016). In addition, the FC helps students to improve their ability to learn on their own because if they have access to the material at their own pace (Chen, et al., 2014; Roach, 2013) they can be effective in skills development and acquiring knowledge and develop essential skills required for 21st century workplaces (Elmaadaway, 2018).

### *2.6.6 Benefits for teachers*

While the above examples illustrate the effect of the FC on student learning, teachers also benefit from this approach in numerous ways, starting with the changing of the teacher's role from the sage on the stage to the guide on the side. In the FC, students change from being passive learners who are simply informed by the teacher, to active ones, who prepare the content at home and come to the class ready to practise. Hence, the role of the teacher is to support students' learning, which alleviates some of the burden on the teachers. The application of flipped class pedagogy helps the teacher to make appropriate use of class time. Teachers can cover more subjects, provide help to low-level students and extend high-level learners (Ziegelmeier and Topaz, 2015). Further, doing homework in the classroom gives teachers the best opportunity to gain a feel for students' problems and to examine their various styles of learning, enabling teachers to adapt lessons on the basis of students' needs (Kong, 2014). This approach encourages the sharing of expertise through sharing instructional methods with others, which enhances the resources of teachers (Altemueller & Lindquist, 2017). A comparative study conducted by Unruh et al. (2016) used survey and interview data from a matched sample of in-service teachers representing the flipped versus the traditional class. The findings suggest that FC teachers have higher technology and teaching efficacy, greater comfort levels using technology, higher frequency of involvement in technology, more positive attitudes toward technology, and greater levels of student engagement. Lastly, by watching their videos and becoming critics of their methods, teachers can now focus on their techniques (Moffett, 2015). Briefly, the FC is an efficient way of encouraging teachers to be better organized; and of considering the practical implications of the provided information in order to develop exercises for students so that they can learn more by doing (Strelan et al., 2020).

Although these advantages tend to improve the classroom environment, a drastic change should be the main reason for changing the teaching approach, particularly regarding student performance. The flipped learning method should be taken as a replacement for conventional lessons only if student achievement is improved.

## 2.7 Potential drawbacks to the FC

Despite the positive aspects of the FC, there remain several challenges and potential drawbacks that must be considered. According to Lo and Hew (2017), the challenges identified in the literature can be categorized into three main themes, namely, student-related challenges, teacher-related challenges, and operational challenges**.**

### *2.7.1 Student–related challenges*

One of the most frequently reported issues is the limited preparation of students before class. If students do not study at home, they will not perform as well in class activities and, therefore, the benefits of the FC are reduced (Mason et al., 2013). Moreover, some students may be less experienced in flipped learning than others may, or they may not yet be able to reverse or change their lifelong learning patterns (Hao, 2016), which causes them to feel discouraged and pessimistic (Van Sickle, 2016). Moreover, successful class participation relies upon pre-class access to video lectures, students need to spend a significant amount of time educating themselves and acquiring and constructing knowledge using pre-recorded lectures. They therefore need to learn certain skills to survive. Students cannot necessarily accomplish these tasks; they struggle to develop these skills and rely on teachers to provide the guidance they need. In order to prevent this situation, there is a need for specific instruction in the use of pre-class time and course material and how students can efficiently learn from home and change their study patterns (Wanner and Palmer, 2015). Some students may have difficulty adjusting to the amount of additional work required for learning (Herreid & Schiller, 2013). More motivated students can adapt more readily to this shift in the learning environment. However, there may be problems with students who are less motivated and who struggle to change their passive learning practices, which could have a significant impact on the learning process (Chen et al., 2014). According to previous reviews, some K-12 students were disappointed that the pre-class workload in flipped lessons increased and they felt overwhelmed by it (Khanova et al., 2015; Wang, 2016). Students need to be able to control their learning well, but the self-regulation skills of students are often underdeveloped (Bjork et al., 2013). Teachers must identify the students' individual learning needs and make sure that they all use the time well in their classes, which can be harder than in the traditional model.

### *2.7.2 Teacher-related challenges*

According to teachers, this strategy may need more time and thus, increase their workload. When implementing the FC, teachers need to spend a considerable amount of time producing new resources, such as instructional videos and in class activities (Lo & Hew, 2017). Teachers must devote time to pre-recording video lectures and producing other flipped model materials. This is a time-consuming process for teachers, and they do not necessarily have the time and expertise to produce them. Wanner and Palmer (2015) stated that the amount of time required to prepare flipped course materials can be six times longer than traditional preparation. The increase in the time required for a teacher to prepare for a new class delivery may make them reluctant to use the flipped class (Cevikbas & Kaiser 2020). Teachers' lack of digital and technical skills is another problem identified; teachers can find it difficult to create on-line activities. Teachers must therefore acquire the technical skills needed to develop the learning resources. However, a possible alternative is to use other people's materials (Long et al., 2016). Teachers who want to flip the classrooms for their first time are not required to produce their own videos. There are many videos on the internet that can be used by teachers whilst they are experimenting with different techniques to create their own videos. However, teachers should be selective when choosing videos online and try to match their students' learning styles and needs (Schultz et al., 2014). Also, by working together, teachers can significantly minimize the amount of time spent on production of materials. Nevertheless, it is easier to plan and adjust classes in the FC once the first activities have been created.

Teachers' beliefs are another challenge reported in the literature, this is because some teachers may be accustomed to their routine teaching practices and reluctant to change. In a recent study in Turkey (Şen & Hava, 2020), 38% of the interviewed teachers claimed that the FC was not appropriate for the mathematics course and they believed that the best way to teach maths is by traditional methods. Additionally, four teachers feared that students would question the role of the teacher in the flipped approach, since they might wonder, since they could learn from the videos, what the teacher contributed to their learning and why they had to go to school (Şen & Hava, 2020).

### *2.7.3 Operational challenges*

The operational or technical challenges associated with the FC, documented in the literature, include equity of access, combined with a lack of institutional support. FCs use technology; therefore, equity and accessibility must be considered when using technology for educational reasons. Research suggests that only 57% of children between the ages of 3 and 17 have access to the internet at home and 79% to computers (Child Trends Data Bank, 2015). It can be seen from these statistics that the digital divide might have an effect on the overall comfort and achievement of students when using the flipped learning model (Jensen et al., 2015). To help address this challenge, teachers need to think about ways of making information accessible. For example, the school library can arrange for students to use computers for watching videos before or after school.  If students who have access to technological devices have issues with internet connectivity, teachers could make content available on flash drives.

Other issues are related to video lectures; some students deemed that watching video lectures was the most inefficient and least pleasurable school activity (Kettle 2013), and videos were sometimes unhelpful (DeSantis et al., 2015). This may be due to the lack of further explanation on the video when students seek further elaboration while watching instructional videos at home. The use of more interactive videos or online discussion tools could contribute to alleviating this issue. Because the FC is heavily reliant upon video, studies run the risk of being interrupted because of technological issues (Ramírez et al., 2014). Researchers have highlighted the issue with video and cautioned that substandard video quality could lead to a negative learning outcome (e.g., He et al., 2016).  While the FC is flexible and individualised in educational processes, studies have also found that some students prefer to attend classes rather than watch or listen to online lessons, due to the lack of support and ability to ask questions immediately when they watch study videos (Bhagat et al., 2016).

Clearly, the switch to the FC potentially posses a variety of challenges, making it important to evaluate whether the likely benefits are sufficient to warrant the change and if so, how the challenges can be addressed, and the change facilitated. However, the literature shows that the FC has become a strongly advocated approach for promoting students' learning and is widely applied in K-12 and higher education institutions around the world.  The review of the previous studies reveals no negative findings regarding the effectiveness of this approach on students' learning, despite the wide variations in implementation across studies.  The literature reports positive effects of the FC on students' knowledge, skills, engagement and, most importantly, achievement. This approach stands out and offers promising results as an alternative to the traditional lecturing approach and teachers across the globe should consider adopting this approach to enhance students' learning in line with the digital era that we live in.

## 2.8 FC in the context of mathematics education

The importance of mathematics comes from its universality. Maths remains among the most important subjects on the school curriculum. In a complex and quantitative society, an individual must understand the mathematical content in order to make informed decisions as both a citizen and as a worker (Wilkins & Ma, 2003). Mathematics is one of the main components of Science, Technology, Engineering and Mathematics (STEM) education and is crucial for students' imagination (Brown et al., 2011). Nevertheless, maths is considered a robotic subject, and learners face difficulty in comprehending high school maths (Offer & Bos, 2009). Teaching mathematics in the traditional manner, with most of the time spent on lectures and limited student-teacher interaction, is ineffective (Burns, 2007). According to Deslauries et al. (2011), a growing body of research has indicated that alternative teaching strategies are more beneficial, including strategies that put more emphasis on students learning in an active way, such as collaborating with their peers, learning through projects, and cooperative learning. The focus of teaching should not be simply on transmitting information, but rather on assisting students to assimilate that information (Brown et al., 2011). Mathematics teachers have been faced with a key difficulty in the enhancement of students' ability in maths (Wilkins & Ma, 2003). Considering the speedy development of educational technology, many researchers have suggested applying technology in diverse sectors of the maths curriculum, due to its ability to generate positive outcomes as far as learning and comprehending concepts is concerned (Anthony & Walshaw, 2009; Lazakidou & Retalis, 2010). Scholars and practitioners have sought alternative teaching methods and techniques to keep students motivated and engaged in the whole learning process. The FC is one such technique that can revolutionize the teaching and learning of mathematics, and it has become a popular way of teaching mathematics at K-12 and in higher education settings (Lo et al., 2017; Muir & Geiger, 2016). Recent research indicates that the increasing use of technology in the classroom or so-called flipped learning has the potential to change the way mathematics is taught and to improve participation levels, attitudes and performance (Chen et al., 2016; Lo & Hew, 2017; Lopes & Soares, 2018). A number of studies have examined the impact of the FC on mathematics learning in different contexts. Much evidence suggests that it has a positive impact on students, notably on their mathematics achievement (e.g., Bhagat, 2016; Lo & Hew, 2017; Zengin, 2017) and mathematics self-efficacy (e.g., Kenna, 2014; Wiginton, 2013). Additionally, the FC could encourage students to be more proactive in their learning, both before the class and during classroom time (Wang, 2016); the FC improves student engagement and performance (Lo & Hew, 2020; Zengin, 2017); the FC gives opportunities for differentiated teaching for various student abilities (Herreid & Schiller, 2013). The FC approach also provides the option for mathematics teachers to overcome obstacles in the prescribed curriculum and meet student' learning needs (Muir & Geiger, 2016). Studies have reported improved learning among students in a flipped model through a fostering of student motivation (de Araujo et al., 2017) and a reduction of the failure rate in 9th-grade mathematics by 31% (Flumerfelt and Green, 2013). The flipped learning technique can enhance the mathematical knowledge of learners and create time to participate in high cognitive demand activities, in line with the suggestions of the Common Core Standards for Mathematical Practice (CCSSI, n.d.). According to Brunsell and Horejsi (2013), teaching time freed up within the scheduled class is the most appealing feature of the FC technique for secondary and post-secondary maths teachers. In this approach, the learners are able to work together while tutors encourage and guide them. According to Strayer (2012) and Tucker (2012), this strategy gives opportunities for differentiation as well as the creation of mathematical discussions capable of resulting in deeper comprehension of mathematical concepts. Video learning has also been associated with the increased quality of what is taught in schools. A flipped class conducted as an experiment showed students' online engagement and homework rates increased from 75% to 100%, eliminating all failures in class (Flumerfelt & Green, 2013).

There are claims that this model makes the best use of the learner's inclination to go online, minimising the time spent by the teacher in presentations and discussions (Hwang et al., 2015). The potential benefits are so many that educators may advocate adoption of the FC strategy to improve students' achievement. Research evidence on specific aspects of the impact of FC in mathematics education is reviewed below.

### *2.8.1 Students' mathematics achievement*

High school students' success in mathematics is associated with their college results and employment in the future. With a strong background in mathematics, students develop reasoning and problem-solving skills that lead to having more career opportunities. Mathematics is a subject in which student achievement has always been considered significant in the educational community, at both the basic and the advanced levels (Wilkins & Ma, 2003). PISA (2012) described mathematical achievement as "An individual's capacity to formulate, employ, and interpret mathematics in a variety of contexts. It includes reasoning mathematically and using mathematical concepts, procedures, facts, and tools to describe, explain, and predict phenomena. It assists individuals to recognize the role that mathematics plays in the world and to make the well-founded judgments and decisions needed by constructive, engaged, and reflective citizens" (OECD, 2013, p. 25). There is no question that during high school, students have to compete academically in mathematics (Sánchez et al., 2019). Research by Harvard University found that 68% of US students were below the standard level of mathematics (Peterson et al., 2011) in a National Center for Education survey. One-third of students in a sample of 24,000 students in Californian schools had to retake the algebra course, while the proficiency rate for 10th-grade students studying Algebra I was 9% (Peterson et al., 2011).

One of the most daunting problems facing students and teachers is the question of students' poor academic success in examinations. There are many reasons for this issue, including psychological, social, and cultural aspects (Sánchez et al., 2019). A great many variables, including teachers, learners, curriculum, services and educational environment affect student achievement. The demographics of students, including sex, age, ethnicity, peer environment and the involvement of parents, may also be factors (Sánchez et al., 2019). Specific factors lead to a lack of motivation (Bobis et al., 2016), which is needed to maintain the focus and activities of students and to provide more resources for the completion of tasks (Bobis et al., 2016). It helps in maintaining effort over a period of time. Such factors are critical for students' desire to participate in education, and their potential to achieve success. Therefore, enhancing the quality of learning is important to increasing student success (Bakar, 2018). The cycle of learning must allow students to acquire the necessary knowledge, skills and values (Bakar, 2018). A new methodology such as the FC and a skilled teacher willing to develop and apply new methods in their teaching practices could combine to create a learning environment that could improve the learning process.

### *2.8.2 Impact of FC on mathematics achievement.*

Several studies have demonstrated a beneficial impact of FC on mathematics achievement. For example, in a recent meta-analysis of 21 studies comparing the FC to conventional teaching, the average effect on achievement was 0.30 SDs (95% CI: 0.16 to 0.44), with most studies (81%) showing a positive impact (Lo et al., 2017). Of 21 studies analysed, 18 were conducted in the USA and one study in each of Germany, New Zealand and Taiwan. The majority of these were conducted at undergraduate level (n=17), with very little research conducted at secondary level (n= 4). The main mathematics content areas studied were Calculus (7), and Algebra (6). Others appeared three times, such as Statistics and others once, such as Trigonometry, Finite Mathematics, Geometry, Mathematics Content for Teachers I and Introductory Differential Equations.

Interestingly, the variance of the effect sizes included was relatively large (ranging from -0.16 SDs to 1.14 SDs; heterogeneity [$I^2$] was 72%) (Lo et al., 2017). For example, a study by Wilson (2013) offered results based on an undergraduate statistics course that is required for social science majors in USA. Overall, the quantitative analysis found significant benefits to flipping over the traditional model, d = .69 SDs. Bhagat et al. (2016) found evidence indicating the positive impact of FCs on academic performance in trigonometry, in comparison to the conventional way in which mathematical concepts are usually taught in Taiwan. Overall, 82 high-school pupils took part in this research and were divided into experimental and control groups. The study's key findings indicate that the learners in the FC performed better than those in the conventional learning setting, with an effect size of d =0.87 (Bhagat et al., 2016). In order to overcome the problems, they had with maths, low achievers in the FC received greater attention from the teachers, which allowed them to improve their mathematics performance (Bhagat et al., 2016). Conversely, teachers could collaborate with average and high attainers so that more problems were solved, and they could participate in more class discussions (Davies et al., 2013).

In contrast, some studies revealed no significant impact on mathematics achievement, despite being designed to detect relatively small effects (e.g., Love et al., 2014; Clark, 2015; Vang, 2017; Yong et al., 2015). For example, Yong et al. (2015) conducted a two-year study to compare flipped instruction with traditional lectures and the results did not reveal any differences in learning, metacognitive, or affective gains between the flipped or the control sections. In addition, Clark (2015) assessed two flipped algebra I classes for high school students aged 13-15 years and evaluated their performance on unit content against learners who were in a non-flipped algebra class. The study did not find any significant difference in performance (d=0.03) between the groups. Likewise, Love et al. (2014) reached a similar conclusion after performing research at a mid-size metropolitan university in the USA, in a sophomore-level (second year) linear algebra course: the author concluded that those in a flipped class had a similar performance to others who received traditional teaching (d=0.03).

Some studies show minimal effect. For example, a study by Ziegelmeier and Topaz (2015) was able to show a small difference between traditional and flipped classes, leading them to conclude that the "flipped model is much more than simply moving lectures out of class" (p.5). Nor were there significant differences in gains from pre to post-test between direct and flipped instructional methods in an algebra course (Kirvan et al., 2015); small sample sizes and emphasis on conceptual teaching in both methods may explain the lack in differences. Those researchers further argued that a variety of activities ought to be integrated into a flipped class redesign in order to optimise its potential. O'Flaherty and Phillips (2015) questioned whether the FC might be applicable to every subject. Additionally, Şen and Hava (2020), emphasised some challenges that students may experience in flipped mathematics education, citing lack of adequate resources as the main obstacle. In addition, numerous studies have reported the absence of immediate explanations by facilitators and teachers as one of the key barriers that hinder learning when using an inverted approach (Kennedy, 2015; Wasserman et al., 2017; Zengin, 2017). The above studies offer varying degrees of evidence and results and are associated with diverse approaches to execution. The FC is perhaps more of a mindset than a pedagogy, enabling teachers to apply it based on their judgement of an appropriate learning setting. Worse, some studies showed that the FC was less successful than traditional teaching. For example, in a study by Gundlach et al., (2015), where the FC was used in an introductory undergraduate course in statistical literacy, students that received traditional instruction outperformed those receiving FC instruction on each of five assessments (effect sizes ranging from -0.55 SDs to -0.11 SDs). We return to the possible causes of the high variability in outcomes at the end of this section.

### *2.8.3 Students' Self-efficacy*

Albert Bandura (1986) has defined self-efficacy as the belief of an individual in their ability to succeed in accomplishing a certain task in a particular situation. Therefore, it can be maintained that self-efficacy refers to the belief about the different means necessary to the accomplishment of certain goals and self-evaluation of the individual's capacity in achieving those goals (Pajares, 1996). Research suggests that students with high self-efficacy set higher goals and show more resilience when facing difficulties (Bandura, 1997; Schunk & Pajares, 2002). Self-efficacy has been shown to predict future behaviour and academic achievement (Hackett & Betz, 1995): those with a strong sense of self-efficacy can lead a person to increasing their personal learning goals, as well as their level of performance (Heslin & Klehe, 2006; Bandura, 1989).

Albert Bandura (1977) states that individuals develop their self-efficacy beliefs by interpreting information from four main sources: mastery experiences, vicarious experiences, social persuasion, and psychological status (see Figure 2.2). The first source of information is mastery experiences or previous performance, which is believed to be the most influential source of self-efficacy. It is based on the previous successful experiences of students. For example, at school, it assumed that once students have completed an academic task, they interpret and evaluate the results achieved, and assess their skills based on their interpretations (Usher & Pajares, 2009). This assessment then, in turn, influence their self-efficacy. Mastery experiences are assumed to have a stronger positive impact on self-efficacy if individuals overcome or succeed in difficult activities, particularly activities that other find difficult (Bandura, 1997). Therefore, students who attain repeated success tend to develop strong efficacy expectations, which also minimizes the negative outcome of failure.

The second source of self-efficacy comes from observing other – or what Bandura refers to as vicarious experiences. Students develop their efficacy beliefs from observing others (i.e., what Bandura refers to as vicarious experiences). When students observe others performing an action successfully, their own self-efficacy beliefs are enhanced (Schunk et al., 2006). Moreover, students who attend school are likely to be similar in interests and habits, making it easier for them to be influenced by modelling. This could be enhanced by students when they compare themselves to particular individuals such as peers and when they form opinions regarding their own academic capabilities (Usher & Pajares, 2009). In other words, observing a similar classmate succeed at a difficult activity may persuade other students that they too can overcome the problem.

The third source of self-efficacy is the social influence of the social environment around students, which includes their families, teachers, and peers (Bandura, 1997). The family has a vital impact on the early childhood development and behaviour of students (Harris & Goodall, 2008). Students first develop views about their potential while they grow up in a family. A student's self-efficacy is impacted by the resources and assets that are provided by their family. The education of parents and the employment of parents correlates positively with the self-efficacy of children (Han et al, 2015). For example, financial stress and emotional tiredness that occur because of poor income and self-efficacy are more pronounced for parents in low socioeconomic level households (Schunk & Meece, 2006), who may then be less able to support and encourage their children. Parents of higher socioeconomic class, on the other hand, may have more time, energy, and understanding about schooling, and therefore be better able to encourage their children (Han et al, 2015). Additionally, students may also be influenced by their peers. Students always perceive the persuader as an individual who is capable of providing reliable feedback. Peer group participation predicts changes in motivation for education through the school year (Wentzel et al, 2014). At the same time, teachers can increase students' self- efficacy by providing credible communication and continuous positive feedback to guide the student through assignments and motivate them to make their best effort. Hence, encouragement from trusted parents, teachers, and classmates can increase trust in the academic capacity of students. Supporting words can serve to increase the effort and confidence of a student, particularly when combined with conditions and instruction that aid in achievement (Schunk, 2012). Conversely, the lack of such support and encouragement from parents, peers and teachers could affect students' confidence in learning, which in turn would influence their self-efficacy. The fourth, and last source of self-efficacy hypothesized by Bandura (1997) is the impact of a person's emotional, physical and psychological well-being, influences hypothesized to to affect how people feel in a certain circumstance in regard to their personal skills. Psychological status may include such aspects as stress, fatigue, anxiety and mood. For example, high anxiety can undermine students' self-efficacy. Thus, individuals can improve their feeling of self-efficacy by learning to handle anxiety and improve their mood in difficult situations.

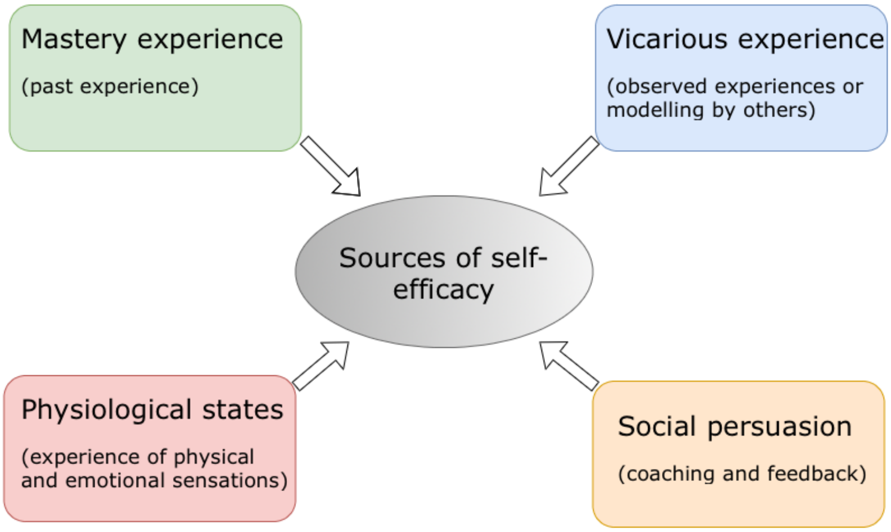


Figure 2-2 The sources of self-efficacy (Bandura, 1997).

#### 2.8.3.1 FC and mathematics self-efficacy.

Mathematics self-efficacy relates to individuals' perceptions or beliefs regarding their own mathematical abilities (Bandura, 1997). That is, individuals' mathematical self-efficacy is their confidence in their own ability to complete various tasks, from understanding a concept to mathematical problem solving. In research conducted in order to design a scale for exploring the sources of mathematical self-efficacy, Usher and Pajares (2009) discovered that perceived mastery experiences are a strong source. A student who has mastered certain skills and who succeeds in completing challenging assignments has increased efficacy beliefs. The theory of self-efficacy explains that the individual's beliefs are an explicit and primary explanation of the motivation. Therefore, a constructive relationship has been found between self-efficacy and motivation. Much reseach suggests that there are two fundamental types of motivation, the first being intrinsic where individuals are motivated for a certain task based on their own desire to achieve, and extrinsic, where individuals are motivated to earn external rewards (Ryan et al., 2000). Hence, someone realizing that he/she possesses certain capabilities to accomplish a task motivates them but on the other hand, there exists a possibility of performing a task for the sake of reward based on motivation with high self-efficacy but with no interest. According to Carpenter and Clayton (2014), self-efficacy beliefs can influence various choices, such as activity, effort, and resilience all of which can have an impact on learning. Self-efficacy beliefs can also have powerful impacts on the decision making of students with regard to their future academic and career choices (Carpenter & Clayton, 2014; Usher & Pajares, 2009). For example, students with high self-beliefs have been shown to make more effort when solving mathematical problems and to be more likely to pursue career goals in STEM fields (Usher & Pajares, 2009; Peters, 2013). Not surprisingly, there is a strong positive relation between mathematics achievement and self-efficacy (Hackett & Betz, 1989; Skaalvik et al., 2015). For example, in a study conducted by Ayotola and Adedeji (2009) with secondary school students, the correlation between mathematics achievement and self-efficacy was r = 0.73. Abele and Spurk (2009) explain that based on their self-beliefs, students are motivated to the fact that they possess an ability to overcome obstacles and difficulties, to solve mathematical problems. Owing to their self-belief, the students are motivated to invest more of their time in solving problems and seeking for the solution, along with making continuous efforts to solve mathematical problems (Abele & Spurk, 2009).

Although sparse, there is evidence that the FC can increase self-efficacy in mathematics. Wiginton (2013), for example, found that self-efficacy was higher in two different styles of FC in algebra courses than the traditional ones. Students in both the Flipped Mastery learning environment (d=1.08), and Flipped Active group had scores which were significantly higher (d= 0.76) on mathematics self-efficacy than those who participated in the traditional learning environment. Additionally, Vang (2017) found that in a sample of 60 students, self-efficacy was higher in the FC group than the traditional one, although the difference did not reach statistical significance. Researchers have suggested various ways by which the FC brings about an increase in self-efficacy. Wiginton (2013) and Sun et al. (2018), for example, suggested that using classroom time for engaging in in active learning and promoting students' self-regulated ownership of the learning process could increase their self-efficacy. Moreover, FC facilitates one-to-one instruction and improves student-teacher relationships, the impact of which appears to be favourably displayed in a self-efficacy increase (Vang, 2017). Furthermore, FC students have more opportunities for observing their peers master specific skills, which subsequently instils confidence in them that they can master the same skills (Usher & Pajares, 2009). Cabi (2018) explains that the flipped classes are based on individual student learning based on individual learning needs; therefore, students are motivated and confident as compared to traditional classrooms. Various studies (but related to different interventions and comparison groups) find that females exhibit an increased level of self-efficacy in FCs as compared to males (e.g., Ibrahim & Callaway, 2014).

### *2.8.4 Impact on perceptions of the flipped mathematics classroom*

Most studies agree that students have generally positive perceptions of the FC in maths classes (e.g., Bhagat et al. 2016; Clark 2015; Lopes & Soares, 2018; Love et al., 2014; Turra et al., 2019; Van Sickle, 2016). The FC approach helps students come to the lesson prepared and able to learn in a more convenient and flexible environment (Chen et al., 2016). In a study by Zengin (2017) to determine the effects of FCs designed by using mathematics software and Khan Academy, the results showed that the approach increased student understanding of the mathematical concepts, making the course more visually based, and promoting retention. Students appreciated the way video lectures helped them to determine their own pacing, prepare for class activities, and watch at times and places convenient for them (Chen et al., 2016; Love et al., 2014; Murphy et al, 2016; Song & Kapur, 2017). Lopes and Soares (2018) found that 86.9% of the students participating in their survey stated that video lectures helped with understanding financial mathematics concepts. Clark's (2015) students remarked that the teacher individually assisting them helped to improve their understanding in their Algebra I FC, since the FC enabled meaningful contact between teachers and students in terms of observation, guidance, commenting, and assistance. Additionally, Bhagat et al. (2016) indicated that students in the FC agreed that tackling mathematical tasks in class was enjoyable and effective. However, a survey by Cilli-Turner (2015) did not find any significant changes relating to student attitude towards the flipped statistics course, while Wasserman et al. (2017) found a degree of dissatisfaction, particularly in regard to use of class time, which according to Wasserman et al. (2017) could be attributed to a lack of training by teachers, making class time less productive. Some students found it difficult to adapt to learning at home before lessons, and so skipped pre-class activities and were not prepared for class (Chen et al., 2016). Furthermore, Strayer (2012) discovered through a survey and interviews that student in flipped classes had less satisfaction with how the format steered them towards their relevant learning goal, possibly due to the poor connection between the face-to-face and online aspects of the course. This ambivalence is consistent with the findings of a recent meta-analysis of 271 studies examining the impact of FC (not limited to mathematics) on students' satisfaction which found only a weak influence of FC on student satisfaction (Låg & Sæle, 2019).

## 2.9 Why are the benefits of FC in mathematics education not consistent across studies?

The differences in outcomes reported in studies of FC in mathematics education can be attributed to two factors: differences in the design of the FC courses investigated and differences in research methodology.

### *2.9.1 Heterogeneity in FC intervention*

Previous studies show that FC designs vary in length, intensity, organization, material, compulsory or voluntary attendance, and type of videos. For example, the studies varied widely in length from two weeks (Song & Kapur, 2017) to a full academic year (Graziano and Hall, 2017; Wasserman, 2017). They also varied in intensity. While most studies used video lectures as out of class activities (Lo & Hew, 2017), others assigned reading materials (Patterson et al., 2018; Nielsen et al., 2018), and others did not specify the type of out of class activities (Briggs, 2014). Moreover, video creation was also highly variable; some studies used teacher-created videos (Anderson & Brennan, 2015; Murphy et al., 2016), and others used ready-to-use online videos such as Khan Academy and YouTube (Wilson, 2013; Kirvan et al., 2015). Besides, in most studies, pre-class videos and class attendance were mandatory, whereas other studies did not detail the physical locations or technological choices of teachers. Some studies did not require students to watch the videos before the class (Hart et al., 2017). Others, such as a study by Young et al. (2015), made the videos that were created for the flipped class available to the students in the control sections. While a majority of studies employed small group activities, other studies implemented strategies, for example, peer instruction (Phillips & Phillips, 2016; Lo & Hew, 2020), cooperative learning (Chen et al., 2015), and collaborative and problem-solving activities (Yong et al., 2015; Wei et al., 2020). Some teachers used a structured formative assessment such as a quiz at the beginning of face-to-face lessons (Van Sickle, 2016; Kirvan et al., 2015; Lo et al., 2018).

### *2.9.2 Heterogeneity in methodology*

Criticisms have been expressed of the methods used in past research. Some studies were conducted in a single classroom, with no reference to a comparison group (Clark, 2015; Lo & Hew, 2017). In addition, there are various ways in which different studies approach measuring students' performance. This literature review suggests that the research has shown comparative improvements in academic performance by considering different measures. Some of those studies applied standardized tests (Wiginton, 2013) while others applied tests that were designed by teachers (Wasserman, 2017), which raises the issue of the reliability and validity of non-standardized tests. In addition, while most of the studies applied comparable pre and post-tests, some used a combination of measures to test the students' performance, such as computer-based skills tests, midterm exams, homework scores, and unit quizzes, in addition to the final exam (Ziegemeier & Topaz, 2015). Such studies, although they may allow compression of FC with non-FC groups do not enable before and after intervention comparison, and there may be differences among students in the skills tested.

Some studies even used surveys and pop quizzes as measures of students' performance (Sahin et al., 2015). Some of the studies used matched pre and post-tests (Bhagat et al., 2016), which raises the issue of the effect of practice, while others applied only a post-test achievement measure (Braun et al., 2014). Some studies used an online platform to investigate students' performance outside the classroom (Katsa et al., 2016). Other studies (Muir & Geiger, 2016; Sahin et al., 2015) relied upon students' self-reporting of their learning efforts outside of classes, rather than data on their online learning. Furthermore, in some studies the flipped and control groups were taught by the same teachers (Graziano & Hall, 2017), whereas in others, they were taught by different teachers (Van Sickle, 2016). In addition, there is variation in participants' ages and their ability levels.

Therefore, differences in the FC design and implementation may account for the discrepancies that have been identified between studies. This idea gained support from O'Flaherty and Phillips (2015) when they pointed out that the current FC studies underutilize conceptual frameworks and pedagogical designs, leading them to call for more powerful evidence when evaluating students' outcomes in a FC. Kim et al. (2014) stated that FC efficacy might be affected in an unpredictable way if not used within a theory-driven framework. Some inexperienced teachers design FCs intuitively, which can alter the approach's efficacy (Overmyer, 2014; Yong et al., 2015). The majority of research on FCs lacks a strong experimental design and was not empirically connected to driving principles (Lo et al., 2017). More powerful evidence is required to evaluate student learning and development in FC environments. This study seeks to address this gap in FC research.

## 2.10 Summary

To conclude, this chapter has conducted a review of the previous literature related to blended learning and FCs. The literature has suggested that more rigorous evaluation research is needed to improve understanding of the potential benefits of the FC in secondary education because a large proportion of previous studies have been focused on higher education. In addition, the current FC studies underutilise conceptual frameworks and pedagogical designs. Kim et al. (2014) argued that if applied without a theory-driven structure, the effectiveness of the FC could be impacted unexpectedly. Song et al. (2017) emphasize that it is necessary to discuss how a FC is designed and implemented. The literature on the FC should be supplemented with pedagogical designs with a sufficient theoretical basis, as the absence of such a basis may hinder the success of learning mathematics in the FC environment. Therefore, this study adopted Lo et al.'s (2017) framework of 10 design principles for FC in mathematics courses, which are based on an extensive review of the challenges and benefits identified in previous studies. In the next chapter, a description of the underlying theoretical framework, as well as the design principles that guided the implementation of the FC in this study will be given.

# Chapter 3 : Designing the Flipped classroom (FC)

This chapter sheds light on the theoretical basis that guided this study, along with a detailed description of the FC design implemented. The design of the FC was based on Lo et al.s' (2017) framework of 10 design principles for FC in mathematics courses, which are based on an extensive review of the challenges and benefits identified in evaluations of FC. This chapter comprises two sections, beginning with an explanation of the study's theoretical basis, followed by a description of the Lo et al. (2017) framework.

## 3.1 Theoretical Framework of the Study

The concept of the flipped class is complex, integrating elements of blended learning, active learning, and individualised instruction. In this process, innovative educators are revolutionising the way students learn by making better use of class time for active learning strategies. The FC also shifts the focus of learning from teacher to student, which has been found to have a positive effect on self-regulation and self-efficacy (Lai & Hwang, 2016). Therefore, this study's framework is drawn primarily from a combination of concepts from constructivist learning theory, the revised Bloom taxonomy and social cognative theory.

### *3.1.1 The constructivism learning theory*

John Dewey (1859) put forward ideas about the ways in which knowledge is constructed by learners, suggesting that it is by their own experience that students form ideas, but it was not until later that the expression "constructivism" was used to describe ideas about learning being developed by Piaget (1968) and Bruner (1961). The principle underpinning constructivism is that learning occurs when abstract concepts are formed in the mind to represent reality (Bruner, 1961; Piaget, 1968). According to Duffy and Jonassen (2013), constructivism hypothesizes that learners build new understanding and knowledge by synthesizing their previous understanding and new information through social exchanges and exploration. From this perspective, students do not simply absorb new information in a sponge-like manner but must be active classroom participants, constantly reviewing their own ideas and how those ideas correlate with the ideas of others (McLaughlin, 2013).

Constructivism is categorized into individual or social forms. Cognitive constructivism, also known as individual constructivism, rests on Piaget's (1950) cognitive development theory. Piaget (1950) proposed the theory that as learners attempt to make sense of the world, they actively construct knowledge as a way to maximise the learning experience. This is done through a complex interplay of activities including exploration, thought, manipulation and assimilation in which new information is connected to knowledge the learner already had. The end result of this process is the incorporation of new experience into learners' existing schema. Social constructivism, on the other hand, is built on the sociocultural theory of Vygotsky (1962). The difference has been described thus: "In cognitive constructivism, ideas are constructed in individuals through a personal process, as opposed to social constructivism where ideas are constructed through interaction with the teacher and other students" (Powell & Kalina, 2009, p. 241).

Both versions of constructivism imply that it is not sufficient simply to give knowledge to students; students must construct their own meanings (Stage et al., 1998). This means that it is not desirable for students to listen passively to teachers. In the constructivist classroom, responsibility for learning rests with the student. Students participate in social discourse. They develop skills to solve problems, apply concepts to situations, whereby in the real world, build on the knowledge they already have, and collaborate both with teachers and with their peers (Vygotsky, 1962). Through inquiry-based learning, students play an active role in predicting outcomes and employing high order thinking skills (Huitt & Hummel, 2003). Constructivists regard passive learning as less effective than interactive activities, which encourage students to be more engaged and motivated to learn. In this view, one of the most important roles of the teacher in a constructivist classroom is facilitating and encouraging the thinking processes of their students, whom they should guide towards understanding and integration of new knowledge. The Southwest Educational Development Laboratory stresses the weight that teachers should give to the skill set, belief system, and knowledge brought to the learning process by the student (Henderson & Mapp, 2002). According to Pailey (2013), the constructivist teacher focuses on the solution of real-world problems, using strategies of active learning that make students look independently for answers, thereby developing their thinking skills and enhancing their ability to construct knowledge. To give students opportunities for meaning construction, teachers themselves need to understand how to design the kind of activities that will enhance the students' understanding. This should include designing projects and tasks to encourage students to set goals, pose problems, and ask questions. The student becomes an active learner not by accident but through informed forethought and planning on the teacher's part, to create activities that encourage enquiry and exploration (Jensen et al., 2015). The teacher supports students' learning by guiding them in strategies that enable knowledge acquisition and by providing opportunities for them to take charge of their own learning (Huitt & Hummel, 2003). Constructivist learning environments, then, are those in which the students become owners of their learning and engage actively in activities that entail thought, problem-solving, sharing, and synthesis.

When applied to the context of the current study, the idea of the FC works well with cognitive and social constructivism. Teachers do not lecture to groups; instead, they work with each individual student, helping them to understand mathematical problems and learn how to solve them. It was suggested by Bergmann and Sams (2012) that this form of learning in a FC, being interactive, has the capacity to encourage students to become collaborative learners through processes of evaluation and analysis. FC class time is spent on collaborative work by students, including finding solutions to problems, discussions, and laboratory work. In this model, teachers guide students towards the consideration, discussion, sharing and solution of problems. The students control the lesson and are able, when at home, to look again at concepts that they may not have properly understood, or that may need to be reinforced, or those that the student finds especially interesting (Jensen et al., 2015; Gilboy et al., 2015). This scenario illustrates the fundamental characteristics of constructivist learning, with students taking an active part in the construction and acquisition of new knowledge (Larochelle, 2010). The arrival of the Internet has given students an increased ability to connect with other students as well as to build additional knowledge layers. Students have thereby achieved greater motivation to learn about the things that interest them (Talbert, 2015).

According to Roehl et al. (2013), when students are able to put new knowledge to use in a situation where feedback from both teacher and peers is immediately accessible, as in the FC, the students are enabled to correct misunderstandings and to organise the new knowledge they have gained in a way that makes it more readily accessible for use in the future. In addition, the FC's ability to provide instant feedback makes it easier for students to be aware of their learning. It follows that a constructivist environment in which students can learn is best achieved through a combination of flipped classroom lecture and active classroom learning activities (Strayer, 2012; Herreid & Schiller, 2013). A number of studies have shown how the performance of students in a variety of subjects is improved by constructivist learning, which has been particularly successful in improving performance in the problem with which this research is concerned: low achievement in mathematics by students (Wilson, 2013; Bhagat et al., 2016).

### *3.1.2 The Bloom taxonomy*

As well as constructivism learning theory, the need to move beyond basic skills to achieve higher level learning targets was emphasised by Bloom (1956). Bloom's taxonomy, introduced in 1956 by Benjamin Bloom, is a classification of levels of intellectual behaviour important in learning. The Bloom taxonomy classifies learning objectives, according to specificity and complexity, into one of three hierarchical models. It distinguishes separate learning domains that range from basic fact retention to applying knowledge in the creation of a new entity. Bloom, using a framework, divided the cognitive domain into six categories. These were organised from the simplest and most well defined to the more complex and abstract: knowledge, comprehension, application, analysis, synthesis and evaluation. The first three categories correspond to concrete thinking, while the next three levels relate to creative and abstract thoughts. During the 1990s, the taxonomy was updated to reflect its relevance to 21st-century work. Krathwohl (2002) subjected Bloom's taxonomy to a re-evaluation process that resulted in the so-called Revised Bloom Taxonomy. In this review, the categories are divided as follows: remember, understand, apply, analyse, evaluate and create (see Figure 3.1).

When the revised taxonomy is applied to the FC, remembering and understanding, which are lower-level cognitive activities, are undertaken outside the classroom. It is in class that students are involved in application, analysis, evaluation, and creation, which are higher-level skills, because it is in class that they find support available both from the teacher and from their peers (Morton & Colbert‐Getz, 2017). This is in contrast with the more traditional approach, in which it is in the classroom, by means of lecture, that the student is firs exposed to new information, and knowledge is subsequently assimilated through homework. For teachers, using Bloom taxonomy allows them to set precise targets based on the areas that require improvement, in addition to defining a learning plan allowing each of the students to progress — from the bottom to the top of the pyramid (Krathwohl, 2002; Wilson, 2016). The teacher is left with more time to spend on developing students' high order thinking skills. Freeing the teacher from some of the burden of information transfer permits development of a classroom that meets students' need for access to a teacher during times of high cognitive load. Teachers can thus assist students in the assimilation of information and the creation of new ideas, which are at the highest level of Bloom's taxonomy (Adams, 2015).

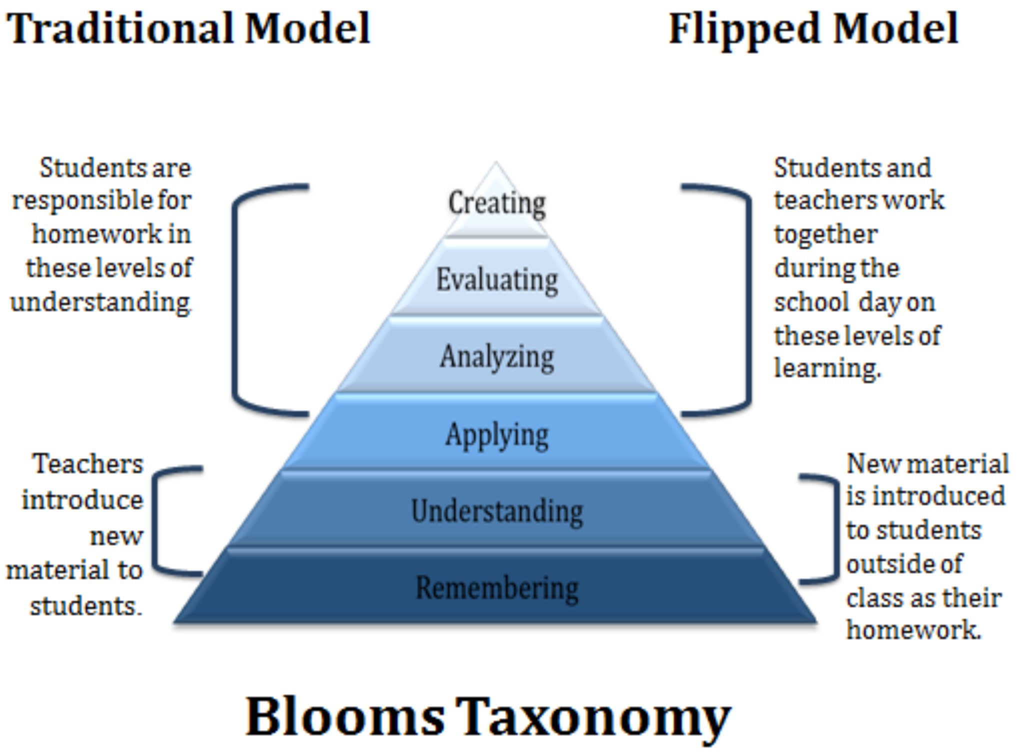


Figure 3-1 The application of Bloom Taxonomy to the FC in the present study (Beth ,2013).

### *3.1.3 Social Cognitive theory (SCT)*

Bandura created his social cognitive theory (SCT) of human functioning in 1986 and suggested that learning takes place in a social setting with a dynamic, mutual interaction between the person, the environment and behaviour (Bandura, 1997). In other words, his goal is to explain how learning results from interaction among three factors: personal characteristics, behaviour patterns and social environment (Bandura, 1986). SCT is now a key prominent theory in psychology in education, sociology, development, health, and reseach on personality with applications to such as school achievement, emotional disorders, mental health, choice of career and socio-political change (Stajkovic & Luthans, 1998; Luszczynska & Schwarzer, 2015). A number of key aspects that determine behaviour are described in the SCT theory. The first is self-efficacy, which concerns the belief of people in their ability to carry out what is necessary to achieve the desired result (Bandura, 1986). Outcome expectations are the other main SCT component which, in addition to the self-efficacy aspect of cognition, comprises aims, perceived barriers and facilitators and are linked to people's convictions regarding the impacts of their actions (Luszczynska & Schwarzer, 2015). Based on this theory, measures can be targeted at improving emotional, cognitive or motivational processes, boosting behavioural skills, or making changes in people's living and working situations (Hackett & Betz, 1995). Another prominent feature of SCT is self-reflection (Schunk & Pajares, 2009). People make sense of their experiences via self-reflection, explore their understandings and beliefs, engage in self-evaluation and adjust their thinking and behaviour accordingly. In addition, emphasis is placed on social influence and social reinforcement, both externally and internally. In other words, SCT takes into account the unique manner in which people acquire and maintain their behaviour, while also considering the social environment in which people conduct their behaviour. SCT indicates interactions between various influences (Schunk 2003). For example, teachers in school have the task of boosting their students' academic learning and trust. Within the framework of social cognitive theory, teachers can enhance student emotion, correct flawed beliefs and thinking (personal factors), increase study skills and self-regulation (competencies) and adjust their class and school structure to assure student achievement (environmental factors) (Bandura,1999). Since individual, behavioural and environmental factors interact, it is possible to affect other variables (e.g., personal, behavioural and environmental variables) by altering one variable type (e.g. automaticity—personal) (Schunk & Dibenedetto, 2016). Bandura's (1997) SCT overlaps with other theories, mainly Vygotsky's (1978) sociocultural theory of learning, which, as stated in the previous section, emphasises the fundamental role of social interaction in the development of cognition. Bandura (1997), however, claimed that disparities in self-efficacy could lead to important variations in the way people see the world around them. Self-efficacy is one of Bandura's most important personal factors. Self-efficacy is assumed to affect and be modified by behaviours and contexts (Bandura, 1986, 1997). It is viewed as an essential element in social cognition theory (Locke & Latham, 2002).

Self-efficacy can determine how a person perceives and accomplishes particular tasks and objectives according to Bandura (1989). In his view, those with high self-efficacy often think that they control their lives more effectively and the decisions they make have a direct impact on their lives (Bandura, 2001). Individuals with poor self-efficacy, on the other hand, often think that such actions and decisions have little impact on their lives and that their life is out of their personal control. Therefore, self-efficacy not only influences the level of drive toward achieving original goals, but it also influences the level of motivation for achieving those goals (Bandura, 1986).

A high sense of self-efficacy fosters personal achievement and well-being. A person with a high level of self-efficacy considers difficulties as challenges to be mastered rather than threats (Benight & Bandura, 2004). These individuals can recover more quickly from failure and are more likely to attribute failure to a lack of effort. Their conviction is that they can control frightening events. They therefore have lower stress levels and lower vulnerability to depression. In contrast, those with little sense of self-efficacy regard challenging tasks as personal threats and are wary of them. Difficult assignments lead them to focus on the skills they do not have. After a failure, they can easily lose confidence in their own capabilities. Low self-efficacy can be associated with increased stress and depression. Self-efficacy could also affect the individual 's belief in his/her ability to produce specific results, whereby a student needs to analyse and reflect on learning tasks, assess the balance of skills and learning goals and further evaluate the need to achieve goals (Shea & Bidjerano, 2010).

Prior study has shown that the self-efficacy of a student in an educational situation can be task or goal related. Moreover, the self-efficacy of a person in attaining learning goals in one subject may differ from the self-efficacy of the student in achieving learning objectives in another subject due to the differing nature of the two subjects. Therefore, subject-specific self-efficacy should be considered, instead of a broad measure of self-efficacy, when investigating the effects of self-efficacy on performance in a specific subject (Pajares and Miller, 1994). As Bandura (1997) claimed, people receive information that measures their self-efficacy through the interpretation of actual achievements, vicarious experiences, forms of social persuasion and psychological status. In accordance with Bandura's view, the self-efficacy of the student grows when a student successfully achieves a task or objective. The increased self-efficacy promotes more perseverance in students. This is particularly encouraging because students frequently worry about their capacity to master the rigors of the course in some academically challenging classes (Hackett & Betz, 1995). These self-beliefs can be weak and can impede the potential of many students.

To apply the SCT to the use of the flipped classroom, the FC approach alters the learning environment by transferring the focus and responsibility for learning away from the teacher and toward the student. This student-centred learning environment transfers the curriculum's pacing and responsibility for acquiring subject matter to the individual, while simultaneously increasing attainment. The change toward a more dynamic classroom culture will increase confidence in students and encourage students' self-efficacy. They will then use their prior experience with the support of their teacher and peers to construct new knowledge. The FC provides the conditions for students to advance and establish the basis to become proficient, autonomous lifelong learners (Bergmann & Sams, 2012). If students are committed, their progress will be considerably more self-regulated and hence self-confidence building (Clark, 2015). This is very important in the context of the flipped classroom, since the approach depends on students being self-motivated and responsible for their own learning (Wiginton, 2013). Therefore, the desire to study as a student becomes a driver for students to pursue their ambition for intellectual progress. Shih and Tsai (2017) note that the flipped classroom enables students to relate critical thought, social interactions and school life to help them develop new knowledge. The out-of-class activities design that incorporates watching videos and answering quizzes could improve students' self-confidence in completing in-class activities (Sun et al., 2018). This is because students can experience success earlier, before engaging with the classroom activities. This early success was argued by Bandura (1986) to be an important source of self-efficacy. This could boost students' confidence when they come to the class to share their understanding of the materials and engage actively with different activities, leading to enhancement of learning. Additionally, based on the SCT, much learning takes place through observer modelling, in which a student creates an idea of how to perform a new behaviour through the observation of others (Bandura 1986). This achievement and verbal persuasion from other students are two key aspects, which influence students' confidence in the completion of a task. Therefore, the adoption of the FC helps students to adapt and enhance social contact with their colleagues. This is because of the nature of the in-class activities, which encourage more interaction and feedback from both teachers and peers, which in turn enhance students' engagement with the content.

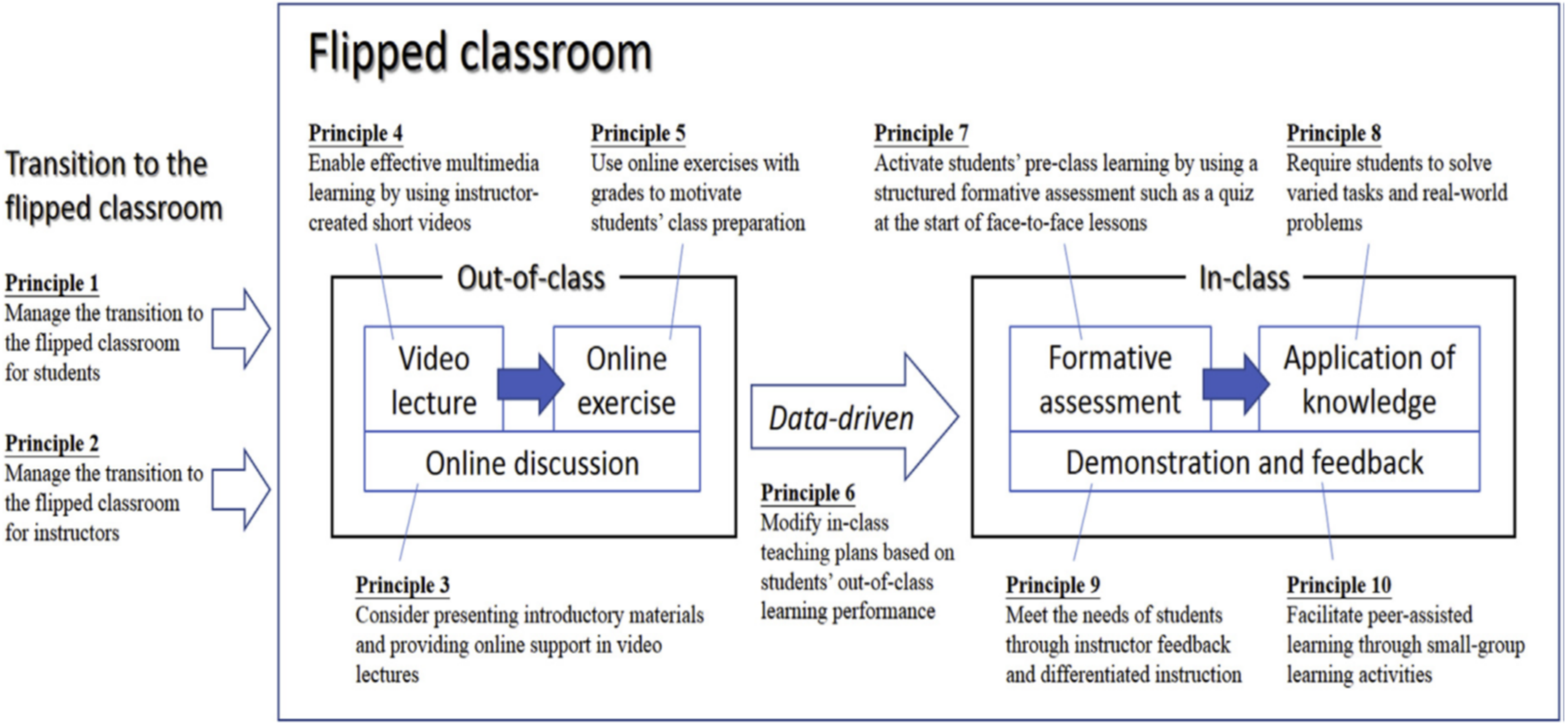
## 3.2 The FC Design

Lo et al. (2017) state that all these principles are based on empirical evidence, and they explain each principle with reference to the 61 studies reviewed in their systematic and meta-analysis. Some of the principles reflect practices found in earlier studies to be beneficial, where others are attempts to avid or reduce challenges identified in previous studies. The discussion of each of the principles below draws on Lo et al's rationale, together with relevant arguments from a range of other literature.

It is important to identify a holistic model to guide students and teachers in FC implementation since there are several variables and elements which could influence the success of an FC approach. A review of the literature revealed a handful of frameworks for the design of FC courses provided by various authors. For example, Strayer (2007) can be considered the first to have developed an FC conceptual framework for investigating learning activity in a classroom which is structured using the FC. His framework depended mainly on two core ideas which influence students' learning environments; the extensive use of educational technology to deliver course content outside the class and active learning during class time. Although this framework considers the main components of the FC, it is a more general idea about how activities are delivered with no detailed description of each component.

A planning template for FC design which considers before-, during- and after-class activities and assessments developed in a nursing education context was devised by Gilboy et al. (2015) on the basis of Bloom's taxonomy with lower-order thinking, for example recall, in the pre-class activities and activities involving higher-order thinking such as analysis and evaluation in class. It did not, however, address the student's experience. A typical lesson plan was provided which might be a useful model for teachers to follow, but the framework did not highlight the need to manage transition to the FC for teachers and students or address the modification or differentiation of teaching based on students' out-of-class performance. Moreover, it was based on limited evidence; the framework was based only on the practices followed in two undergraduate courses. Another framework put forward by Moffett (2015) gave twelve tips for flipping the classroom based on the literature together with the author's experience of using the FC in the context of university medical education. A weakness of that framework is that some of the tips were expressed in quite general terms. For example, under 'capitalize on the positive features', the author noted that the FC frees class time for experiential, team-based and job-based learning, but gave no guidance on how this could be achieved. Also, some potentially important issues such as access to technology and student motivation are missing and almost lost within broader discussions. Kim et al. (2014) proposed nine design principles for the FC. The first three were derived from existing theory: provide an opportunity for students to gain a first exposure prior to class, provide an incentive for students to prepare for class and provide a mechanism to assess student understanding. The other six principles were new suggestions for creating flipped events to better foster student-centred learning. The framework contained some useful guidance; for example, it highlighted the importance of familiarity with, and accessibility of the technology used, and the important role played by feedback. But it did not address transition to the FC and was based on limited evidence – the experience of three university courses in engineering, humanities and social studies.

Lo et al. (2017) proposed a framework with a set of ten design principles which were based on the benefits and challenges of FC through an extensive review and meta-analysis of 61 studies of FC. These principles focused on three aspects: the transition to the flipped classroom (principles 1 and 2), out-of-class learning design (principles 3 to 5) and in-class learning design (principles 6 to 10). Lo et al.'s (2017) design was considered the most suitable framework to adopt for this current study for several reasons. The quality and quantity of the underpinning evidence provided gave persuasive evidence of the validity of the principles. The framework is clear and comprehensive since it described all the FC components in great detail and in a logical sequence. The authors gave examples of the ways in which the principles have been applied in other courses, which offers practical support to guide teachers and students through a flipped model of teaching and learning. This model is therefore more explicit and better explained than other models. In addition, it was developed from studies carried out in a mathematics context including K-12 as well as higher education, so it was more suitable for this current study than the other models discussed above, which were all based on studies with university students and did not look specifically at mathematics courses. The framework is shown in Figure 3.2, followed by an elaboration and explanation of each of the principles.



**Principle 1**
Manage the transition to the flipped classroom for students

**Principle 2**
Manage the transition to the flipped classroom for instructors

**Principle 3**
Consider presenting introductory materials and providing online support in video lectures

**Principle 4**
Enable effective multimedia learning by using instructor-created short videos

**Principle 5**
Use online exercises with grades to motivate students' class preparation

**Principle 6**
Modify in-class teaching plans based on students' out-of-class learning performance

**Principle 7**
Activate students' pre-class learning by using a structured formative assessment such as a quiz at the start of face-to-face lessons

**Principle 8**
Require students to solve varied tasks and real-world problems

**Principle 9**
Meet the needs of students through instructor feedback and differentiated instruction

**Principle 10**
Facilitate peer-assisted learning through small-group learning activities

Figure 3-2 Framework for the flipped classroom design from Lo et al., (2017) Lo et al. (2017) stated that all of their principles were based on empirical evidence, and they explained each principle with reference to the 61 studies included in their systematic review and meta-analysis. Some of the principles reflect practices found in earlier studies to be beneficial, whereas others were attempts to avoid or reduce challenges identified in previous studies. The following discussion of each of the principles draws on Lo et al.'s (2017) rationale together with relevant arguments from a range of other previous studies.

***Transition to the FC (Principles 1 and 2)***

According to Lo et al. (2017), it is important to manage the transition from the traditional teaching approach to flipped instruction because, according to their extensive review of FC implementations in mathematics courses, they found that unfamiliarity with the flipped instructional approach was the main challenge for both the students (Principle 1) and the teachers (Principle 2) (Lo et al., 2017).

#### 3.2.1.1 Principle 1. Manage the transition to the FC for students.

Lo et al. (2017) stated that 26 of the studies which they reviewed had reported problems related to students' unfamiliarity with the FC. They accordingly emphasised the responsibility of teachers to encourage students to understand this new strategy. Previous studies suggested that before flipping any course, teachers should articulate the rationale for using the FC (Talbert, 2015); explain in detail the implementation process and the potential benefits and challenges; and outline the assignments that students must complete (Bergman and Sams, 2012).

One strategy recommended by Lo et al. (2017) based on practices found to be effective in other studies is for teachers to play the instructional videos during class time, before the actual implementation, to discuss the content, to give students advice on watching educational videos and to teach them some note-taking strategies, because there are differences between watching these and other videos on YouTube (for example, Moffett, 2015) and in the classroom. Additionally, since some of the reviewed studies reported technical problems, it is important to identify as early as possible any technological challenges which the students might encounter, such as not having devices, a poor internet connection at home, and difficulties in accounts setup, material download or assignment submission. Teachers may need to increase their working hours to provide the requisite assistance in the first flipping weeks (Kraut, 2015). To overcome access difficulties, D'addato and Miller (2016), for example, arranged for those students to use reserved computer facilities on campus if they did have devices at home, so that they could also benefit from flipped learning. Others, such as Clark (2015) prepared flash drives for those without home internet access. The better a student is prepared, the more learning that can be achieved (Herreid & Schiller, 2013).

#### 3.2.1.2 Principle 2. Manage the transition to the FC for teachers.

When teachers change their course to a FC format, the start-up efforts can pose many challenges for them. For example, Lo et al. (2017) cited evidence fromTalbert (2015) that a five-minute video took 30 minutes to produce and fromAdams and Dove (2016) that it took approximately 70 working hours to flip their undergraduate calculus course. In addition to the videos, other flipped materials require preparation, for example, assessment tasks, in-class problems, and online follow-up quizzes (Adams & Dove, 2016). Lo et al's (2017) reviewe suggested that, to address these challenges, it is better to take small steps in flipping at the beginning (Grypp & Luebeck, 2015). Teachers can start with online videos available on the internet then create their own videos when they get more comfortable. Secondly, it is beneficial to work as a team in the planning of flipped courses, as demonstrated by Bernard and Ghaffari (2019), as teachers can exchange tips for video production, ideas for activities, and even philosophies. In addition, teachers can use and share pre-existing, publicly shared content such as Khan Academy and Teacher Tube especially if the teachers are not familiar with technology and creating videos (Altemueller & Lindquist, 2017). This type of sharing of knowledge can gradually build up education resources and enable teachers to gain experience.

### *3.2.2 Out-of-class learning designs (Principles 3, 4 and 5)*

#### 3.2.2.1 Principle 3: Consider presenting introductory materials and providing online support in video lectures.

Videos are widely utilized as a typical pre-class learning material in the FC (Bishop & Verleger, 2013). Video could be a better tool than text reading alone for cognitive and emotional processing, as auditory and visual input provide bi-sensory stimuli in order to lead to collective learning (Moreno & Mayer, 2002). However, some research cited by

Lo et al., (2017) revealed that some teachers, when they flipped their classes, encountered some students who were unable to fully understand the materials presented in the video lectures because of the complexity of the content (Scott et al.,2016). To avoid such problems, it is important to make videos in an effective way or choose from those available online the ones that best meet students' needs. The ability to produce effective videos may take time and practice and is likely to improve over time. When teachers are planning to integrate the FC in their practice, they should first decide which part of the content should be delivered by videos. According to the literature, the part of the content designed to delivered by videos should be introductory materials that introduce students to the main content, avoiding more complex ones (Lo et al., 2017; Lo & Hew, 2017). Consequently, teachers had to re-teach the concepts in class meetings (e.g., Kirvan et al., 2015). Some topics can easily be learned via video, but some are too complex for students to understand without support (Lo & Hew, 2017). Therefore, teachers should consider producing instructional videos to cover the introductory materials, with advanced and detailed content tackled in the classroom so that students can receive support from their teachers and peers (Lo & Hew, 2017). Alternatively, teachers could consider using or creating interactive video lessons or enabling an online discussion forum (Sun et al., 2018). All are crucial to minimising students' problems with during out of class preparation.

#### 3.2.2.2 Principle 4. Enable effective multimedia learning by using teacher-created short videos.

Lo et al's (2017) review, and other literature, suggest that use their own developed instructional videos to serve as key instructional materials, and to make use of internet resources such as YouTube or Khan Academy as supplementary resources (Bergmann & Sams, 2012; McGivney-Burelle &Xue, 2013). The rational for this is research evidence that students usually prefer their own teachers' videos to others (Fulton, 2012; Zack et al., 2015). In a survey conducted by Zack et al. (2015), students expressed a high preference for their teacher-created videos. This could be because having videos in their own teacher's style makes transitioning from videos to in-class activities easier for the students (Van Sickle, 2016). In another study, by Long et al. (2016), teacher-developed videos were one of the students' favoured pre-class learning materials, as they were used to of listening to their teacher, making the pre-class videos more attractive. However, teachers who are technologically lacking in confidence can use videos from alternative sources such as Khan Academy, YouTube, and others as a viable solution (Long et al., 2016). If teachers want to use videos available online, produced by others, they should be careful to select appropriate ones that meet their intended content outcome and students' needs (DeSantis et al., 2015).

In order to plan and produce instructional videos in mathematics, two main issues should be considered by teachers: the style and duration of the video (Lo et al., 2017). Pre-class video length and quality have been found to significantly affected the engagement of students in the FC's pre-class learning phase (Long et al., 2016). The creation of a video lecture can be a complicated process that needs careful planning and implementation. In order to evaluate the contents of a video lecture and decide on the best delivery elements, learning theories and the consequences for implementation are important (Chorianopoulos & Giannakos, 2013). The Cognitive Theory of Multimedia Learning (CTML), for example (Mayer, 2014), focuses on the properties of developing digital materials for students. According to the CTML, teaching works by providing the learner with the correct cognitive processing, and so the theory directs the teacher in choosing relevant content, organising the content into a cognitive representation, and representing this with other information. Lo et al. (2017) recommended using a write-while-speaking video style in the flipped mathematics classroom, on the rationale that the impact of the natural motion of human handwriting causes the learner to be more engaged with the material than static computer-generated fonts (Guo et al., 2014). There is research evidence that in mathematics, students tend to engage more with the teacher's writing and drawing, especially in problem solving, because it connects the process of mathematical reasoning to visual presentation, as with the teacher writing on the board in the class (Greiffenhagen, 2014). This kind of animated approach can offer students a staged approach to dealing with a problem and therefore improve their learning (Kay, 2014; McGivney-Burelle & Xue, 2013). Regarding video duration, many of the studies reviewed by Lo et al. (2017) adopted the principle that teacher-created videos should be less than six minutes in length. This is based on Guo et al. (2014) analysed 6.9 million visualisation sessions over four larges open edX courses online (MOOCs). The most important forecaster of engagement was video duration; median engagement time was found to be 6 minutes. Evidence also suggests that for all combined portions of video a total of 20-25 minutes is the best, or else students can get overwhelmed by pre-class work needs (Schmidt & David, 2016). The students in Long et al.'s (2016) study reported that certain videos were too long, and the authors advised that the combined video time should not exceed 20 minutes.

#### 3.2.2.3 Principle 5. Use online exercises with grades to motivate students' class preparation.

When assigning video lectures as a pre-class activity in FCs, pre-class online exercises are recommended, to ensure that students acquire the knowledge in the videos and are ready for in-class activities. This principle is based on the fact that fourteen of the studies reviewed by Lo et al. (2017) reported a lack of students' motivation toward the pre-class preparation, but conversely about half of the studies reviewed had incorporated pre-class exercises and the authors had reported that they had a motivating effect (Kennedy et al., 2015; Van Sickle, 2015).Some strategies were found useful in the literature to ensure that students engaged with educational content prior to the face-to-face class and to check students' pre-class learning include video-embedded quizzes, or online quizzes (e.g., Nielsen et al., 2018; Murphy et al., 2016), pre-class assignments (e.g., Hung, 2015). In Nielsen et al.'s (2018) study, students were encouraged to watch videos by quizzing and by checking their understanding of key concepts before they took part in classroom activities, and every quiz accounted for a small amount of their final grade.

Lo et al. (2018) used three to six online follow-up questions with computerised feedback, which prompted the students to check their application of the knowledge and assess their mastery of the material. Further, Wilson (2013) regularly employed (graded) quizzes not only to give concrete reasons for completing tasks, but also to encourage students to participate in out-of-class learning activities. In another study, Wei et al. (2020) used 15 minutes of quizzes and parents were invited to attend the learning activities to supervise their students. They found that teachers can inspire students to complete their tasks before class and be accountable for their work (Wei et al., 2020). Further, Ziegelmeier and Topaz (2015) discovered that students in the FC tended to complete checkpoint quizzes more regularly than students in the traditional group. However, the quizzes should not be too long, to reduce the workload of students. Petrillo (2016) considered the importance of incorporating elements of computerized feedback on the online exercises for students' practice and self-checking, because it enables students to track their own learning progress to provide an objective review of video lectures, so that their understanding is improved.

### *3.2.3 Out-of-class learning designs (Principles 6 to 10)*

#### 3.2.3.1 Principle 6. Modify in-class teaching plans based on students' out-of-class learning performance.

In the flipped approach, teachers can assess the students’ understanding of the topic before the class activities take place, from their participation and performance in the pre-class activities. Teachers then can adapt their plans to satisfy their students’ needs based on their students’ performance (Lo & Hew, 2017). Lo et al. (2017) cited a number of examples of studies in which instructors had effectively used the online pre-class data as a basis for formative assessment and then adapted their teaching to address any identified misunderstandings; other literature makes the same point.

According to Cilli-Turner (2015), pre-class activities provided additional opportunity to look at the problems’ students faced and address misunderstandings in the face-to-face session. Other students report a variety of ways that mathematics teachers respond in many ways to the learning performance of students out of class. In Zack et al. (2015), for example, pre-class involvement led them to develop a list of in-class discussion issues focused on students’ misunderstanding of their out-of-class study.

#### 3.2.3.2 Principle 7. Activate students' pre-class learning by using a structured formative assessment such as a quiz at the start of face-to-face lessons.

Lo et al. (2017) encouraged teachers to start their face-to-face session by using standardised formative tests like quizzes to evaluate the students’ learning of the out-of-class materials. They based this recommendation on evidence in the reviewed studies that this kind of formative assessment was beneficial both in motivating students and in helping teachers to assess students’ readiness for the planned tasks and to decide whether a review of the materials or a modification of the teaching plan was needed (for example, Mercer, 2002; Kirvan, 2015; McBride, 2015; Talbert, 2015). In order to evaluate students’ learning from online videos, Kirvan et al. (2015) posed one to three questions at the start of each lesson period via in-class quizzes. Similarly, Van Sickle (2016) used a two-point, open note quiz that covered the material in the lecture videos. Pre-assessment at the start of the in-person lessons has advantages for students’ learning and teachers’ practices. In a study by Lo and Hew (2020) at the beginning of class, they posed two or three simple questions to identify the mistakes of the students through their written review. After that, there was a short discussion about the pre-class materials and the quizzes. As well as being a warm-up tool to recall pre-class student learning, the quiz is also a formative evaluation method to aid in classroom teaching (Lo & Hew, 2020). As Lo et al. (2018) pointed out, the results of such assessments could give teachers the most up-to-date information to inform their final lesson design. Students were asked to recollect and apply their out of class learning by taking this assessment. The previous experience of students facilitates their learning as it is the basis for learning the new material presented inside the classroom (Merrill, 2002). Additionally, it acts as a tool to regulate learning by ensuring that students have to watch the videos before in class activities. So, FC quizzes can be considered as external regulators to help students keep track of their progress (Chen et al., 2016; Kim et al., 2014).

The outcomes of the quiz also provide evidence of students' preparedness regarding their ability to take on the challenges of classroom learning (Moffett, 2015). Depending on the performance of the students, teachers can determine if they should repeat the pre-class video lectures or alter teaching plans. Other benefits of incorporating quizzes before face-to-face class time are identified by McBride (2015) who claimed that getting a questionnaire at the start of an in-class session increased attendance at class time in the FC. Chen et al. (2014) revealed that the effectiveness of the face-to-face classroom was also dependent on how well students prepared for in-class tasks. Lo et al. (2017), based on their extensive review of previous FC studies, found that by utilising a standardised formative evaluation at the beginning of flipped classes, student achievement in mathematics was greatly supported.

#### 3.2.3.3 Principle 8. Require students to solve varied tasks and real-world problems.

In the flipped environment, teachers have more time in the classroom to deal with problem-solving activities or important concepts with students, which benefits student learning, As reported in 30 of the studies reviewed by Lo et al. (2017), with the support of their teachers and peers, students can also practise solving problems, which cognitive psychology suggests is conductive to enhancing learning (Mayer, 1992). From this perspective, several authors suggested that FC tasks should start with a couple of basic exercises and advance towards ones which pose a greater challenge (Long et al, 2015). The problem-solving exercises in class time thus strengthen and expand the scope of the video lectures (Wei et al., 2020). Many studies have shown the FC's advantages in assisting students to learn properly and shown educators the value of involving students in real-world learning (Hwang et al., 2015). Students need to recognizenthe relevance of what they learn, as the aim is to develop skills that can be applied to practical environments. The real-world problems should give the students the opportunity, particularly in the development of higher-level thinking skills, to practise and assess their mastery or competence during class (Persky & McLaughlin, 2017). The teacher is therefore responsible for designing a rich environment for student leaning. In-class learning activities should therefore be planned to enable students to respond to real-life issues and to gain knowledge from everyday experiences. Depending on the course unit objective, the in-class activities may centre on the application, analysis, assessment, and creation of knowledge (Hwang et al., 2015). Some studies cited by Lo et al., (2017) used real world problems, which gave students the experience of using course material in a manner closer to that encountered in a real-world setting (Yong et al., 2015). For example, in a linear algebra course, Talbert (2015) used the least squares method to deal with systems that arise from real-world scenarios. The students acquired basic knowledge of the procedures through videos consumed outside of class, and then they deepened and extended their knowledge through group work in class (Talbert, 2015). Similarly, in an introductory differential equations course, Yong et al. (2015) used an active learning modality, based on problem-based learning, in which students solved identified, ill structured problems, thus increasing transfer of course material outside of textbook examples, by requiring students to derive a differential equation for a physical scenario. However, based on the review of Lo et al. (2017), using real-world problems was not a major part of every mathematics FC.

#### 3.2.3.4 Principle 9. Meet the needs of students through teacher feedback and differentiated instruction.

An early research study of the FC conducted by Lage et al. (2000) suggested that one of the potential benefits of the FC is the opportunity for teacher-student interaction. According to Lege et al. (2000), “This interaction is beneficial in two ways: the student is able to clear up any confusion immediately, and the teacher is able to monitor performance and comprehension” (p. 37 A widely reported benefit of the FC is the provision of opportunities for interaction and feedback which involve elaborate and organisational cognitive processes which help students to restructure their own schema (Clynes & Raftery, 2008; Smith & Higgins, 2006). In the FC, as some of the materials are provided outside class, teachers have more time in class to answer students’ questions when they show confusion about complicated concepts. In addition, teachers can immediately monitor the student's work in the classroom, have conversations and give mini lectures on subjects as needed, increasing the teacher's ability to provide timely feedback (Bergmann & Sams, 2012). Gilboy et al. (2015) note that during the face-to-face phase of FC, teachers are available to provide instant feedback, while students take part in learning activities aimed at higher levels of Bloom’s taxonomy. The findings of Thai et al. (2017) suggest that when studying in an FC setting, quick feedback from the teacher resulted in a greater learning performance in comparison to studying in an e-learning environment. Another study performed by Song and Kapur (2017) revealed that low performing students gained the most from the flipped approach, and the researchers attributed this increase in performance to the opportunity for students to obtain formational feedback and scaffolding, from both their teacher and peers during face-to-face sessions. The beneficial impact of feedback has been attested by many researchers in different studies. For example, in that study conducted with middle school students, , the teachers used tablets with screen-sharing capability and an online feedback system so students could get feedback from the teachers and from peers. Feedback can include personalized instruction to ensure students’ understanding and provide guidance on future study (Clark, 2015). Fulton (2012) described the feedback being used in a high school flipped calculus classroom. He described the teacher moving among the students, watching, listening and noticing who needed support. When many students are struggling with a question, the teacher can give further explanations at the front of the class.

Additionally, this principle advocates the differentiation of teaching based on students’ performance level. In this respect, Lo et al. (2017) cited Talbert (2015) to suggest that higher-performing students can engage in more challenging tasks  and problems, while lower- performing students can be provided with simpler exercises at the start of lessons, to assist them with acquiring the basic concepts (Talbert, 2015).It is important to note that teachers should devote special attention to students with low confidence, such as individuals not engaging in group debates or classroom activities (Lo et al., 2018). In order to increase their confidence in learning, teachers should praise their development and attribute a lack of commitment or appropriate approaches to lack of effort or suitable strategies, and motivate them to make further efforts (Margolis & McCabe, 2006). By such means, teachers can help to build these students’ self-efficacy, which, as noted earlier, encourages motivation and persistence, leading to greater achievement (Carpenter & Clayton, 2014; Kenngwe, 2014). Moreover, the FC can benefit gifted and talented students by offering room for effective instructional strategies for differentiating instruction (Siegle, 2014). For example, gifted students may not be required to watch a video; links to different websites will be offered to help them to discuss a specific subject in greater detail. From the philosophy of self-determination theory, effective feedback from teachers plays a crucial role in development of a feeling of self-efficacy in flipped classes (Niemiec & Ryan, 2009).

#### 3.2.3.5 Principle 10. Facilitate peer-assisted learning through small-group learning activities.

Peer-assisted learning (PAL) is defined by Topping (2005) as "the acquisition of knowledge and skill through active helping and supporting among status equals or matched companions" (p.631). In Lo et al.'s (2017) review, 33 of the reviewed studies reported benefits of PAL/group activities. Having to explain their understanding of a problem to their classmates helped students to formulate their ideas more clearly and enhanced their own understanding (Jung et al., 2015). Students are often better able to understand the words of a fellow student than those of the teacher (Persky & McLaughlin, 2017; Touchton, 2015). Boud et al. (2014) presented some pedagogical benefits of PLA, such as higher academic achievement, skills development, engaging students through cooperative learning and improving students' attitudes toward learning. FCs provide many opportunities for peer-assisted learning, such as out-of-class activities using technology (e.g., social network sites, discussion boards) and in class activities (e.g., collaborating to solve problems, small group activities, and feedback) (Nederveld & Berge, 2015). Using class time for active learning rather than lectures offers the possibility of increased peer-to-peer collaboration, teacher-to-student interaction, and cross-disciplinary participation. According to Johnson and Johnson (1999), students reported feeling confident in their ability to collaborate with peers and complete learning objectives as a team. As a result, skilled colleagues can therefore encourage students' learning (Vygotsky, 1978). Designing learning assignments in groups so that students can witness how their peers tackle challenges is one alternative teaching method that can be used for increasing the confidence of students when completing in-class activities. Students may be more confident in their own talents if they watch their peers successfully handle a difficulty (Johnson & Johnson, 1999), consistent with Bandura's (1986) idea of vicarious experiences as a source of self-efficacy. PLA is reportedly appreciated by student participants in flipped courses. Clark (2015), for instance, pointed out that the students in her flipped section were more pleased with the collaborative work, as they could address concerns and share their ideas with their peers, affirming their thought processes. Song and Kapur (2017) found students expressed their preference for the flipped approach because the FC helped them when they experienced challenges, as they were able to seek assistance from their classmates. In another study by Danker (2015), students commented on their experience of the FC. One student for example, said, “Discussions with my peers are stimulating and I can retain the information better” (p. 182). This led Danker (2015) to assert that peer learning aided the majority of the students in better understanding the material and engaging in the learning process. Lo and Hew's (2020) results indicate that improved peer engagement in the flipped class facilitated student maths and cognitive engagement. In the flipped environment, more time is available in class meetings, so that students have even more opportunities to obtain guidance from their peers as well as their teachers (Bergmann & Sams, 2012). Therefore, teachers should design their instructional practices to provide many opportunities to encourage students to participate in debates, collaborate and obtain assistance from their peers in the classroom.

## 3.3 Implementation of Lo et al.’s (2017) design principles in this study

Following Lo et al.’s (2017) design principles, the researcher divided the study design into three phases. The first phase was managing the transition to the FC for both teachers and students (principles 1 and 2). This was conducted before the actual experiment to ensure that both teachers and students understood the changes in their roles and their responsibilities in the FC environment. The researcher provided two weeks of training for teachers and for students to familiarise them with the new approach and to ensure that they had sufficient knowledge about using Moodle as an online learning platform outside the classroom. For example, how to set up an account, how to watch the video lectures and some tips and hints to help them to get the most out of the presented materials.

In the next phase, the researcher considered the design of the out-of-class activities. One important point considered was the careful choice of the materials which should be presented in the video lectures. The mathematics content should be an introduction to the main topic. Therefore, the content of all the video lectures was introductory, and none of them contained any complex ideas, so that students would be more likely to understand the materials and participate in the out-of-class activities. In addition, the researcher managed the Moodle platform and tried to support students and teachers in their teaching and learning process. Furthermore, although Lo et al. (2017) recommended using teacher-created videos, in this current study the teachers were unwilling to design their own videos because of their lack of confidence in using the technology, the lack of time and their fear that this could increase their workload. The researcher therefore designed the materials by herself for all the out-of-class activities. Careful consideration was given to the validity of the content, and this was ensured by sending all the resources to the head of the mathematics department and all the five participating teachers, who confirmed their approval of the design and the quality of the materials presented. In addition, quizzes were an integral part of the out-of-class activities. The researcher designed the quizzes to enhance students' learning after watching the video lectures and also provided them with immediate feedback on their answers, which could help them to be confident about their performance.

The third phase was the design of the in-class activities, which emphasised five main principles. The teachers were requested to monitor their students' learning on Moodle and to check their understanding using all the analytical tools which Moodle offers. Based on all these data, teachers were advised to design the in-class activities based on their students' performance in the out-of-class activities. For example, if the data on Moodle showed that a high percentage of the students had watched the videos and answered the quizzes correctly at the first attempt, the teachers could be confident that they could design the in-class activities to include more intensive and complex activities since their students had grasped the basic knowledge. In contrast, if they noticed that students had difficulty in understanding the video content, they should be prepared to design the in-class activities to give more clarification of the presented materials until students understand them fully and only then move on to more complex ideas. Another strategy suggested by Lo et al. (2017) was to activate the students' pre-class learning by asking teachers to design a pre-class assessment to be carried out at the start of each face-to-face session. This pre-assessment would provide information about which of the students understood the materials very well and which still needed more help from the teacher. Furthermore, teachers were encouraged to design the in-class activities to encourage different learning styles and the use of different techniques of active learning strategies such as problem solving, critical thinking, real world problems and higher-order thinking activities. Teachers were also encouraged to provide a supportive classroom environment which would enhance the interactions between students and teachers. This was done by designing activities which encouraged group and peer learning. At the same time, the teacher played an important role of enhancing the learning process by encouraging and supporting students while they worked on the activities by providing feedback on their performance, which could enhance their confidence and encourage them to further advance in their learning. It is important to note that the teacher acted mostly as a guide to students' learning, rather than as the authority figure in the classroom. Table 3.1 summarizes how each principle was implemented in the version of the FC employed in the present study.

Table 3-1 Overview of the design principles for the FC approach, and how those principles were implemented in the present study.

| Lo et al.'s (2017) design principles | Implementation in the present study |
|---|---|
| Principle 1: Manage the transition to the FC for students. | Two weeks pre-intervention training to ensure that the students (1) have adequate knowledge of the new teaching approach, and (2) know how to access and use Moodle. |
| Principle 2: Manage the transition to the FC for teachers | Two weeks of training for teachers to ensure that they (1) have adequate knowledge of the implementation of the FC and the in-class activities, and (2) know how to use the Moodle site. |
| Principle 3: Consider presenting introductory materials and provide online support in video lectures. | All video lectures were an introduction to the topic that the students had learned in class.<br>Online support was provided to teachers and students. |
| Principle 4: Enable effective multimedia learning by using teacher-created short videos. | The videos were designed by the researcher, a former mathematics teacher.<br>The videos were reviewed by the head of the mathematics department in the district and the five participating mathematics teachers. |
| Principle 5: Use online exercises with grades to motivate students' class preparation. | Students had to complete online quizzes after watching each video lecture. The quizzes were graded, and students received immediate feedback on their performance. |
| Principle 6: Modify in-class teaching plans based on students' out-of-class learning performance. | Teachers could monitor their students' progress and performance and were advised to adapt their teaching accordingly. |
| Principle 7: Activate students' pre-class learning by using a structured formative assessment such as a quiz. | There was a short quiz covering basic knowledge from the videos at the beginning of each face-to-face lesson. |

| Lo et al.'s (2017) design principles | Implementation in the present study |
|---|---|
| Principle 8: Require students to solve varied tasks and real-world problems. | Students were engaged in a variety of problem-solving and real-world problem activities during class time. |
| Principle 9: Meet the needs of students through teacher feedback and differentiated instruction. | Teachers were on hand to provide individualized feedback to students.<br>Teachers spent extra time answering questions from students. |
| Principle 10: Facilitate peer-assisted learning through small-group learning activities. | Students were working in groups on most tasks.<br>Students were often asked to explain their reasoning to other students. |

### *3.3.1 Design of activities*

Since the classroom environment is an essential part of the successful implementation of the FC, it is important to create a learning environment which supports different forms of active learning strategies, collaboration and higher-order thinking skills (Jensen et al., 2015). To design those activities, teachers were advised to use a wide range of active learning techniques. They were advised to split the class into groups of three or four and hand out worksheets which they had designed to help the students to plan their group inquiries. For example, one active learning technique used by teachers was 'think-pair-share', based on suggestions made by Braun et al. (2018). In this technique, the teacher assigns a short task to students, such as completing a step in a proof or formulating a hypothesis or conjecture to a maths problem. After giving the students two to three minutes to think about the task independently ('think'), they take two minutes to compare their answers with those of other students sitting nearby ('pair'). Finally, some or all of the students are asked to share their responses either with the groups next to them or with the entire class ('share'). In the subsequent lesson, the students discuss their individual questions with one another and provide constructive criticism to one another. This activity is intended to promote peer feedback, which was considered by Laurillard (2012) to a valuable form of learning since each student can learn how the others work, what they say and how they address the topic through the reciprocal process of articulating and critiquing their points of view (Laurillard, 2012).

Another particular concern was to provide opportunities for collaborative learning which Swan (2006) defined as a team of students who learn through working together to share ideas, solve a problem or accomplish a common goal. Laal and Ghodsi (2012) and

Barkley et al. (2014) agreed that collaboration enhances students' learning by improving knowledge retention and promoting a wider range of knowledge and skill acquisition. By following Mercer's (2008) design principles for collaboration in class activities such as that talk should be necessary to the activities and not just incidental, the activities should encourage cooperation not competition, and students must clearly understand the point and purpose of each activity. The teachers in the current study were therefore advised to use questions, problems and scenarios to help students to learn through both individual and collaborative thought and investigation. This was achieved by designing activities in which students were encouraged to talk about a problem and draw on their intuition to understand it. As a result, class time was spent with students working individually or in groups on problem sets, presenting solutions and/or proofs to the class, and receiving feedback from peers and teachers. Some activities were for individuals, some for pairs, some for small groups and some for the entire class. Some activities simply involved translating a mathematical expression into words so students were asked to work with partners for this activity. Each pair was given a set of rational equations to work with, but before they solved these equations, they had to translate the numerical notation into language which makes sense. This supported the ideas of Mercer (1995) and Mercer and Sams (2006) that students use language to explain ideas, make decisions and interpret information, all of which facilitates problem solving and promotes understanding. Another technique is to devise lessons promoting the use of exploratory talk by giving students standard reasoning test problems to solve together in groups (Wegerif, 2005).

Some activities were designed specifically to promote effective class discussion. Teachers were advised to guide students' discussion by setting ground rules, such as that the students should share all the relevant information and ideas, ask others for their reasons for their thoughts and reach agreement on an action if possible, and to emphasise that it is the group and not individuals who are responsible for the decisions and outcomes (Mercer, 1995). For example, students were given some equations and several potential answers to choose from, then asked to discuss all the possible choices in order to select the correct answer, justify it and explain the outcome. Another strategy used was modelling, in which students were shown a real-life problem and then after questioning and discussing it together, they were able to explain why it was a model of what it was. In other instances, a critical situation was discussed and analysed, and decisions were made about how to resolve it. Activities such as these were supported by Laurillard (2012) who stated that learning through discussion provides the motivation for each student to articulate her/his own concepts and ideas, defend them and use them to challenge other students' ideas, which provides a powerful engine for conceptual development. In addition, teachers were advised to encourage classroom discourse by paying close attention to their use of questions and feedback strategies to promote the use of alternative discourse strategies such as probing, re-voicing, student questions and uptake questions (Hardman & Hardman, 2017).

It was important to include activities which enhance higher-order thinking skills. These activities were based on the ideas put forward by Brookhart (2010) and Su et al. (2016), who found them useful for developing students' ability to analyse, evaluate and create so that they can develop the critical thinking and creativity for solving problems in everyday life. To improve creative problem-solving, opportunities were provided by encouraging students to try new approaches when solving mathematical problems. This was accomplished by engaging them in non-routine problem-solving activities, helping them to develop the ability to analyse and evaluate them and encouraging them to construct their own knowledge, because this makes the whole exercise meaningful for students. Teachers presented students with a variety of non-routine problems which are relevant to everyday life and encouraged them to ask 'why' and 'how'. Also, during the in-class teaching period, students were asked to apply the concepts which they had just learned to novel situations. Equations representing direct, inverse and joint variation are examples of rational formulas which can model many real-life situations. Examples of such activities were to solve a rational formula for a specific variable, solve work problems and define and solve an equation which represents the concentration of a mixture. All these examples need students to develop higher-order thinking skills and analysis, evaluation and creative skills.

## 3.4 Summary

This chapter has provided a full explanation of the FC design adopted in this study, beginning by clarifying the applied theoretical framework and then the presentation of Lo et al. s' (2017) framework of 10 design principles for FC in mathematics courses. These principles are based on an extensive review of the challenges and benefits identified in previous studies, giving the current intervention greater chances of being beneficial. The next chapter discusses the research methodology, beginning with the description of this research's ontological and epistemological assumptions, and followed by an account of the quantitative and qualitative techniques that were used in this investigation.

# Chapter 4 : Methodology and Design

To develop and conduct research requires an appropriate approach and making the right choice is vital if reliable results are to be achieved. Therefore, based on the main research questions stated earlier in Chapter One, a variety of methodological approaches have been considered in order to define the right path for the accomplishment of the study objectives and to answer the research questions. Hence, this chapter consists of fourteen sections. The first section discusses the adopted methodology together with the research philosophy behind it and factors influencing the research design. The following sections discuss how appropriate strategies were selected and suitable instruments identified, as well as presenting the methods used in the study to collect data. This involved quantitative instruments (pre and post proficiency tests, self-efficacy questionnaires and students' perceptions questionnaires) and a qualitative instrument (semi-structured interviews with the participating teachers). The validity and reliability of the instruments are then presented followed by the ethical constraints governing this study and detailed descriptions of the data analysis of such methods. The chapter's contents and conclusions are then summarised.

## 4.1 Research philosophy and Paradigm

The term 'paradigm' is defined as "a loose collection of logically related assumptions, concepts or propositions that orient thinking and research" (Bogdan & Biklen, 1998, p.22). The paradigm is an interpretative research framework because it sets out all of the relevant procedures and actions, including the research questions, data collection techniques, analytic methods, and the selection and recruitment of participants (Cohen, et al, 2011). The study framework thus allows for continuity and consistency between these various aspects of research (Denzin & Lincoln, 2005). Paradigms are also a reference for scholars to use to construct their study (Creswell & Clark, 2017). To comprehend the research phenomena, the researcher must first establish the philosophical pillars of ontology, epistemology, and methodology. From a philosophical perspective, the paradigm includes a point of view of the nature of reality (i.e. ontology) - either internal or external to the knower; a similar informational perspective that can be produced and the criteria which explain it (i.e. epistemology); and a disciplined approach for knowledge production (i.e., methodology) (Guba, 1990; Mackenzie & Knipe, 2006). Paradigms are mainly defined by the research questions. The illustration below (Figure 4.1) illustrates the following concepts and the association between them:

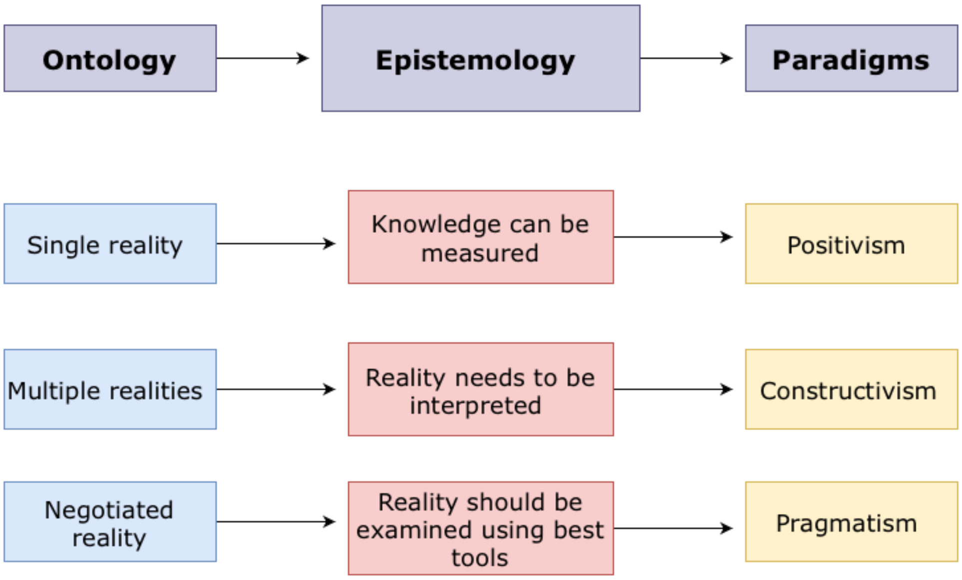


Figure 4-1 Ontology sources explained Creswell (2014).

Methodologically, researchers tend to position their research as positivist, interpretivist, or pragmatic (a blend of the first two, employing mixed methodologies), and they should provide a clear reason and justification for whichever methodology they have chosen. Positivism and Interpretivism are two major paradigms in social science research (Cohen et al., 2011). Later, the pragmatic model was introduced as a basis for combining qualitative and quantitative techniques under the principle of mixed methods. There is no perfect research paradigm however, each has a purpose in providing a distinct method by which to obtain unique knowledge. This section provides descriptions of these paradigms, followed by a discussion and justification of the chosen paradigm that is applicable to the purpose of the current research.

A positivist sees reality as something apart from social norms and assumptions and develops theories that rely on observation, experiment, and similar forms of empirical research (Cohen et al., 2011). Thus, a positivist works objectively and with precision through logical reasoning on the basis of observation and evidence and does not rely on intuitive or subjective responses to the data. Variables are identified and relationships between them are analysed to measure the degree of the covariance (Cohen et al., 2011). Hypotheses on such relationships will also be established, which allows the manipulation of experimental variables in order to test the hypotheses and draw conclusions from these studies (Creswell, 2014). For a positivist, theories are developed by finding data variables that are causally connected and such researchers are likely to carry out quantitative research.

The interpretivist paradigm, on the other hand, examines feelings and behaviours connected with the studied phenomena (Denzin & Lincoln, 2011). An interpretivist sees the construction of knowledge as a subjective process arising from interactions between the researcher and the researched, and that such interactions generate a co-constructed reality (Cohen et al., 2011). In this approach, the researcher's mission is to behave naturally, and the researcher would be subjective in his or her interpretation and understanding of a current phenomenon (Denzin & Lincoln, 2011). Cohen et al. (2011) point out that interpretivists are likely to carry out qualitative research, developing understanding through the collection of mainly verbal data arising from an intensive study of cases, after which the data is analysed inductively.

The pragmatic paradigm prefers to avoid ontological and epistemological debates between paradigms by combining reality from different philosophical points of view (positivism and interpretivism). It also uses various forms (quantitative and qualitative) of methodological approach, combined in a single study, offering a compromise between subjectivity and objectivity in the investigation (Mertens, 2007). The pragmatists' ontological view holds that there are different social realities, as each individual sees truth or reality on the basis of their own beliefs and values. From an epistemological perspective, this model includes both subjective and objective elements, dependent upon the research processes and inquiries (Onwuegbuzie & Leech, 2005). Methodological pragmatism for practitioners requires pluralistic assumptions and depends entirely on the research questions when choosing the design that works best to answer them (Tashakkori & Teddlie, 2003; Teddlie & Tashakkori, 2009). Some researchers have criticized this paradigm for its flexible approach to research and the methodologies it employs (Mackenzie & Knipe, 2006). Nonetheless, pragmatic research is characterized by its dynamic and inventive nature, and is versatile and adaptable in handling evolving situations. The pragmatic paradigm researcher is more interested with solving real-world problems than in philosophical viewpoints (Onwuegbuzie & Leech, 2005).

In line with the explanation above and in light of the research needs and priorities, a synthesis of both positivist and interpretivist paradigms was needed in the current research. Therefore, the researcher has taken pragmatism as an appropriate paradigm for this research, since the research aim was to investigate the potential effect of the FC on students' mathematical proficiency and self-efficacy in a high school setting. This aim has some objective elements (e.g., proficiency). The role of the researcher in this approach is as the controller of the research process and she is external to the research site. The research aim required the collection of accurate, measurable data that could be subjected to statistical analysis. Data could be collected from students, who were the research subjects, in the form of their test grades. This form of study relies on causality, whereby researchers work with quantitative methods of a kind that say that 'X causes Y' (Morgan, 2007). This addresses the first key research problem in this study, which explores the causal effect of a teaching approach on mathematics proficiency and self-efficacy. However, given that this study also has some subjective elements (teachers' own experiences, perceptions, beliefs and feelings toward the teaching approach), this study needed qualitative data as well to get a full picture of the FC impact. Neither positivism nor interpretivism would fully capture all the dimensions of the research problem. Capturing all these aspects needs different kinds of data and, therefore, different approaches and methods. Denscombe (2008) claims that pragmatism is especially suitable for research by mixed methods and notes that there are a number of ways in which these methods can be used. More details on the mixed methods approach are presented below.

## 4.2 Mixed Methods Approach

What dictates the design of a research project are the objectives the research aims to achieve. In the view of Cohen et al. (2011), the research questions should govern which method is most appropriate and suitable. As discussed above, this present research is based on a pragmatic approach, using methodologies combining quantitative and qualitative approaches which are brought together to build a body of evidence and data that is convincing, and both strengthens and deepens understanding in the field under study (Creswell & Clark, 2017). Using this approach makes it possible to produce better research by developing understanding as well as obtaining answers. The simplest definition of mixed methods, given by Creswell (2014) is that it uses both qualitative and quantitative data in a single study. Mixed methods studies can be seen as a modern approach that emerged in the late 1980s and early 1990s that has gone through many phases of growth (Creswell & Clark, 2017; Teddlie & Tashakkori, 2009). Since then, the mixed-method methodology has been used by social researchers and has seen an increase in importance due to federal research funding programmes (Creswell, 2014). Mixed-methods research has obtained widespread acceptance because the analysis of both qualitative and quantitative data produces an integrated result (Cohen et al., 2011; Mackenzie & Knipe, 2006). The increase importance of this approach stems from the belief that problems exist, the complexity of which it is not possible to research fully unless both qualitative and quantitative approaches are taken (Cohen et al., 2011). The view is that neither a qualitative nor a quantitative approach alone can provide complete understanding, or establish the root cause of a complex problem. Therefore, the main rationale for the choice of mixed methods as the approach of the current study is due to its strength in enabling a more complete understanding of the research questions. In the current study, the causal impact of the FC intervention on students' proficiency and self-efficacy can best be understood by collecting quantitative data. Further, understanding of the experimental results and the context can be balanced by incorporating the perspectives of participating teachers. Semi-structured interviews are an appropriate way of obtaining these perspectives to complement the quantitative findings because they help to fill gaps in the quantitative analysis of the data, and thereby to deepen understanding of the empirical results (Teddlie & Tashakkori, 2009).

It has been emphasised that using different methods does not necessarily justify using the term 'mixed'. Teddlie and Tashakkori (2009) determined that a suitable mixed methods design employs each approach even-handedly and in an interconnected manner. Conversely, it is also indicated that quantitative or qualitative methods may take priority in order to be suited to the type of inquiry (Creswell et al., 2014). In addition, based on this prioritisation and the order of the data collection, suggested convergence, connection, and/or data embedding, integration can be achieved (Creswell & Clark, 2017). Thus, a concurrent embedded design was used in this study to integrate methods (Creswell, 2014). This model has also been referred to as a concurrent nested mixed methods design (Creswell, 2014). The concurrent embedded mixed methods design mixes the different data sets at the design level, with one type of data being embedded within a methodology framed by the other data type (Creswell, 2014). Under this approach, the quantitative, experimental methodology has priority, and the qualitative data is subordinate within that methodology. The researcher started by collecting quantitative data based on an experimental design (pre-test, self-efficacy and pre-treatment surveys), and in the final stage of the intervention period, quantitative data was again collected (the post-achievement test, post self-efficacy questionnaires and post- treatment questionnaires). Then, qualitative data from teachers' interviews were embedded immediately after the intervention. Each data set was analysed and afterwards combined in order to answer the study questions.

There is widespread agreement that the findings generated by mixed methods designs have greater reliability and credibility than those from either qualitative or quantitative research alone (Creswell, 2014). Nevertheless, such designs have received some criticism in the literature. Researchers using mixed methods must have experience in a variety of research techniques and need additional resources and time for the effective combination of the two approaches (Creswell & Clark, 2017). Because this design is complex, it also needs clear, visual models so that the details and flow of research activities in the design can be understood. In the present study, however, the researcher tried to overcome these obstacles by developing an awareness of the various research methodologies for each approach. This study's mixed-methods design is, therefore, expected to contribute in a worthwhile manner to the literature on the FC and to blended learning studies. This study made primary use of a design that was quantitative and experimental in order to investigate a comparatively recent phenomenon, the effects of the FC on mathematics education, but a qualitative procedure was also used so that results from the quantitative study could be corroborated, extended and validated. The next section provides detailed explanation of the research design and the instruments used to collect the data.

## 4.3 Research Design and Data Collection Process

### *4.3.1 Experimental Design*

Cohen et al. (2011) define research methods as "the range of approaches used in educational research to gather data which are to be used as a basis for inference and interpretation, for explanation and prediction" (p. 201). The quantitative data in this study were collected in multiple forms: a quasi-experiment design through a pre-test and a post-test and a survey of students' perceptions. A quasi-experimental design aims to establish a cause-and-effect relationship between different variables (Cohen et al., 2011). It involves some type of intervention and control designed by the investigator. It requires an independent treatment variable that can be applied to the experimental group and dependent variables that can be measured in all groups (Punch & Oancea, 2014). According to Cohen et al. (2011), what distinguishes experimental research is the control and manipulation exercised by the researcher over conditions that determine events of interest to the researcher.

A quasi-experiment, unlike a true experiment, does not rely on random assignment (Cook, 2002). When the researcher can be fully in control over selecting when data collection procedures are scheduled, but is unable to randomise exposures, then this is deemed to be a quasi-experiment (Cohen et al., 2011). Although schools were randomised in this study (using four different schools and then classrooms), and the classrooms were randomised to either flipped or traditional group, this scenario cannot be considered completely random. Thus, the study design is deemed to be a quasi-experiment.

So that bias can be reduced, credible alternative explanations are required. Thus, research should include pre-tests to disclose maturational trends, which can then be compared to the post-tests (which includes a control group). This study uses pre-tests and control groups so that bias is reduced and specific threats to validity are avoided (Brown, 1992; Cook, 2002). A pre-test can minimize differences between groups before the intervention takes place (Creswell, 2014). The present study used two groups to gather data for the research; one group participated in the FC model, and the other participant group learned in the traditional classroom. The question of whether the use of a FC approach would improve students' mathematics performance was addressed by comparing the results of both groups after the intervention took place (difference in the post-test), while taking into account any pre-intervention differences (measured by the pre-test). Attendance to mathematics classes was regular for all groups, but only the experimental groups received a treatment that included FC instruction. The treatment was implemented using an online platform ("Moodle") containing a video that teachers had designed for home viewing. Each video was followed by homework in the form of quizzes. When students were in class, their task was to practise lessons taught by the video. Only conventional mathematics instruction was given to the control groups. The subjects taught to both the control and experimental groups were the same, only the method of teaching differed. The teacher/student contact time in each session amounted to 45 minutes. The independent variable was the teaching approach (either flipped or traditional classroom), and the dependent variables were the mathematics proficiency test and self-efficacy scores. The researcher ensured that the experiment was as well controlled as possible to maximise the researcher's ability to infer causality from the findings. Therefore, both groups were as alike as possible. The materials the teachers presented to the students were based on the same lesson plans, worksheets, assessments, pre- and post-tests for both the traditional and flipped classes. The only difference was the teaching approach. The FC involved the mathematical content being taught by watching videos through Moodle as homework, whereas class time was invested to work on collaboration, discussions and high order thinking problems. For the traditional classroom group, classroom time was used primarily for the delivery of lecture material to students, with additional class time sometimes used to engage students in basic comprehension activities and some exercises left for homework.

### *4.3.2 Interviews*

At the end of the intervention phase (experiment), the participating teachers were interviewed to elicit their perceptions on their experience of the FC approach and investigate any challenges associated with its implementation. This answered the fourth research question in the Saudi context: What are the participating teachers' perceptions toward their experience in teaching mathematics with the implementation of the flipped class approach? The interview method is an excellent tool by which to obtain qualitative data (Silverman, 2017). King et al. (2019) define an interview as a way of interacting with individuals or groups to retrieve information, for example, views, attitudes or a mixture of them. Interviews allow researchers to enter the interior world of another person in order to understand their perceptions in some depth (Kvale & Brinkmann, 2009; Denzin & Lincoln, 2005). Its emergent and exploratory nature is a key feature of the interview that can produce exciting results and test findings previously untested in quantitative analysis. Therefore, the interview facilitates flexible approaches to enable discovery of new issues related to the study subject (Silverman, 2017). In addition, it can be useful as it allows non-verbal signals to be used to evaluate the validity of responses. In addition, interviews are the most appropriate way of explaining beliefs, attitudes, values and motives. However, some drawbacks of conducting an interview in social science research are documented in the literature: it can be expensive to implement, time-consuming, requires a trained interviewer, there is a possibility of interviewer bias and fatigue and this type of data collection can be unreliable. (King et al., 2019; Galletta, 2013). The researcher established a rigorous procedure to address these challenges so that the interview process could be successfully completed. This involved adequate planning and piloting the questions in advance, so that the investigation was protected from threats to validity and reliability (for more detail see section 4.9.2). To summarize, data from both quantitative and qualitative sources was gathered from students and their teachers (Figure 4.2 describes when those different measures were taken).

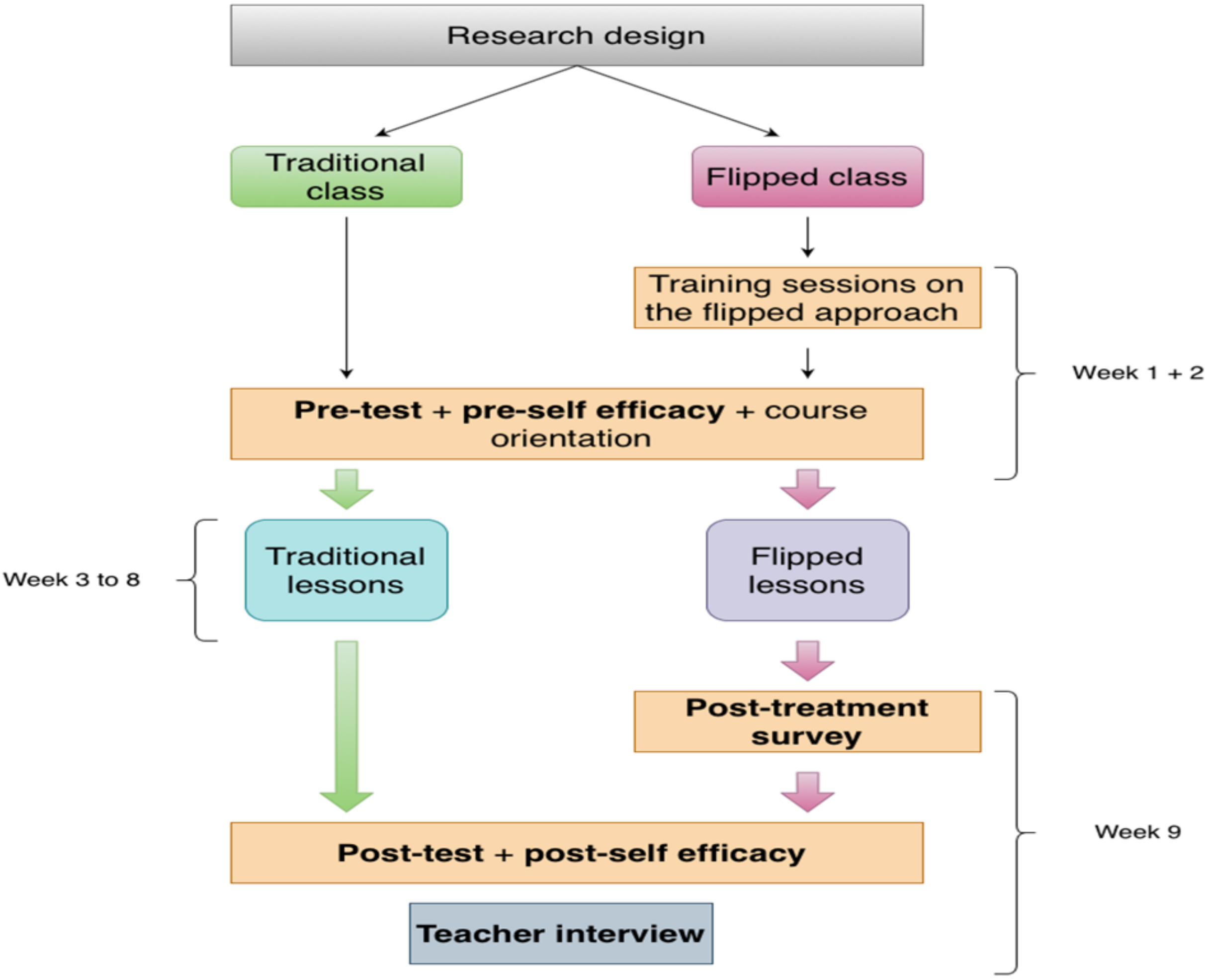


Figure 4-2 Reseach design.

## 4.4 Context and Participants

This study was conducted in Jeddah, a city in Saudi Arabia, over 9-week period (23 December 2018 to 29 February 2019). Only all-girls schools took part in the project (all Saudi Arabian schools are segregated by gender; the researcher is female and so could only access all-girls schools). The region has a large range of socio-economic classes, making it an ideal location to evaluate the applicability of FC. The population sample was drawn and was comprised of second grade high school mathematics students (ages 16-

17). Convenience sampling was used to select the participants in this study, which is a specific type of non-probability sampling meaning that the participants are conveniently available to participate and willing to be involved in this study (Creswell, 2014). This is a practical sampling strategy because it saves time and uses willing participants (Cohen et al., 2011). Hence, the researcher contacted the mathematics department in Jeddah and discussed with them the research aims and objectives and asked them to send all the information about this study to all maths teachers in the district to seek their participation for the next semester. Five teachers in four different schools agreed to take part. Then the researcher visited the participating teachers with their classes. All participants accepted voluntarily to participate after having the teaching procedure explained to them. Ten pre-existing classes were randomly assigned to either the intervention or control groups (a total of 281students in four different schools). They were homogeneous in terms of gender, age, and level of competence. The requirement was that they all studied maths with about the same educational background and age group. The school was mainly from Saudi background, with some students having an Arab heritage, such as, Egyption, Syrian and Yemeni. Pre-testing was conducted to ensure that mathematical capacities of groups were equivalent. There were five participating teachers across all the schools. Importantly, each teacher led two classes: one implementing flipped mathematics instruction (the intervention group) and one receiving traditional instruction (the control group). This within-teacher design allowed for the separation of teacher influence from the effect of the intervention (Melnyk et al., 2018). All participants were voluntary participants in the study. More information about the consent form is presented later in the section (4.9).

According to Cohen et al. (2011), the number of participants depends on the nature of the study. In this case, the sample size required to address the research questions was determined based on the weighted average effect of FC (0.3 SDs) reported in Lo et al. (2017)'s meta-analysis on the topic. To increase statistical power, the main outcomes – mathematics proficiency and self-efficacy – were measured before and after the intervention, enabling baseline scores to be included as a covariate in a regression model. Assuming a pre/post-test correlation of r = 0.7 – a reasonable assumption given the short time interval between the two measures – the number of participants needed to obtain a reasonable chance (i.e., 80%) of detecting an effect of 0.3 SDs was deemed to be 180 participants in total. More participants than this (n=281) were recruited to account for the fact that they were clustered within teachers – who in turn were clustered within schools – and that the estimated impact in Lo et al. (2017) could be overestimated (see, for example, McShane & Böckenholt, 2014). Although no meta-analysis was found summarizing the effect of FC on self-efficacy, a brief survey of the recent literature suggested that 281 was also a reasonable number of participants to detect the impact of FC on that outcome. Before the study, students in the intervention and control groups had comparable background and learning experience. The five teachers, all female, were full-time high school mathematics teachers with a long experience of teaching (from 7 to 18 years of teaching practice, mean = 12.2; SD=4.14). During the pre-intervention training, students in the intervention group were administered an ICT survey to ensure their access to technology and the internet. Table 4.1 presents students' distribution relating to schools and teachers.

Table 4-1 Overview of the Participants.

| | | Intervention Group | Control Group |
|---|---|---|---|
| School | Teacher | N of students | N of students |
| 1 | A | 32 | 35 |
| 1 | B | 31 | 30 |
| 2 | C | 21 | 18 |
| 3 | D | 27 | 28 |
| 4 | E | 31 | 28 |
| Total | | 142 | 139 |

## 4.5 The FC implementation

This part provides information regarding the course description and the in-class and out-of-class activities used in the flipped classroom, pre-intervention training, descriptions of the setting, and instructional procedures for the comparison groups.

### *4.5.1 Topics coverage*

The mathematics curriculum covered in this study was related to Algebra. The reason for choosing to conduct a study of algebra mathematical content was that research has shown that most robust mathematical skills, as found in algebra, have often been associated with university retention and career success (Allen & Lester, 2012). Algebra is frequently known as the gatekeeper subject. It is equally a place where learners are subjected to abstract reasoning, besides making decisions founded on given information. Algebra probably remains the first subject in which learners are able to shape their problem-solving abilities, and become capable of engaging in extrapolation and step-by-step assessment (Stacey & Chick, 2004). In addition, basic algebra remains the initial link in a chain of higher-level maths classes required by the students to show success in university and life (Stacey & Chick, 2004). Therefore, two units from the year 9 maths course were selected, which concentrated on important concepts of algebra, such as Arithmetical operations with rational expressions, direct and inverse variation, Solving rational equations and inequalities, and sequences as functions. More information about the topics covered can be seen in Table 4.2. The course objectives were follows: 1) To simplify rational expressions and complex fractions; 2) To find the least common multiple of polynomials; 3) To define the properties of reciprocal functions and rational functions and represent them graphically; 4) To identify vertical and horizontal asymptotes and separation point discontinuity of a function; 5) To apply arithmetic operations with rational expressions. 6) To solve rational equations and in inequalities; 7) To identify and use arithmetical sequences and geometric sequence; 8) To find the sum of the terms of a series of finite and infinite sequences

Table 4-2 Content covered during the study.

| Week | Topics |
|---|---|
| Week 1 | Training sessions for the teachers and students. |
| Week 2 | Training sessions for the teachers and students. |
| Week 3 | Arithmetical operations with rational expressions. |
| Week 4 | Graphing reciprocal functions.<br>Graphing rational functions. |
| Week 5 | Discontinuities of rational functions.<br>Direct and inverse variation. |
| Week 6 | Solving rational equations.<br>Solving rational inequalities. |
| Week 7 | Sequences as functions.<br>Arithmetical sequences. |
| Week 8 | Geometric sequences.<br>Infinite Geometric Series |

The online course materials were created by the researcher and are related to algebra based on the course textbook (Mathematics 4) which is authorised by the Ministry of

Education in Saudi Arabia as a core module for the year 9 mathematics course (Ien, 2019). Additionally, the course textbook was used for sourcing the activities, which were based on the teaching objectives for that week.

### *4.5.2 Out-of-Class Activities (pre-class learning activities)*

#### 4.5.2.1 Learning management system.

Out-of-class material was made available on Moodle, a popular and free course-based cloud platform (Rice, 2006). Moodle was used as a learning management system to manage the flipped classroom activities in the online environment. Within the course materials in Moodle, a welcome page showing the course aims and a work plan was presented to the learners (see Figure 4.3 below). The platform's overall structure was built on a weekly basis to make it more comfortable for students to fulfil their tasks (see Figure 4.3,4.4 and 4.5). Via the Moodle platform, students could interact with the out-of-class activities, including video lectures and online quizzes and other resources (e.g., course materials) and were able to do their homework by watching videos and performing tests. Additionally, Moodle recorded detailed log information of the online behaviour of the students, which included the time and date of access, the IP address from which the access request originated, usernames, types of actions and details of each access, and the time (in seconds) that students spent on each activity. All these functions helped the teacher and administrator to monitor student progress in real time, with many informational reports on the students' activities.

صف الرياضيات المقلوب (رياضيات 4)

الصفحة الرئيسية / تصنيف المقررات الدراسية / FM

عام

رسالة ترحيبية

أهلا وسهلا بكم طالباتي العزيزات لنتعلم مادة الرياضيات بطريقه الصف المقلوب. أتمنى لكم دراسه ممتعة ومفيدة

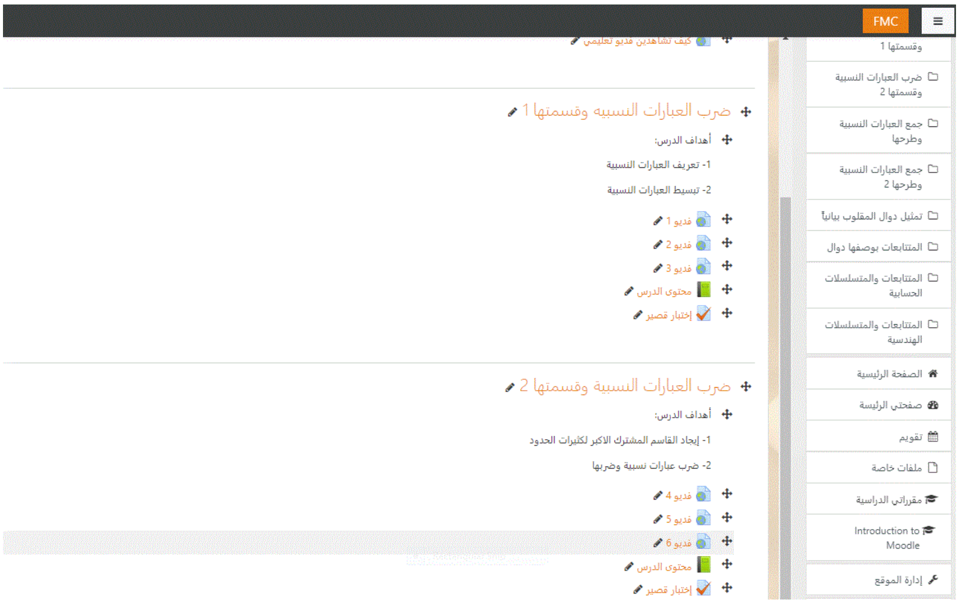
Announcements

الصف المقلوب Flipped Classroom

في هذا الملف تجدون معلومات قيمه عن الصف المقلوب ودورك كطالبه في هذة الاستراتيجية الجديدة للتعلم

كيف تشاهدين فديو تعليمي

Figure 4-3 Flipped maths class welcome page on Moodle (the word "Math" is written upside-down [flipped] to illustrate the notion of flipped classroom).



كيف تشاهدين فديو تعليمي

ضرب العبارات النسبيه وقسمتها 1

أهداف الدرس:

1- تعريف العبارات النسبية

2- تبسيط العبارات النسبية

فديو 1

فديو 2

فديو 3

محتوى الدرس

إختبار قصير

ضرب العبارات النسبيه وقسمتها 2

أهداف الدرس:

1- إيجاد القاسم المشترك الاكبر لكثيرات الحدود

2- ضرب عبارات نسبية وضربها

فديو 4

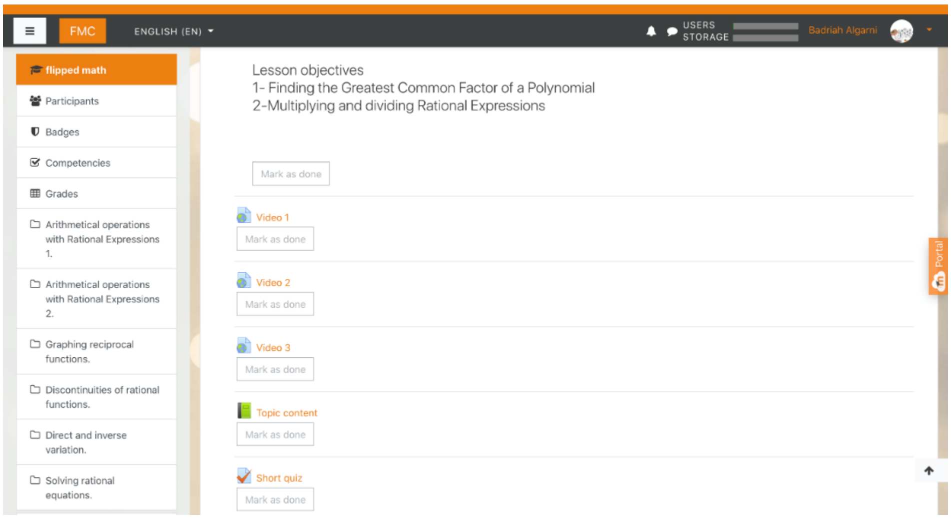
فديو 5

فديو 6

محتوى الدرس

إختبار قصير

Figure 4-4 Page content on Moodle (Arabic version)



Lesson objectives
1- Finding the Greatest Common Factor of a Polynomial
2-Multiplying and dividing Rational Expressions

Figure 4-5 Page content on Moodle (English version)

### Video lectures.

The out-of-class activities included video lectures that would expose students to the main concepts before the class. Video is widely utilized as a typical pre-class learning material in the flipped classroom (Davies et al. 2013). Each student was requested to watch the videos at a convenient time and answer a short quiz in connection with each topic. The implementation of quizzes prior to a classroom activity was used in an attempt to regulate video viewing and ensure the required exposure to up-to-date course material. A total of sixty-four videos were designed by the researcher to ensure the quality and consistency of the materials presented between the teachers involved in the study. To ensure the accuracy of the video content, these videos were reviewed by the head of the mathematics department in the district, as well as by all five participating teachers who were invited to provide feedback. Any required adjustments were made on this basis. The researcher followed the video production guidelines of Guo et al. (2014) and Mayer's (2014) Cognitive Theory of Multimedia Learning (CTML), which provides design guidelines for educationally effective multimedia materials. A summary of these guidelines is presented in Table 4.3. The video production process consisted of three important stages. Pre-production, filming and editing. Videos were posted weekly, lasting a total of 18-25 minutes for each set of video segments. No video exceeded 6 minutes to avoid the learners losing interest (McConville & Lane, 2006). A write-whilst-speaking video format was used, which has been shown to generate greater engagement than static computer-generated font (Cross et al., 2013). The videos were arranged according to the objectives of the topic; in particular, they describe the elements planned for each of the topics.

Table 4-3 Video production guidelines.

| Video production main Principles | Aim | Source |
|---|---|---|
| Segment videos into chunks no longer than 6 minutes. | It enables students to digest manageable pieces of educational material intellectually before moving to the next section of information (Sweller, 1999). | Guo et al., (2014), Mayer (2014) |
| Create a one-screen introduction and summary for each segment and add text-based cues for the main concepts. Introduce motion and continuous visual flow into tutorials, along with extemporaneous speaking | (1) To direct the attention of students towards facilitating knowledge of the important information (2) to concentrate on core subjects in instruction and their organisation; and (3) to strengthen ties between elements to support their incorporation (Koning et.al ,2009). | Mayer (2014); Guo et al., (2014) |
| Weed out or remove irrelevant content in order to reduce the negative cognitive effects of extraneous materials in audio visuals. | Learning materials are best understood when they contain few extraneous phrases, pictures, and sounds, and students learn more from a succinct description that illustrates the relevant terms and images than from a longer version of the description (Mayer & Moreno, 2002). | Mayer (2014) |
| Film in an informal setting; it might not be necessary to invest in big-budget studio productions | Videos produced with a more personal feel could be more engaging than high-fidelity studio recordings | Guo et al., (2014) |

#### 4.5.2.2 Online quizzes.

When students finished watching each video, they were instructed to complete a short quiz about the materials presented. The aim of the test was to check learners' understanding of the presented materials. Eighteen quizzes were designed (about three per week), each containing two or three multiple-choice questions. Students were provided with immediate feedback on their answers, which they could correct before submitting their final answers. This instant computerized feedback helped students to check their answers and correct inaccurate first responses (Epstein et al., 2002). Students were asked to show their teachers written evidence that they had completed the quiz.

### *4.5.3 In-Class Activities*

In-class activities focused on problem-solving, discussion and feedback. These activities were inspired by constructivist learning theory to increase students' learning via active learning and group-based problem-solving activities. At the start of the in-person lessons, teachers used structured formative assessments, such as quizzes, to assess student handling of out-of-class learning materials. The quiz results provided data regarding students' preparation for the in-class learning tasks. Kirvan et al.'s (2015) method of dealing with in class activities was adopted. At the start of each class a pre-assessment of 1-3 simple questions was provided to evaluate what students had learnt from the online videos. Teachers then graded the quizzes right immediately after they were given, so that they could easily identify students' misconceptions. Then, the flipped group was divided into two subgroups, a "re-teaching" group and an "exploration" group, based on the results. In the re-teaching group, the teacher reviewed sections of lessons that students seemed to have misunderstood. When the teachers were satisfied that the students were prepared to proceed, they joined the explorer's group. The exploration group participated in collaborative learning, problem-solving, discussion and feedback, in addition to individual or group-based activities. Previous research suggest that in-class short lectures were still necessary to deliver some of the more complicated concepts and to support struggling students (Lo & Hew, 2017). The flipped and control groups each had five, 45-minute scheduled classes per week. Student attendance in FCs was the same as for traditional classes.

### *4.5.4 Pre-intervention training*

In the two weeks preceding the start of the intervention, teachers and students completed a training session. The objective of the training was to familiarise students and teachers with the idea of the FC, discuss how to implement the in-class activities and how to use Moodle, to ensure that they were comfortable with the technology and to provide students with Moodle access details. The training session, which was about two hours long, included PowerPoint slides and printed supporting materials, such as a guide on the FC and the use of Moodle. There were practical sessions for students to familiarize them with online independent learning, provide any required assistance for tasks such as downloading materials, the setting up of accounts etc, and teach them how to watch educational online videos. In addition, regular visits were made (about three each week) to the participating schools to meet the teachers and their students and to offer any assistance required to ensure a smooth transition to flipped learning. A trial flipped session was conducted with the same group of students before the actual implementation in order to identify and deal with any technical issues.

### *4.5.5 Traditional instruction*

Control groups were taught using a lecture-based approach in which classroom time is used primarily for the delivery of lecture material to students with additional classroom time for working on problem-solving exercises and practical exercises at the end of the class meetings. The class time of 45 minutes was divided into three phases: at the beginning of the class time, teachers and students revised some of the homework questions; the next phase was the lecture delivery, which usually took 20 minutes; the remaining time was used to engage students in class activities. At the end of each class, teachers allocated homework to be conventionally completed. Students were required to complete math problems based on mathematical concepts covered during the class study. Each homework containing four to six questions required students to work individually on their homework and be ready to show the teacher written evidence of their answers at the beginning of the next lesson. Materials and delivery: In- and out-of-class learning materials were in print format and were supplied during in-class activities.

### *4.5.6 Instructional Procedures*

The FC differed from traditional instruction, mainly in how new content was delivered and how the activities were carried out. Therefore, before the actual implementation of the FC, there were several visits to the participating schools to meet teachers and students and to discuss the transition to the FC. The flipped group in each school was given four hours (divided into two hours with the teachers and two hours with the students) of training for each school before the teaching period and trial sessions began in order to familiarise themselves with the flipped approach. Following this, the pre-test and self-efficacy questionnaires were administered to the two groups, on the same day. After this, the actual experiment started for both groups over 7 weeks, with five classes each week, lasting about 45 minutes each. Both groups of students (flipped group and traditional group) were assigned the same topics every day, with identical learning objectives for each group. However, the participants in the flipped group covered more activities each day because of the increase in the class time that enabled the teacher to cover much of the curriculum. In the flipped group, homework involved using Moodle to watch videos and answer the online quiz before coming to the class session, while homework in the traditional group was traditional homework consisting of many problem-solving exercises that students needed to do alone at home. The management of the in-class sessions was different between the two groups. In the flipped groups, the teacher started with pre-assessment quiz, then divided the classroom into two groups (as mentioned in section 4.5.3) and started directly to work in groups or individually with the content, while the teacher in the traditional groups started with checking homework, and then lectured about the new topic for about 20 minutes, before doing some exercises and problem-solving activities until the end of the session. At the end of the experiment, both groups were administered post- test and self-efficacy questionnaires. For the flipped group, there was a post treatment survey administered to them at the end of the final class session in each participating school. See table 4.4 for more detailes.

Table 4.4 Components of instruction for both the flipped group and the traditional one

| | Flipped Group | Traditional Group |
|---|---|---|
| Pre- training | Two hours training and trial session for each FC group in each school | None |
| Mathematics Tests | Pre and post test | Pre and post test |
| Self-efficacy survey | Pre and post test | Pre and post test |
| Course duration | 8 weeks | 8 weeks |
| Number of classes per week | 5 classes (45 minutes each) | 5 classes (45 minutes each) |
| In class-activities | Problem-solving, group and individual work, peer instruction, discussion and feedback | Teacher lecture and group and individual work, problem-solving, discussion and feedback |
| Accessibility of online content | Yes | No |
| Online activities (videos and quizzes) | Yes | No |
| The teacher's role | To facilitate, evaluate, and synthesise new knowledge | To facilitate and provide knowledge |
| Type of homework | Watching videos and answering quizzes on Moodle at home before the class session | Traditional homework after the in-class session which consisted of many exercises. |
| Post- treatment survey | Yes | No |

## 4.6 The Research Instruments

To achieve the aims of this current research, the researcher had to collect quantitative data in the form of mathematics assessment tests and a self-efficacy measure. Therefore, before the actual implementation of the intervention, the students were asked to complete a pre-test assessment, to assess their prior knowledge and ensure that the participant groups had similar levels of maths proficiency. In addition, students were asked to conduct self-efficacy questionnaires, to assess their self-efficacy levels before the intervention. Then, when the intervention phase started, the flipped group received the flipped instruction; therefore, the use of home videos taught them new content. Then they also had to collaborate on numerous in-class activities at school in the presence of their classmates and teachers. Meanwhile, the traditional group were learning mathematics in the traditional way, so the classroom time was used primarily for the delivery of lecture material and some basic comprehension activities. At the end of the session, the teacher assigned activities to be completed at home (homework). At the end of the intervention phase, a post- mathematics test and post-self-efficacy scale were administered to all students to measure the changes in their maths performance and self-efficacy over the intervention. Additionally, a post-treatment survey was administered to the flipped group to elicit their perceptions towards their experience of the flipped intervention. During the final stage of the data collection process, qualitative data (from in-depth interviews) was collected. Then each dataset was individually analysed. Table 4.5 below represents the research instruments used in the current study.

Table 4-5 Research instrument

| Focus Questions | Data Collection Methods | Rational | Source | Data Analysis |
|---|---|---|---|---|
| RQ 1. How does mathematical proficiency compare between students who learn mathematics with the flipped class model and students who learn mathematics with the traditional class model? | Pre- and post-intervention mathematics proficiency test comprising 30 multiple-choice items | To examine the changes in maths performance | Questions were taken from national standardized tests: The Scholastic Achievement Admission Test (SAAT) | Mixed effect model |
| RQ 2. How does mathematical self-efficacy compare between students who learn mathematics with the flipped class model and students who learn mathematics with the traditional class model? | Pre and post measures of self-efficacy | To examine the changes in self-efficacy prior and over the intervention | Usher and Pajares' (2009) Sources of Self-Efficacy in Mathematics questionnaire (SSEM). 12-item scale | Mixed effect model |
| RQ 3. What are the participating students' perceptions toward their experience in learning mathematics with the FC? | Post-treatment questionnaires | To investigate the students' perceptions towards their experience of the FC approach. | Students' perception of the flipped model Sletten's (2015) 30-item scale | Descriptive analysis |
| RQ 4. What are the participating teachers' perceptions toward their experience in teaching mathematics with the FC? | Semi-structured interviews | To gain a comprehensive understanding of the teachers' perceptions of their experience of the FC approach. | Audio-taped, researcher-led interviews of the participating teachers | Thematic analysis |

## 4.7 Quantitative Outcome Measures

To answer the first three research questions, outcome measures included pre and post measures of mathematics proficiency, pre and post measures of mathematics self-efficacy and post-treatment questionnaires. The following sections describe and discuss each of them, including their validity and reliability.

### *4.7.1 Pre- and Post-intervention mathematics proficiency test*

To measure the students' degree of understanding of mathematics, a mathematics pre-test (see Appendix A1 in English and A2 in Arabic) was administered to all students to measure their prior mathematical knowledge before beginning the experiment and a mathematics post-test was administered when the experiment had been completed. The usual way of measuring the extent of a person’s knowledge of mathematics is academic achievement, which, in a school, can be assessed by an examination at the end of term to establish how far the objectives of each unit have been met (Algarabel & Dasi, 2001). Achievement tests are defined as tests that measure competence in an area of content after an individual has been exposed to a particular learning experience (Algarabel & Dasi, 2001). Students who meet the criteria for the unit are considered to have adequate understanding of the mathematics knowledge required (Carpenter & Lehrer, 1999). These tests were administered by the researcher with the supervision of the five participating teachers involved in the study in the first week of the study (pre-test) and at the end of the experiment (week nine). These tests were implemented for the experimental and control groups' students. Each test comprised 30 multiple-choice items, for a maximum score of 30 (see Appendix B1 in Arabic and B2 in English). Each item scored either one point or zero. As no question required complex calculation, use of electronic calculators was not permitted. Both pre and post-tests lasted for one hour. All the questions were taken from standardised tests and were approved by the teachers involved in the study. The questions were taken from the maths section of the Scholastic Achievement Admission Test (SAAT) from the previous four years (2015, 2016, 2017, and 2018). The SAAT is designed and administered by the Saudi National Education Organization to measure proficiency at the high-school level in Saudi Arabia (Education & Training Evaluation Commission, 2016). The test measures students’ achievement levels in mathematics, physics, chemistry and biology. All students in high school in Saudi Arabia are required to take the test and it is important for students to achieve a good score as admission to university and entry to their preferred field depend on their scores in the SAAT test (Bakr Khoshaim & Ali, 2015). The pre and post-tests were based on a range of topics representative of curriculum content (see Table 4.6). This was done to minimize over-alignment of the test with the intervention groups. The pre-test was different from the post-test to minimize the practice effect. Pre and post-test content were chosen to be of similar difficulty.

Table 4-6 Topics covered in the mathematics proficiency measure.

| Topics | Numbers of questions |
|---|---|
| Arithmetic operations with rational expressions | 6 |
| Reciprocal and rational functions | 8 |
| Direct and inverse variation | 5 |
| Equations and inequalities | 4 |
| Arithmetic and geometric sequences | 7 |

### *4.7.2 Questionnaires*

The instrument chosen to measure students' self-efficacy and students' perceptions toward the FC approach was a survey questionnaire. Cohen et al. (2011) indicate that questionnaires are a typical approach in educational research as they enable researchers to gather vast amounts of data and are straightforward to analyse. The questionnaire is described as a list of questions or subjects to be answered in writing by a person. Wilson and McClean (1994) noted that there are several types of questionnaires, such as open and closed questionnaire objects, such that for a given purpose each questionnaire type will have its own criteria. The questionnaire has numerous advantages, as pointed out by Cohen et al. (2011), who argued that questionnaire answers are not influenced by the bias of the interviewer, they are quick to distribute, easy to administer and convenient for the respondents. In addition, some of the most important advantageous features of a questionnaire include the standardised format and the ability to collect a vast volume of data by administering the questionnaire to a large sample (Wilson & McClean, 1994). Hence, a questionnaire was a suitable instrument in this research because it facilitated the study's overall purpose and answered the second and third research questions. The researcher decided to use an existing questionnaire identified in the literature that showed high validity and reliability and was relevant to the current study.

#### 4.7.2.1 ICT survey questionnaire.

An ICT survey questionnaire was conducted at the beginning of the study for students in the flipped group to provide information about their access to and use of ICTs (see Appendix C1 in English and C2 translated into Arabic). The questionnaire used closed questions. Student participants were asked whether they owned a device at home, including computer, laptop or mobile devices and whether they had access to the internet at home. They were also asked whether they had any problem accessing online materials, especially downloading videos from YouTube or other sources or restrictions on their usage of the internet at home. The results showed that students had access to either a computer (65% of students) or a mobile device (94%). Five students did not have access to an internet connection permitting them to complete the out-of-class activities. These five students were provided with a prepaid internet connection for their phones (20 USD per student). A letter explaining the aim of the study was sent to the parents of ten students for whom their parents' consent to use the internet was required.

#### 4.7.2.2 Pre- and Post-intervention self-efficacy questionnaire test.

Self-efficacy was measured using items from the Sources of Self-Efficacy in Mathematics (SSEM) questionnaire by Usher and Pajares (2009), a questionnaire with documented reliability and validity (e.g., Carpenter & Clayton, 2014). Due to time constraints, only the subscales mastery experiences (e.g., 'I make excellent grades in maths tests'), and social persuasion (e.g., 'People have told me that I have a talent for maths) were kept, totalling 12 items. Those subscales were considered most relevant to the present study, because mastery learning, and social persuasion have been regarded as crucial elements for increasing the confidence of students in all study fields (Bandura, 1997). Mastery experience has proved to be consistently able to predict student self-efficacy across academic levels and domains (Usher & Pajares, 2009). In addition, influence on students' learning from external supporters, termed social persuasion, can be measured directly so that the self-efficacy of students can be determined. People regularly interacting with maths learners could have a large impact on their self-efficacy beliefs. Because teachers, parents, and peers can all positively or negatively affect a student through support and encouragement, their self-efficacy could be increased (Usher & Pajares, 2009). It was discovered that the highest correlation occurred between personal experiences (0.61) and mathematics self-efficacy; a significant relationship existed between social persuasion (0.54) and mathematics self-efficacy (Usher & Pajares, 2009). A more comprehensive overview of the mathematics self-efficacy levels of students was achieved by examining both the social persuasion and mastery experiences of their mathematical experiences. Students were requested to answer how confident they were in their belief in their ability for each of the statements using a 5-point Likert scale (1 = definitely false; 5 = definitely true). The original questions and response scales were translated into Arabic by a language expert (see Appendix D1 in English and D2 translated into Arabic).

#### 4.7.2.3 Students' Perceptions of the FC.

A survey of student perceptions of the flipped model was developed by Sletten (2015). The survey items were identified in previously published surveys (McLaughlin et al., 2013; Pierce & Fox, 2012; Roach, 2014; Smith, 2013) and compiled into a 30-item instrument by Sletten (2015) (see Appendix E1 in English and E2 translated into Arabic). The thirty items were divided into two sets reflecting the two dimensions of the flipped model—the online video lectures and in-class active learning. The scale assesses two key dimensions of perceptions of the FC model: Flipped Video Perceptions and Flipped Class Perceptions (see table 4.7). The Flipped Video Perceptions items consisted of four sub-scales: (a) video preference (3 items), (b) video value (7 items), (c) technical aspects of accessing videos (6 items), and (d), viewing frequency (3 items). The Flipped Class Perceptions items consisted of two sub-scales: value of active learning (7 items) and learning enhancement (4 items). Each participant was asked to rate each item based on their attitude towards FC implementation using a 5-point Likert scale, ranging from 1 (not at all true of me) to 5 (very true of me).

Table 4-7 Students' perceptions scale items.

| **Dimensions** | **Subscale** | **N of Items** |
|---|---|---|
| **Flipped video perceptions** | Preference of Video | 3 |
| | Value of Video | 7 |
| | Technical aspects of accessing videos | 6 |
| | Viewing Frequency | 3 |
| **Active learning perceptions** | Learning Enhancement | 4 |
| | Value of Active Learning | 7 |

## 4.8 Qualitative Instrument

In order to respond to the final research question, a qualitative approach was employed to gain deep insight into teachers' perspectives of their experience of FC implementation. This qualitative data was obtained through interviews with the participating teachers.

### *4.8.1 Semi-structured interviews*

Silverman (2017) enumerates different interview types with different protocols for use in different circumstances, which include individual and group interviews. An individual interview can be anywhere on a range from fully structured to fully unstructured; structure refers to the degree of freedom available to the interviewer to ask supplementary questions not included in the original script, so that the interview may be structured, evolving or semi-structured (Galletta, 2013). Structured interviews use scheduled, formally structured questions; evolving interviews have no schedule of questions; and semi-structured interviews are somewhere between the two. Semi-structured interviews use predetermined questions that act as a guide to the topics to be discussed; they are generally conducted with limited participant numbers and are designed to learn how participants regard an event, a setting, or an experience (Cohen et al., 2011). The present study utilised semi-structured interviews. Questionnaires and fully structured interviews were deemed unsuitable for this research because they would be unlikely to yield the required depth of meaning. Semi-structured interviews allowing points to be followed up were, therefore, conducted with participating teachers to obtain feedback, and probing questions were asked to ensure that interesting points were pursued (Galletta, 2013). Each interviewee was asked these questions consistently and systematically, but with freedom for the interviewer to seek further information. Interviewers are permitted and, indeed, expected to probe well beyond the answers to initially prepared, standardised questions (King et al., 2019). There were two reasons for choosing semi-structured interviews as the main method of qualitative data collection for this study. The first was that semi-structured interviews were deemed the technique best equipped for exploring participants' opinions (Cohen et al., 2011; Punch & Oancea, 2014). The second was that interviewers who use semi-structured interviews have the ability to alter and adjust interview themes in response to data collected from interviewees in order to provide deeper understanding. Brown (1992) states that "Classroom life is Synergistic" (p. 141), implying an interdependence between a classroom's various elements, including teachers, students, teaching style, curriculum, and assessment. It is not possible to study these aspects independently from each other and one aspect can be changed without affecting others only with great difficulty. The semi-structured interview technique used in this study asked participants about their personal experiences of flipped classes and how they perceived the initial class structure, the overall process, and outcomes. They were also asked for suggestions for the future improvement of flipped classes. Semi-structured interviews are open-ended in style, although they do require a collection of pre-prepared guidance questions (Kvale & Brinkmann, 2009). This open coded format is important for developing broader questions and enabling a deeper and more detailed understanding of the topic.

### *4.8.2 Interview protocol*

In this study, the researcher followed the Interview Protocol Refining (IPR) structure, which consists of a four-phase method to systematically design and refine an interview protocol (Castillo-Montoya, 2016). The four-phase process is comprised of: (1) making sure that the interview questions are matched to the research questions; (2) the development of an investigation-based conversation; (3) gathering input on interview protocols; and (4) piloting the interview protocol (Castillo-Montoya, 2016). The IRP method helps to improve interview protocol reliability and is used for qualitative research, which therefore contributes to the improvement of the quality of the data collected from research interviews. In addition, the IPR framework provides a common language for qualitative researchers to show the rigorous steps taken to establish interview protocols and to ensure that they are compatible with the analysis at hand (Castillo-Montoya, 2016).

The researcher can also ensure thorough brainstorming and assessment of interview questions by asking questions for details on the goals of the analysis. Hence, a pre-written script of questions guiding the interview was prepared by the researcher after a review of the literature on approaches to FCs, as well as the views of other educators and forums for educators currently engaged in flipped teaching. The researcher took care to write interview questions that were understandable, accessible to participants and would promote a conversation between the interviewer and the interviewee. Although specific questions were designed, if required, the questions could be altered based on the perceptions of the investigator and what appears to be most applicable to the context (Kvale & Brinkmann, 2009). The main purpose of the interviews was to help the teachers think about their experience in terms of specific topics in a structured way. Each of the five participants received the same guiding questions for the interview. The interviewer tried to allow the participants to address the interview subjects openly and encouraged the participants to freely discuss interview subjects without any interruptions.

The researcher drafted a script using an interview protocol. The script is a written text that guides the interviewer and helps to support a natural conversational style. The researcher then moved to phase 3—obtaining feedback on the developed interview protocol. The objective was to obtain feedback on the interview protocol with the goal of enhancing its trustworthiness as a research tool (Galletta, 2013). During the process of piloting the interview guide, two volunteer participants, who are mathematics teachers in Saudi public schools, were requested to answer the questions so that their responses could be evaluated and their comprehension of the questions in the interviews could be assessed. The objective of a pilot process is to ensure that questions yield sufficiently rich data (Silverman, 2017). From the pilot study, the researcher discovered the best technique for handling and monitoring the interview and obtained greater experience and familiarity. This included understanding the practical manner in which data is gathered and how participants could be made to feel relaxed and enthusiastic about answering the questions. The pilot study also tells the researcher if sufficient data and answers are being collected from the type of interview (Silverman, 2017). The reactions of participants to the pilot process were considered while refining and modifying the structure of the interview procedure. No adjustments were needed as the questions appeared to be understandable and the wording of the questions was straightforward (the interview questions can be found in Appendix F1 for the English version and Appendix F2 for the Arabic version).

Participating teachers were interviewed at the end of the experiment, interviews were recorded (with permission), and the interview with each teacher lasted approximately 20 to 30 minutes. The interviews were conducted in Arabic and then transcribed. All the analysis was performed using the original transcripts to maintain the meaning (Al-Amer et al, 2016; Van Nes et al., 2010), some of the quotations were then translated into English for presentation by the researcher.

## 4.9 Validity and Reliability in Mixed Methods Research

Validity and reliability are concepts used to determine the quality of a study. They demonstrate how well a process, procedure or test measure something. In order to establish the quality of social research, the validity and reliability of every instrument are important (Teddlie & Tashakkori, 2009). Validity-free study is regarded as null and ineffective because validity is one of the fundamental research pillars (Onwuegbuzie & Johnson, 2006).

### *4.9.1 Validity and reliability of quantitative data*

Validity in quantitative research is accomplished when a scale or metric is capable of measuring exactly what it aims to measure (Creswell, 2014). The reliability and validity of both methods and measurements should be considered in quantitative research. To maintain validity and reliability and to maintain a neutral stance during the data collection phase, the researcher avoided making any pre-assumptions or hypotheses. Since the quantitative data obtained from the experimental design considered cause and effect relationships in this study, validity could be divided into two types: internal and external validity.

#### 4.9.1.1 Internal validity.

Internal validity threats are “experimental procedures, treatments, or experiences of the participants that threaten the researcher’s ability to draw correct inferences from the data about the population in an experiment” (Creswell, 2014, p.291). Thus, to avoid threats to internal validity and reduce bias, the current research design applied pre-tests to show the maturity trends and then made a comparison of these trends to post-tests. Additionally, this study involved a control group so that the researcher could compare the effect of the treatment between the flipped class and the traditional one. If comparable treatment and control groups face the same threats, they will not affect the study outcome. Using both pre-test and control group enhances the accuracy of the results and ensures internal validity (Slack & Draugalis, 2001).

Another concern was related to the possibility of the treatment being diffused or contaminated. Contamination occurs when individuals are assigned to different treatment but, for some reason, certain individuals receive treatment features that they are not assigned to (Cook et al., 2002). In the current study, this could apply if the flipped groups shared the videos with the control groups. To avoid this, the researcher sought to keep the two groups as separate as possible. The researcher talked to the teachers and students in the intervention groups and explained that they should not share any materials and resources with the control groups. In addition, she informed the control group that they would learn the same content and aim for the same learning outcomes; the only difference would be in the teaching instruction, since the researcher wanted to examine its effectiveness. Another problem could be compensatory competition, that is, when control participants believe they are devalued in comparison to the experimental group, as they are not receiving the treatment (Slack & Draugalis, 2001). To address this issue, all materials and videos were made accessible to both groups after the experiment and both groups appreciated those as a good resource for revision for the final exam. Additionally, to avoid the effect of testing, the researcher ensured that all questions in the two tests (pre and post) were different in content, in order to minimize the practice effect, but their content was of comparable difficulty. This was confirmed by the participating teachers.

#### 4.9.1.2 External validity.

Another important factor in experimental research is external validity (Cohen et al., 2013). This is the extent to which outcomes for participants can be generalized to a wider community, different cases, locations, times, or scenarios for the future. The researcher believes that the current study has a high external validity, since careful steps were taken to protect against possible threats. The researcher ensured that she had clearly defined the population of the current study and made sure that participants were experiencing the events of the study in real life, as students in their classrooms.

Additionally, she adopted a convenience sampling technique to generate a sample of the population from which the participants were taken. However, the researcher made an effort to sample schools (or teachers) from a variety of backgrounds and socioeconomic status. To ensure the selected participants were as diverse and representative of the population as possible, the researcher recruited schools with different socio-economic backgrounds. All groups were nearly balanced with similar numbers in the flipped and traditional group. This is the average class size in high schools. As every class was recruited in its entirety, it is therefore assumed that the study has ecological validity (Bracht & Glas, 1968). The researcher then randomly selected groups of students, who were already assigned to the course by the schools' administrations, to the flipped or the traditional group. The sampling size in this study was chosen to detect a range of plausible effects. Further, the design of the experiment was based on theoretical principles and an extensive review of recent studies conducted in different contexts. Sufficient description has been provided of the independent variables. The instruments to measure these variables had already been used in other contexts in the literature. This would permit another researcher to reproduce and replicate the research to a reasonable extent. Generalisation of results relies upon identifying the dependent variables and selecting the instruments so that these variables can be measured (Bracht & Glas, 1968). Further, the measure of mathematics proficiency was educationally relevant (that is, the questions were taken from national standardized tests rather than the researcher or the participating teachers creating their own questions), and the analysis controlled for students' pre-intervention performance and teachers' influence.

#### 4.9.1.3 Reliability.

Reliability refers to two main concepts: the accuracy of an instrument (whether all items in a scale are measuring the same thing), and repeatability (whether the same results would be obtained if the instrument was used in the same situation on repeated occasions

(Cohen et al., 2011). Several ways of assessing the reliability of an instrument exist. Internal consistency was adopted following the key data collection (Marshall & Rossman, 2014). This kind of reliability tests whether various items function in the same way (Silverman, 2017). The alpha coefficient is the best-known technique to achieve this (Marshall & Rossman, 2014). For every included measure, high Cronbach's alpha measures of reliability were obtained. Further details are presented in the following sections.

#### 4.9.1.4 Validity and reliablity of the measures.

The validity and reliability of the quantitative measurements used in the present study are evaluated in the following sections.

##### *4.9.1.4.1 Pre- and Post-intervention mathematics proficiency test.*

There are various types of validity, such as face validity, content validity, concurrent validity and construct validity. Although the SAAT tests are national exams and their validity and reliability are meant to have been checked, the researcher also tested the validity and reliability of the tests. To determine the validity of the pre-and post-tests, the face validity approach was employed. Face validity is the degree to which expert judges perceive that measurement items are suited to the design and evaluation objectives (Hardesty & Bearden, 2004).

As a result, after the tests had been prepared by the author, the tests were presented to the head of the mathematics department and the five teachers who participated in the review study and they were asked for their opinions on the adequacy and importance of the content of the test items. This test was important for establishing the validity of scores on the instrument and for improving questions, formats and scales (Creswell, 2014). Their views were taken into account in preparation of the final exam versions. In addition, the assessments also included a pilot research population of Grade 11 school students. Thirty students from a school not involved in the study were selected to pilot the tests. The purpose of this was to collect their input and use their answers to further refine the tests and assure their validity. The reliability of both tests was adequate (pre-test: $\alpha = 0.78$; post-test: $\alpha = 0.87$). The achievement test is available in the supplemental material.

#### *4.9.1.4.2 Self-Efficacy Questionnaire.*

In terms of the content validity of the self-efficacy questionnaire, the scale was derived from an existing questionnaire, the Sources of Self-Efficacy in Mathematics (SSEM) designed by Usher and Pajares (2009). Thus, the validity of the scale is assured in middle school mathematics and it has been adopted by various researchers with different mathematics courses across all age groups. In the current study, the researcher reassessed its validity and reliability in a Saudi context. For this purpose, to ensure the language of the translated version was understandable for students, questionnaire items were presented to students who had similar characteristics to the target respondents in the current sample. It was also sent to the participating teachers for further validation. These teachers agreed that the scale was suitable for the targeted population, with minor recommendations to reduce the number of questions. Therefore, the researcher confined the final version to two main sub-scales, named mastery experience and social persuasion. The internal consistency of the overall scale was high (pre-test: α = 0.89; post-test: α = 0.90) (see Table 4.8).

Table 4-8 Subscales of the Self-Efficacy Questionnaire.

| Subscales | Number of items | Reliability pre | Reliability post |
|---|---|---|---|
| Mastery experiences | 6 | α = .86 | α = .88 |
| Social persuasions | 6 | α = .81 | α = .84 |

#### *4.9.1.4.3 Students' Perceptions of the FC.*

Items for the students' perceptions questionnaire were derived from an existing questionnaire, the Flipped Model Perceptions Codebook designed by Sletten (2015). This had the advantage of high reliability with post-secondary students and the validity of the original format was measured by applying exploratory factor analysis to assess the validity of any sub-constructs within the two dimensions (Sletten, 2015). The reliability coefficients of each subscale and of the entire questionnaire ranged from α = 0.78 to α = 0.95. Since the Saudi context is different from that of the USA where the instrument was initially validated, the researcher re-examined the scale within the aim of the current study to examine if it was suitable in the context of Saudi Arabia. The survey was then re-tested and found to have internal consistency (Cronbach's alpha) of between .79 and .93 (see table 4.9). This means that the Flipped Model Perceptions Codebook remained reliable for testing high schools in a Saudi context.

Table 4-9 Students' perceptions measure scale items.

| **Dimensions** | **Subscale** | **N of Items** | **Reliability** |
|---|---|---|---|
| **Flipped video perceptions** | Preference of Video | 3 | α = .79 |
| | Value of Video | 7 | α = .92 |
| | Technical aspects of accessing videos | 6 | α = .91 |
| | Viewing Frequency | 3 | α = .84 |
| **Active learning perceptions** | Learning Enhancement | 4 | α = .93 |
| | Value of Active Learning | 7 | α = .87 |

### *4.9.2 Validity and Reliability in Qualitative Research*

Validity and reliability in qualitative data refer to trustworthiness, which simply means whether the findings can be trusted (Lincoln & Guba, 1985). According to Lincoln and Guba (1986) trustworthiness involves establishing: credibility (the qualitative equivalent to internal validity), transferability (equivalent to external validity), dependability (equivalent to reliability), and confirmability (equivalent to objectivity). More details are presented in the following sections.

#### 4.9.2.1 Credibility.

Credibility of qualitative data means that the researcher tests data consistency, which is similar to the internal validity of quantitative research and is concerned with truth-value (Golafshani, 2003). Several techniques exist to maintain credibility and contribute to trustworthiness, such as peer debriefing, prolonged engagement, triangulation and member checking (Lincoln & Guba, 1985). Based on the current study objectives, some of these strategies were applied to ensure the accuracy of the data, including prolonged engagement and member checks. Firstly, via frequent visits to the participants at their schools to offer support or removal of misunderstandings, the researcher gained a deeper understanding of the phenomenon during the study. The greater the experience a researcher has with participants, the more insights the researcher can gain to explain the outcomes (Creswell, 2014).

Another way to improve the credibility of interview data is by member checking, which is one of the most effective strategies for establishing the credibility of a qualitative investigation. During this step, the representatives or participants who provide the data, analyse the data documents, interpretations and reports of the researcher to see whether the transcripts match their recollections (Lincoln and Guba, 1985). Member checking was conducted as the researcher emailed the transcripts to the five teachers. A review of the completed transcription may provide more elaborations or correction to the transcript (Brenner, 2006; Shenton, 2004), which may reduce validity and reliability threats. As a result, one teacher made some modifications to her interview transcript, while other participants did not respond, indicating that they were satisfied with their transcripts.

#### 4.9.2.2 Transferability.

Another issue to be considered in qualitative research is transferability, which refers to the degree to which the results of qualitative research can be transferred to other contexts or settings with other respondents (Miles & Huberman, 1994). Merriam (1988) asserts that qualitative research aims to find unique interpretations of events, rather than generalising. It is difficult to obtain equivalent results from qualitative data. Despite this caveat, it can be suggested that, while this study examined the effect of the FC on students' mathematics proficiency and self-efficacy in Saudi Arabia, it is likely that the conclusion can be extrapolated to other Arab nations, as there is a high degree of similarity between Arab nations in characteristics such as culture, education systems and policies. In addition, the Ministry of Education establishes educational policies and curricula for each school in Saudi Arabia. These include matters such as qualification and the standards of professional learning and the role and function of information technology in the national curriculum. Thus, it can be argued that the findings of this study can be extrapolated to some degree to other schools in Saudi Arabia. In terms of transferability of this study's results to other cultures or participants, Lincoln and Guba (1985) argued that in qualitative research the mission of the researcher is not to ensure transferability, but to provide rich data to those reading the study, to enable them to decide if the findings are relevant to the new situation or not. To increase the chances that the results of this study may be applied in other settings, detailed explanations have been provided of the context, the students, the data gathered, the research design and other details deemed relevant. On this basis, readers can assess the extent of similarities and differences between their own settings and the research context so that an informed judgement can be made about the transferability of the research conclusions.

#### 4.9.2.3 Dependability and confirmability.

Dependability is parallel to quantitative research reliability (Guba & Lincoln, 1989). Dependability can be explained as the degree to which the researcher can demonstrate that he/she has applied appropprate proceders for achiving trutful interbritations (Guba & Lincoln, 1989; Miles & Huberman, 1994). Golafshani (2003) mentioned that dependability is very important in qualitative questioning, because interviews have a high propensity for discrimination, and subjectivity or research bias can arise because of the researcher's significant role in the data collection and interpretation (Punch & Oancea, 2014). To address this possible bias and to boost the accuracy of the account in this study, it was critical to guarantee that the findings were based on the beliefs of the participating teachers rather than the researcher's inclinations or predispositions (Lincoln and Guba, 1985). In section 4.14.2, a full methodological description is given, including an explanation of the analysis process, and interview quotations are presented in the results chapter to allow the reader to assess if the primary claims or findings are supported by the collected data. Member checks, as described in regard to credibility, were also used to achieve dependability. Additionally, the researcher employed peer review. This method includes the selection of an individual (the peer debriefer), who discusses the qualitative analysis and asks questions so that this account resonates with those other than the researcher (Creswell, 2014). This technique requires an understanding outside the researcher's understanding and decreases the potential for subjectivity arising from the investigator's understanding. In the coding and analysis of interview data, the research supervisors were involved, by reviewing the final thems and codes to verify that all the qualitative interpretation were based on the data obtained, which strengthened the dependability. Additionally, Confirmability is concerned with ensuring that the researcher's interpretations and findings are clearly drawn from the data, and it necessitates the researcher demonstrating how conclusions and interpretations were arrived at (Shenton, 2004). Confirmability is established when credibility, transferability, and dependability are all met (Guba & Lincoln, 1989). Throughout the study, all of the justifications for theoretical, methodological, and analytical choices were explained, so that others can understand how and why decisions were taken.

## 4.10 Ethical Considerations

The permission of the Research Ethics Committee was used as a starting step for guaranteeing the appropriate ethical concerns in this investigation. An application was made to the University of York Ethics Committee for ethical approval to implement the study in Saudi Arabia, and this was granted in September 2018. Documents such as testing instruments, informed consent and a report of any potential risks were required to be submitted for the ethical approval process. Approval was then received from the Ministry of Education in Saudi Arabia to facilitate the researcher's access to schools in Jeddah (see the letters in Appendix H1and H2).

It should be noted that all the study participants, both students and teachers, were taking part voluntarily. Participants in the study, including students, teachers and principals of the four participating schools signed consent forms. The consent form contained full information about the study, explaining in detail the study's main purpose and how it would be conducted. In addition, it provided a description of the procedures for the gathering of data (according to the class participants, type of information and nature) (Cohen et al., 2011). These steps were taken to ensure that all the actions at the school were legal under Saudi law. In addition, the consent form contained their agreement that the data gathered would be strictly limited to use within the research context and publication purpose. The consent form also provided contact details to be used if the participants had any concerns or wished to ask any questions about the research. Consent forms for the heads of participated schools, teachers, and students in both the flipped and the traditional group all are presented in Appendices I1, I2, I3, I4, I5, I6, I7 and I8 in both languages, English and Arabic.

Additionally, there were some possible ethical concerns that were addressed in this study relating to confidentiality, anonymity, data protection, the risk of research bias and the risk of harm to participants (Cohen et al., 2011). These issues have been resolved in different ways. With respect to privacy, the participants in the study were told that their identities would not be disclosed at any time. This was because the students used their real names and personal emails to register and log in to the Moodle site. Therefore, the researcher made sure that the students could not be identified by anyone else. Participants were assured that the pre and post-tests, questionnaire data usage and interview transcript would contain no information that could possibly harm the students' or teachers' reputations and that all data would be made anonymous, with codes substituted for anything that could identify any of those taking part. Therefore, each student was assigned an ID number that was associated to their names during data collection. To maintain confidentiality of the participating teachers, pseudonyms (A, B, C, D, E) were used by the researcher to represent the teachers' identities in the interview data (King et al.,2019). In addition, the names of the schools in which the research was conducted were kept confidential. All data files were saved safely in various locations such as the computer account at the University, an online storage application called the Box, and also on an external drive for backup purposes and to maintain the validity and reliability of the data obtained. All data was password-protected, with only the researcher having access to them.

In addition to the above, the possibility of psychological harm was also taken into consideration for the control group participants, as they were not exposed to the FC components. Therefore, they were also given access to the Moodle site containing the videos and activities at the end of the data collection period. Additionally, consideration was given to the psychological harm that participants may be caused by overloading, for example, feeling overwhelmed. This was especially the case in the treatment group because they were new to the flipped approach and independent online learning. The researcher therefore ensured that the videos were short, and the quizzes that followed each video were simple to grasp. More complicated tasks were left to class time activities, so students could work with the support of their teachers and peers. In addition, there were training sessions at the beginning of the study and a trial session to familiarise students with the new learning approach. Regular visits were made to the participating schools to meet the teachers and deal with any concerns or difficulties raised by the students and to ensure the smooth transition to the flipped approach. In addition, at all stages of the research the rights and interests of the participants were respected.

## 4.11 The Researcher's Position

Positionality is defined as the links and interactions between the investigator and every feature of the person being studied (Dwyer & Buckle, 2009). This includes aspects such as identity, gender, class, formal education, research expertise, race and socioeconomic status (Dwyer & Buckle, 2009). The identity of a researcher may differ, depending on the situation, the position of an outsider or an insider who is sensitive to a specific context, social, political and cultural values. It is essential in collecting and analysing data to consider all aspects of positionality, since the researcher's various identities may influence research processes and findings (Brannick & Coghlan, 2007). The aim of the current study was to examine the effect of the FC approach on students' mathematical proficiency and self-efficacy in high school settings. Therefore, the researcher followed what Dwyer and Buckle (2009) have called "the space between." The latter paradigm states that all researchers are located somewhere between complete insiders and complete external subjects. Dependent on the circumstances of a certain study effort, researchers are likely to take up different areas. In the current research, the participating schools and teachers participated voluntarily and had no previous relationship with the researcher. However, the researcher of this study is a mathematics teacher in a Saudi public school (not involved in the study), and has experience of the Saudi context and the study environment is therefore very familiar. The researcher shares the same culture and faith as the teachers and the students, so she understands and respects them, taking their cultural values into consideration (Unluer, 2012). In these respects, the researcher can be considered as an insider of the study setting.

The researcher's position as an insider has benefited the research in terms of applying the research method and eliminating challenges. For example, being an insider to the research can increase participants' trust in the researcher, which can contribute to improved access and approval by participants (Dwyer & Buckle 2009). If the researcher is perceived as an insider, participants may feel more secure about the ability of the researcher to reflect their past, so that participants are more likely to participate in the study (Unluer, 2012). This feature helped the researcher gain access to the schools and be accepted by teachers in the district. Furthermore, being inside the situation provided a great opportunity to see, analyse and integrate all the learning facets, which allowed the researcher to connect all the small elements together and build a clear image of all the different study factors. All schools' administrators were at hand to help the researcher to gain access at any time during the school day, to smooth data progress and provide any assistance needed.

Nevertheless, positioning as an insider poses drawbacks for the method of study. It is likely that researchers in such a position could have difficulty separating their own experience from those of study subjects, and they may have to confront questions about potential bias in their research, since they already think they know something about the topics and subjects they are exploring (Brannick & Coghlan, 2007). During data collection, study and interpretation, a researcher cannot remain entirely unbiased (Cohen et al., 2011).

On the other hand, it should be noted that the researcher has been absent from teaching in Saudi schools, being a postgraduate student in the UK for five years. Having been in the UK for several years exposed the researcher to different ideas and practices about education, so that in this respect the researcher came to the research as an outsider. In addition, none of the schools, teachers and students involved in this study were in close contact with the researcher and the researcher was not a member of any of the participating schools. Over the experimental phase, the relationship of the researcher to the teachers and the school students developed progressively. The environment between them was relaxed enough that the participants could speak openly about their experience of the FC implementation. Thus, by thoroughly understanding the issues of positionality in all respects and bearing in mind the actual role of the researcher (Brannick & Coghlan, 2007; Dwyer & Buckle, 2009), the researcher was able to reflect as accurately as possible the experiences, opinions and outcomes of the participants, regardless of her own experiences, assumptions and expectations.

## 4.12 Challenges During the Current Study

Various challenges were faced by the researcher when designing and conducting this study. First, since the researcher designed the out-of-class activities, including video lectures, online quizzes and online resources, and designed suitable video lectures for the mathematics content for this study, all this took considerable time. It was necessary to learn how to design and edit educational videos, and how to deal with Moodle. During the design process, the researcher contacted some mathematics teachers to discuss the research aims with them and ask them if they were able to design the videos by themselves, but they were not very confident because of the increase in their workload and lack of time. Therefore, to encourage the participation rate and to keep the design consistent across different teachers, the researcher did everything herself.

Other challenges were related to the possibility that the lack of online learning experience could have deterred students from participating in out-of-class activities. To overcome this challenge, the researcher designed the out-of-class activities that were based on video lectures and online quizzes. This meant that they would be easy to deal with and would not require high technological competence, and so the researcher would not experience a problem with lack of technological skills on the part of the participants. Using the Moodle app helped to eliminate any further risks, such as students disliking the online experience and resisting using the online environment. Accordingly, some aspects of the current study design were received positively by participating students such as the idea that they could do their homework through their mobile phones, which gave the learning process great flexibility. In addition, the change in design of the homework, from solving multiple maths problems individually at home, as happened in the traditional teaching, to watching videos and answering multiple choice questions with immediate feedback, gave them a degree of confidence about their performance on the homework.

Additionally, there was a challenge that not all students had access to technology or an internet connection, which was a significant concern since the proposed design was highly dependent on them. However, since the participating students were of high school age, this helped to ensure that students at least had their own mobile phones to access the online learning. The researcher made sure that all students had devices such as a laptop, tablet or mobile phone and checked that they had an internet connection at home. Some students were provided with an internet card prepaid by the researcher for the duration of the study. However, in terms of the internet connection, the researcher still received complaints from some students regarding poor internet connection at home. This issue was beyond the researcher’s ability to control. The researcher served as an assistant for both teachers and students to overcome any challenges raised during the implementation process.

## 4.13 Data Analysis Procedures

Various analytical methods were used in this research to analyse the collected data. The open-source statistical package R and NVivo were used to facilitate the data analysis. The procedures used for analysing the quantitative and qualitative data are presented in the following sub-sections.

### *4.13.1 Quantitative data analysis*

Quantitative data analysis was conducted through a series of steps. The initial phase of the analysis was coding. Once the data had been collected from the mathematics pre and post-test, self-efficacy, students' perceptions questionnaires and the ICT survey, data reduction was carried out by quantitative data coding. All data collected was first transformed into numeric data format and entered into an Excel file. Analysis of quantitative data was done using R. Prior to this stage, the variables in this study were defined: FC approach (independent variable), self-efficacy, and mathematics proficiency (dependent variables). There were three sources of quantitative data in this study: the ICT survey, the mathematics pre and post-tests, self-efficacy questionnaires and students' perceptions survey. For the self-efficacy and students' perception questionnaires, each online survey was given an ID code by the researcher, which matched the participants' mathematics achievement tests. As the collected data was obtained in the form of Likert scales, the researcher used the ordinal data coding procedure, whereby each of the categories was allocated a value from 1 to 5. Prior to analysis taking place, the negatively worded item scores were reversed, and an average was taken of the respective sub-scales. Subsequently, descriptive analyses such as frequencies and percentages were conducted, including the mean and standard deviation for all data.

#### 4.13.1.1 Assumptions of the mixed effects model.

To identify the type of statistical test that was used to evaluate the data collected in this study, various concerns needed to be addressed. These included the type of study design, type of data (i.e., continuous, dichotomous or categorical), and the number of groups for comparison (Baayen et al., 2008). In dependent sample t-tests were used to compare the pre-test scores for the two groups. To test whether the intervention had a significant impact on mathematics proficiency and on self-efficacy. Based on the nature of the data in the current study, the statistical test best suited to analyse the data obtained was the mixed-effects model, which is a statistical model containing both fixed effects and random effects as predictor variables. The rationale behind using the mixed-effects model among other statistical tests was that the data was organised hierarchically, with students clustered within teachers, which were, in turn, clustered within schools. When data is organized hierarchically, the assumption of independence is typically violated, i.e., participants within a given cluster tend to be more similar to each other than to participants from different clusters. This assumption is particularly important, as ignoring it can lead to considerable overestimation of the precision of the measurements, and as a result, increase Type 1 error rate (i.e., the probability of assuming there is a difference when there is none). Mixed model analysis provides a general, flexible approach that takes into account dependency between observations caused by clustering (Bates et al., 2014). As such, Mixed model provides a more accurate estimate of intervention effect than would more traditional approaches (e.g., repeated-measures ANOVA) while minimizing Type 1 error rate (Singmann & Kellen, 2019).

To apply the mixed effect model, the R package LME4 was used to conduct this analysis (Bates et al., 2014). The assumptions of the mixed effect model were checked. There are main three assumptions that should be met for application of the mixed effect model, namely linearity, homogeneity of variance, and normality of residuals (Bates et al., 2014). None of the assumptions of the model was violated (full details in Appendix G).

Mixed-effects models were constructed, with post-test score as the dependent variable, condition (intervention vs control) and pre-test score as fixed factors, and, as random effects, intercepts for school and for teachers (nested within school). This analysis made it possible to minimize any baseline differences in the dependent variables between the two experimental groups, as well to consider the dependency caused by students being clustered within schools and teachers. The R package LME4 was used to conduct this analysis (Bates et al., 2014). Moreover, for both dependent variables, we explored whether the impact of the intervention differed for students with varying pre-test score by testing a second mixed-effects model including an interaction term, 'Pre-test score X Condition'. The researcher created a model using following command in R:

```
model. math = lmer (post. math ~ pre. math+ condition + (1|School/Teacher), data = data.t)
```

```
model. self = lmer (post. self ~ condition + pre. self + (1|School/Teacher), data = data.t)
```

This syntax uses the LME4 function to create a mixed-effects model (model. math, model. self) in which the dependent variables post. math and post. self are being analysed in terms of the independent variable, the fixed effect pre. math and condition. The next part of the formula (1|School/Teacher), specifies crossed random effects for participants (i.e. teachers) and schools, while the final part specifies which data frame is being analysed (Cunnings, 2012). All the code used presented in appendix G2. The impact of the intervention was measured using effect size (Cohen's d). Effect size helps to quantify the magnitude of group differences or relationships amongst variables in quantitative research (Cohen et al., 2011). This is used to determine the variance between two or more variables of the difference between group means. Cohen suggests that d=0.2 represents a ‘small’ effect size, 0.5 is a ‘medium’ effect, and 0.8 is a ‘large’ effect (Cohen et al., 2011).

### *4.13.2 Qualitative data analysis*

Qualitative data analysis is based upon an iterative process that involves repeatedly progressing backwards and forwards between data collection, analyses, interpretations, and reaching a conclusion based on the results (Grbich, 2012). First, the interview data was transcribed by the researcher, and was then organised into individual files and uploaded to the qualitative data analysis computer software program NVivo (Version 12). This program facilitates the process of organising, coding and reviewing the study data (Bazeley & Jackson, 2013). In order to understand teachers’ perceptions of their experience of the FC approach, thematic analysis, as described by Braun and Clarke (2006), was used for analysing the interview data. The following section presents the thematic analysis procedures in detail.

#### 4.13.2.1 Thematic analysis.

Thematic analysis is used to identify, analyse, and report data patterns (themes). It organises and describes the dataset in detail, but can frequently do much more, such as interpreting different aspects of the research (Grbich, 2012). A theme can have multiple aspects and will show an item of importance in the data, which is connected to the research question. Thematic analysis can be used to identify data patterns or themes in one of two primary ways: a theoretical or deductive “top down”, or an inductive, “bottom up" way. In the former, concepts are identified from the research questions and literature and used to categorize the data. This provides a useful starting point and facilitates consistency of interpretation, but may distort the data or fail to capture fully participants' perceptions and experiences. An inductive approach identifies themes that have a strong link to the data. Inductive analysis codes the data without trying to fit it into the researcher's analytic preconceptions or a pre-existing coding frame (Braun & Clarke, 2006). In order to benefit from the strengths of each approach, in the current study, both deductive and inductive approaches were used in a complementary manner for interview data analysis, as explained more fully below.

The data from the semi-structured interviews was analysed by following six main phases identified by Braun and Clarke (2006). For these phases to be applied in this study, the first stage was for the researcher to become familiar with the data. The researcher immersed herself in the data by first listening to the audio recordings and then transcribing each interview and each interview file was electronically saved into NVivo. The interview data was analysed on the original untranslated transcripts. The researcher began by reading the transcripts, commenting, and highlighting notable quotes, while reading and rereading the interview data analytically and critically. The second phase was coding, a method to reduce the data volume that involves selecting and labelling important segments from lines, phrases or paragraphs in the transcript of collected data (Grbich, 2012). The researcher first coded deductively and then inductively for the full dataset. In the deductive coding, the researcher started with a predefined set of codes derived from the literature and existing knowledge and applied them to the interview data. Other codes that were identified inductively in the dataset provided additional details and interpretations of why and how the features identified in the deductive coding operated in the context of those teachers' experience.

The process involved constructing semantic (explicit) or latent (interpretative) codes through looking at the segments of data (Braun & Clarke, 2006). All of the generated codes were semantic. For example, the code "Enriching Practice" was derived from teachers' language, such as when one teacher said, "a mathematician, ...it is an important part of maths to practise what they have watched and understand the content better". Additionally, the code "students' lack of motivation'' captured a concern indicated by teacher A when she mentioned that "We used to take our education seriously, but today you feel like the students come to school to have fun and to make friends. Some students do not even have real goals; they come to school because their parents want them to do so". Certain codes referred to substantial segments of data, while others only referred to a single line. The researcher constantly coded and recoded each data item that could be important for the research questions (Braun & Clarke, 2012). Systematic coding continued until the data for each interview was completely coded. The next stage was developing themes that capture important aspects of the data and present patterns or meaning in the dataset (Braun & Clarke, 2006). Therefore, after the coding process had been completed, the assigned codes were reviewed to recognize patterns, similarities and overlaps between codes. Many codes were organised into subthemes. This phase finished with a set of nominee themes and the researcher's sense of the relationship between themes, where together they told a coherent story about how teachers saw their experience of the FC implementation in high school settings.

The following stage was reviewing the themes and checking them. Two types of verification were used when checking the themes. The first considered whether the themes correctly represented the coded data with respect to the research questions; the second considered whether the themes were implemented consistently in the whole of the dataset (Baurn & Clark, 2014). Thus, the researcher read each theme's extracts, first, to ensure that a coherent pattern was formed and second, to ensure that the themes had meaningful, mutual relationships and were independent of each other. As a result, some specific codes were relocated under another theme. For example, in the theme, the advantage of FC, the two codes "support for lower achievers" and "stretching higher achievers", were first located under the active learning sub-theme. Then after more consideration, they were moved to the differentiated learning sub-theme. This is because the coded extracts of data for the code more clearly represented an aspect of the differentiated learning sub-theme.

This stage also involves defining and naming themes. It was very important for each theme to have a specific intent and scope and for all the themes presented together to create a valuable narrative tale. Four main themes were identified, reflecting the teachers' perceptions of the FC teaching approach. The final stage was writing-up the final qualitative report. Both descriptive and conceptual styles were used by the researcher to generate the analysis, as well as an analytical discussion. Data was used in some places in an illustrative way, while other data required more detailed discussion and a clear interpretation of the meanings constituted by the data. In the latter, the researcher tried to build an argument that attempted to illuminate how teachers perceived their experience with the FC approach. Accordingly, the final themes are illustrated with extensive quotations (raw data), which were selectively translated into English for citation purposes in the results chapter in order to add authenticity.

## 4.14 Summary

This chapter has described the tools and methods used for gathering data to deal with the study problems and to fulfil the goals of these research. The underlying pragmatic philosophical stance was elaborated, accompanied by a brief empirical description of the qualitative and quantitative dimensions of mixed methods approach. An experimental design was adopted to collect quantitative data about students' mathematical proficiency, self-efficacy and perceptions. Furthermore, qualitative data were obtained in the form of interviews with the teachers to examine their experience with the FC implementation. Finally, the validity, reliability, and ethical concerns have been shown to be essential components of the nature of the study. The next two chapters will shed light on the interpretation of the data along with the results of the study.

# Chapter 5 : How did the FC affect mathematics proficency and self-efficacy?

Drawing upon the quantitative data gathered in this mixed methods study, this chapter addresses the following two research questions:

(1) How does mathematical proficiency compare between students who learn mathematics with the flipped class model and students who learn mathematics with the traditional class model?

(2) How does self-efficacy compare between students who learn mathematics with the flipped class model and students who learn mathematics with the traditional class model?

The following sections will describe the results related to each research question in detail. It is worth pointing out that there was no attrition in the samples during the study (i.e., none of the students in the intervention or control group dropped-out of the study between the pre and post measures). Also, important, participation in the out-of-class activities was high: on average, students in the intervention group accessed 83% of the videos and completed 90% of the quizzes. That being said, the researcher noted a sligh decrease in the level of engagement of the students between the beginning and the end of the study: a comparison of the first and second halves of the intervention revealed a significant decrease in video access (from 88% to 78%, t(141) = 38.15, p < .001) and in quiz completion (from 92% to 86%, t(141) = 59.01, p < .001).

## 5.1 RQ 1: How does mathematical proficiency compare between students who learn mathematics with the flipped class model and students who learn mathematics with the traditional class model?

Comparison of the mathematics pre-test scores between the two groups, the flipped pre: M = 16.51, and the traditional groups pre: M = 15.84, suggested no floor or ceiling effects. As shown in Table 5.1, mathematics proficiency at the pre-test did not differ between groups (t(279) = 1.11, p = .267), suggesting that both groups were of comparable ability prior to the FC implementation. Thus, the two groups had a similar level of mathematics knowledge before the experiment was conducted. Performance in the post-mathematics test was, for the flipped group; M = 21.01, and for the traditional group, M = 19.99. Both groups improved their overall scores in the post-test; however, the flipped group improved more than the traditional group. Thus, the intervention group had higher overall scores than the control group in their post-mathematics proficiency test (as shown in Table 5.1 and figure 5.1). As assumed when estimating the required sample size, students' mathematics performance in pre and post-tests was strongly correlated r(280) = 0.75, p <. 001. The post-test mean score of the intervention group (M= 21.01) was slightly higher than that of the control group (M= 19.99)

Table 5-1 Descriptive statistics of the pre and post-tests between the two groups

| Time | Groups | N | M | SD |
|---|---|---|---|---|
| Pre-test | Flipped | 142 | 16.51 | 5.16 |
| | Traditional | 139 | 15.84 | 4.85 |
| Post-test | Flipped | 142 | 21.01 | 6.50 |
| | Traditional | 139 | 19.99 | 5.95 |

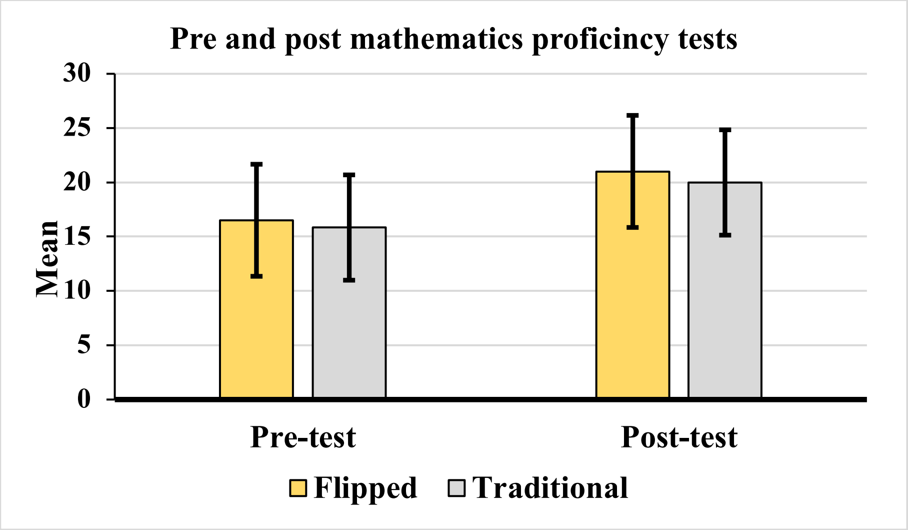


Figure 5-1 Comparison of average mathematics proficiency scores of the two groups on pre and post-test. Error bars represent SD.

To test whether the FC had a significant impact on mathematics proficiency, mixed-effects models were constructed, with post-test score as the dependent variable, condition (flipped vs traditional) and pre-test score as fixed factors and as random effects, intercepts for school and for teachers (nested within school). The impact of condition, the parameter of interest, was not statistically significant in our mixed-effect model: $t(275.05) = 0.801$, $p = .424$ (see Table 5.2 for a full list of coefficients). The difference between the two groups on the post-test corresponded to a standardized effect size of 0.06 SDs. Effect sizes were computed by dividing the adjusted mean difference (unstandardized beta representing difference of condition means) by the SD of the outcome computed from raw data (Baguley, 2009). To explore if the impact of the intervention differed for students with varying pre-test scores, a second mixed-effects model including an interaction term, 'Pre-test score X Condition', was run. This analysis enabled us to minimize any baseline differences in the dependent variables between the experimental group and the control group, as well as to consider the dependency caused by students being clustered within schools and teachers. The interaction was not statistically significant. Therefore, there was no evidence that the FC had an effect on improving students' mathematical proficiency.

Table 5-2 Regression analysis for the post-test between the two groups.

| | Maths achievement (post-test) | | |
|---|---|---|---|
| Predictors | Estimates | CI | p |
| (Intercept) | 5.28 | 3.56 – 7.00 | <0.001 |
| Condition [intervention] | 0.4 | -0.57 – 1.37 | 0.423 |
| Pre-test | 0.93 | 0.83 – 1.03 | <0.001 |
| | | | |
| Random Effects | | | |
| $\sigma^2$ | 17.13 | | |
| $\tau_{00\ \text{School:Teacher}}$ | 0 | | |
| $\tau_{00\ \text{School}}$ | 0.11 | | |
| $N_{\text{School}}$ | 4 | | |
| $N_{\text{Teacher}}$ | 5 | | |
| Observations | 281 | | |
| Marginal $R^2$ / Conditional $R^2$ | 0.562 / NA | | |

### 5.1.1 Testing the difference between the two groups on each sub-component of the post-test

Since the post-test was comprised of five topics, the researcher explored how the performance of the two groups (experimental and control) differed on each sub-component of the post-test. As shown in Table 5.3, the group scores were similar across the sub-components; none was statistically significant after correcting for multiple comparisons.

Table 5-3 Average performance of both groups on each sub-component of the post-test.

| Sub-component | N. of questions | Flipped group | Traditional group |
|---|---|---|---|
| Arithmetical operations with rational expressions | 6 | 4.27 (1.59) | 4.23 (1.65) |
| Reciprocal and rational functions | 8 | 5.59 (1.97) | 5.32 (1.76) |
| Direct and inverse variation | 5 | 3.63 (1.32) | 3.24 (1.31) |
| Equations and inequalities | 4 | 2.61 (1.18) | 2.44 (1.05) |
| Arithmetical and geometric sequences | 7 | 4.90 (2.14) | 4.76 (2.23) |

*Note.* Numbers in parenthesis are standard deviations.

### 5.1.2 Testing the impact of the intervention by teacher

Since this study included different teachers, the analysis also explored the impact of the intervention by the teacher. Figure 5.2 shows that for all the teachers except one (Teacher B), the group receiving the intervention obtained a comparable or higher post-test score than the control group. Although this should be interpreted with caution, excluding Teacher B from the analysis revealed a significant impact of the intervention (t(214.15) = 2.719 p = 0.007), and a moderate effect size (0.37 SDs; 95%CI: 0.10 to 0.63).

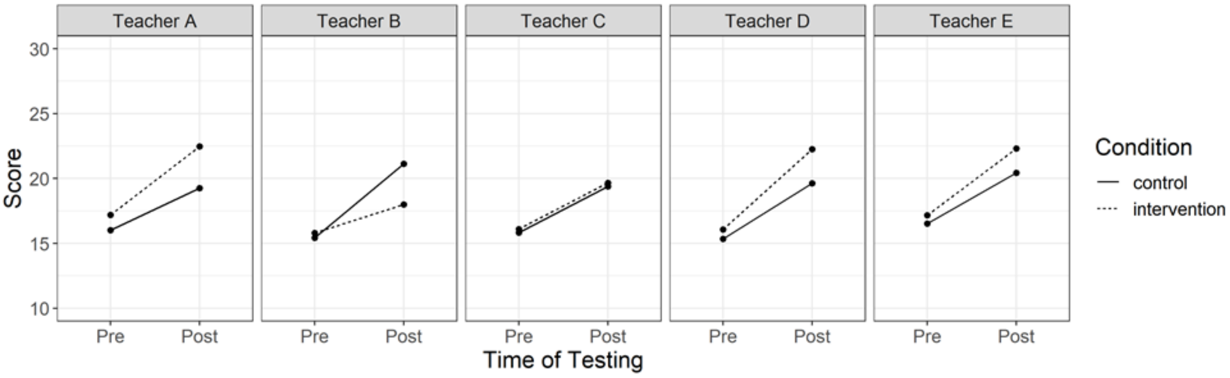


Figure 5-2 Pre and post-score test mathematics proficiency scores of students in the experimental and control conditions by teacher.

This suggests the possibility that teacher and/or school effects impacted the performance of class B, and that the result counteracted the improvement in the other four classes, to produce the non-significant result for the experimental group as a whole. Factors potentially explaining this result will be discussed in later chapters.

### *5.1.3 Comparing the effect of the intervention between the high and low achievers among the experimental group.*

Another area explored was whether the intervention produced greater gains in high than in low achievers. To do this, we first categorised participants into low, average and high achievers based on their performance on the pre-test. Low achievers were defined as students in the lower quartile of the distribution, High achievers were the students in the highest quartile, and average students were any participants in the second and third quartiles. Comparison of pre-test post-test gain between Low and High achievers did not reveal any significant difference (High: M=3.14, SD=3.35; Low: M= 3.67, SD=4.48, t (70) =.565, p=.528) suggesting that the intervention was equally beneficial for both ability groups, see Table 5.4.

Table 5-4 Descriptive results for comparing pre-post gain between high and low achievers in the intervention group.

| | | M | SD | t | p |
|---|---|---|---|---|---|
| Achievement Gain | High Achiever | 3.14 | 3.35 | .565 | .574 |
| | Low Achiever | 3.67 | 4.48 | | |

Overall, the results indicate no significant differences in the students' performance on the mathematical proficiency test between the flipped group, compared to the traditional group, although the students in the FC performed slightly higher than the traditional group. However, the possibility was considered that teacher and /or school effects had an impact, since students in class B performed less well in the flipped condition than in the other four classes.

## 5.2 RQ 2: How does self-efficacy compare between students who learn mathematics with the flipped class model and students who learn mathematics with the traditional class model?

Another goal for this study was to examine whether there was any significant difference in self-efficacy between the intervention group (FC) and the traditional classroom, prior to and after the implementation period. The descriptive test is first compiled and followed by the test of significance. In this case, a mixed effect model is used to examine changes in the students' self-efficacy scores between the compared groups. The self-efficacy scale consisted of two main subcomponents, namely, mastery experience and social persuasion. In the analysis of the self- efficacy results, these are analysed separately, since this contributed to more detailed or fine-grained analysis.

### *5.2.1 Comparing the students' self-efficacy scores before the experiment*

When both groups were asked to respond to statements that reflected their mathematics self-efficacy, a considerable agreement with particular statements was found. These are presented in Table 5.5 and include 'I have always been successful with maths', with a mean score of 3.87(.917), of out of five. This was followed by 'I do well on maths assignments' 3.77(.98), and 'I have always been successful with maths' 3.87(.917). The lowest degree of agreement has been observed for the statement 'I have been praised for my ability in maths', with a mean score of 2.38(1.30). Comparing the responses between the two groups, in general, the traditional group had high responses in eight out of twelve statements, while the flipped group had high responses on the other four statements. Looking at the subcomponents of the self-efficacy scores, both groups had similar scores on the mastery experience subscale, while on the social persuasion subscale, the traditional group outperformed the flipped group and had higher scores in five statements out of six, compared to the flipped group. Comparing the overall means for both groups, the mean score for the traditional group was 3.41(0.15), while that for the flipped group was 3.39(0.13). Table 5.7 shows a comparison of the flipped and traditional students before the intervention.

Table 5-5 Descriptive statistics of both group responses to the items of the students' Mathematical Self-Efficacy Questionnaire before the experiment.

| Items | Flipped group Mean (SD) n=142 | Traditional group Mean (SD) n=139 |
|---|---|---|
| I make excellent grades on maths | 3.69(1.08) | 3.71(.96) |
| I have always been successful with maths | 3.92(.94) | 3.83(.88) |
| 3. Even when I study very hard, I do poorly in maths | 3.33(1.30) | 3.30(1.30) |
| 4. I got good grades in maths on my last report card | 3.56(1.32) | 3.52(1.37) |
| 5. I do well on maths assignments | 3.70(1.01) | 3.83(.94) |
| 6. I do well on even the most difficult maths assignments | 2.83(.96) | 2.96(1.00) |
| 7. My maths teachers have told that I am good at learning maths | 3.42(1.21) | 3.50(1.11) |
| 8. People have told me that I have a talent for maths | 3.24(1.15) | 3.63(1.15) |
| 9. Adults in my family have told me what a good maths student I | 3.45(1.20) | 3.51(1.20) |
| 10. I have been praised for my ability in maths | 2.51(1.33) | 2.26(1.25) |
| 11. Other students have told me that I'm good at learning maths | 3.47(1.15) | 3.56(1.16) |
| 12. My classmates like to work with me in maths because they think I'm good at it | 3.36(1.13) | 3.37(1.22) |
| Overall | 3.39(0.13) | 3.41(0.15) |

The comparison between the flipped and traditional students prior to the FC implementation is illustrated in Table 5.7 and Figure 5.3 in the next section, 5.2.2. There was no significant difference between the self-efficacy scores of the two groups at baseline (t(279) = -0.2, p = .842), suggesting that both groups had comparable levels of self-efficacy at the beginning of the study. Again, as expected, students' self-efficacy scores at pre- and post-tests were highly correlated r(280) = 0.83, p < .001, as shown in Table 5.7.

### *5.2.2 Comparing students' self-efficacy scores at the end of the experiment*

After the implementation of the intervention, the FC group displayed a significant increase in self-efficacy, as demonstrated in Table 5.6 (below). The increase in the FC students' self-efficacy was observed in all statements in both sub-components of the self-efficacy scale, 'mastery experience' and 'social persuasion'. The overall score was higher in the FC group, 3.73(0.13), than in the traditional instruction group, 3.48(0.16). The statements that obtained the higher scores in the mastery experience component were 'I have always been successful with maths', where the mean score for the flipped group was 4.07(.950), compared to 3.84(.84) for the traditional group; 'I make excellent grades on maths', with a mean score of 4.00(1.06) for the flipped group and 3.85(1.06) for the traditional group; and 'I do well on maths assignments', where the mean score was 4.01(.956)for the flipped group and 3.94(.85)for the traditional group. In the meantime, the statement that received the lowest degree of agreement, was 'I do well on even the most difficult maths assignments', where the mean score was 3.24(1.05) for the flipped group, and 3.17(1.12) for the traditional group. Moving to the social persuasion component, two statements obtained the highest level of agreement, namely, "My maths teachers have told that I am good at learning maths", where the mean score for the flipped group was 3.82(1.16), compared to 3.58(1.21) for the traditional group and "Other students have told me that I'm good at learning maths", where the mean score for the flipped group was 3.81(1.17), compared to 3.50(1.07) for the traditional group. The least agreed with statement was 'I have been praised for my ability in maths', where the mean score was 3.11(1.40) for the flipped group, and 2.35(1.25) for the traditional group. Whereas the flipped group showed a fairly consistent increase in scores across all items compared to the pre-test, the traditional group showed more variability, with increases (albeit often small) on some items, but scores slightly lower than in the pre-test for items 8, 9, and 11.

Table 5-6 Descriptive statistics of both groups' responses to the items of the students' Mathematical Self-Efficacy Questionnaire at the end of the experiment (n=281).

| Items | Flipped group Mean (SD) n=142 | Traditional group Mean (SD) n=139 |
|---|---|---|
| 1. I make excellent grades on maths | 4.00(1.06) | 3.85(1.06) |
| 2. I have always been successful with maths | 4.07(.950) | 3.84(.84) |
| 3. Even when I study very hard, I do poorly in maths | 3.72(1.23) | 3.45(1.32) |
| 4. I got good grades in maths on my last report card | 3.81(1.29) | 3.60(1.39) |
| 5. I do well on maths assignments | 4.01(.956) | 3.94(.85) |
| 6. I do well on even the most difficult maths assignments | 3.24(1.05) | 3.17(1.12) |
| 7. My maths teachers have told that I am good at learning math | 3.82(1.16) | 3.58(1.21) |
| 8. People have told me that I have a talent for maths | 3.77(1.11) | 3.59(1.13) |
| 9. Adults in my family have told me what a good maths student I | 3.73(1.18) | 3.45(1.17) |
| 10. I have been praised for my ability in maths | 3.11(1.40) | 2.35(1.25) |
| 11. Other students have told me that I'm good at learning maths | 3.81(1.17) | 3.50(1.07) |
| 12. My classmates like to work with me in maths because they think I'm good at it | 3.68(1.18) | 3.50(1.15) |
| Overall | 3.73(0.13) | 3.48(0.16) |

Table 5-7 Comparison of Average Self-Efficacy Score of Both Groups on Pre- and Post-Test.

| Time | Groups | N | M | SD |
|---|---|---|---|---|
| Pre-test | Flipped | 142 | 40.74 | 9.70 |
|  | Traditional | 139 | 40.96 | 9.11 |
| Post-test | Flipped | 142 | 44.84 | 10.02 |
|  | Traditional | 139 | 42.10 | 9.77 |

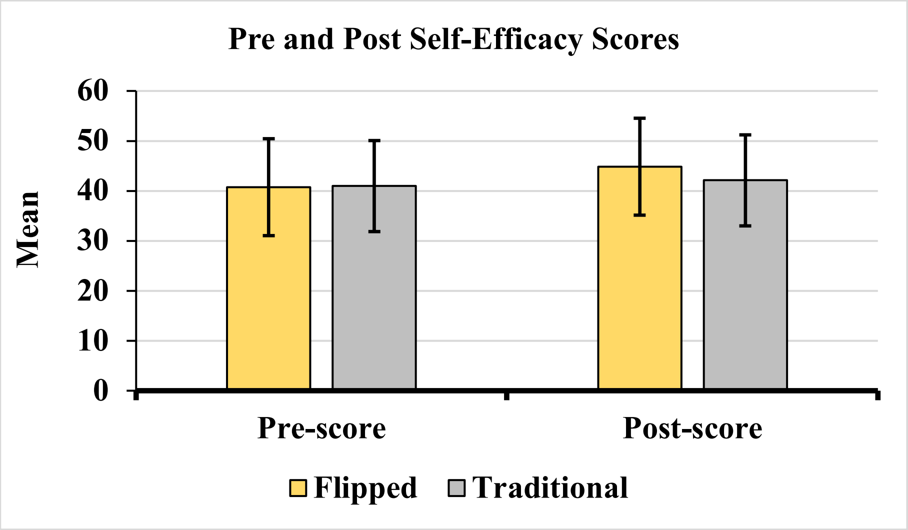


Figure 5-3 Comparison of Average Self-Efficacy Score of Both Groups on Pre- and Post-Test. Error bars represent SD.

To test the significance of the differences, a mixed effects model was used. The model included the post-intervention self-efficacy score as the dependent variable and fixed effects: the pre-intervention self-efficacy score and condition as independent variables. Random effects were intercepts for school and for teachers nested within school. The analysis revealed that students in the intervention group had higher levels of self-efficacy than students in the control group: $t(274.05) = 4.75$, $p < .001$ (see Table 5.8 for the full list of coefficients of the mixed model). Both fixed effects were significant ($p<0.001$), so the researcher assume that changes of pre-intervention self-efficacy score and different levels of the condition variable are associated with changes in the dependent variable. The researcher may assume, now, that the post self-efficacy score variable has a linear relationship with condition. The standardized difference between the self-efficacy of the two groups corresponds to an effect size d = 0.30 SDs, suggesting that FC can increase students' self-efficacy. To explore whether the intervention's impact on self-efficacy was influenced by the students' initial level of self-efficacy, the model was re-tested including the interaction term 'Pre-test score X Condition'. The interaction was not statistically significant, showing that the intervention group had higher levels of self-efficacy than the traditional group.

Table 5-8 Regression analyses for the post self-efficacy test.

| | Self-efficacy (post-test) | | |
|---|---|---|---|
| Predictors | Estimates | CI | p |
| (Intercept) | 6.17 | 3.03 – 9.32 | <0.001 |
| Condition [intervention] | 2.97 | 1.74 – 4.19 | <0.001 |
| Pre-test | 0.88 | 0.81 – 0.94 | <0.001 |
| Random Effects | | | |
| $\sigma^2$ | 27.34 | | |
| $\tau_{00\ \text{School: Teacher}}$ | 1.01 | | |
| $\tau_{00\ \text{School}}$ | 1.16 | | |
| $N_{\text{School}}$ | 4 | | |
| $N_{\text{Teacher}}$ | 5 | | |
| Observations | 281 | | |
| Marginal $R^2$ / Conditional $R^2$ | 0.703/0.725 | | |

In addition, the results showed how the performance of the two groups differed on each sub-component of the self-efficacy scale. As shown in Table 5.9, the flipped group outperformed the traditional group in both of the self-efficacy components.

Table 5-9 Descriptive Results for Students' Post-Self-Efficacy by Scale.

| Subcomponent | N. questions | Flipped group | Traditional Group |
|---|---|---|---|
| Mastery Experience | 6 | 22.85 (5.27) | 21.84 (5.21) |
| Social persuasion | 6 | 21.92 (5.62) | 19.96 (4.86) |

*Note.* Numbers in parenthesis are standard deviations.

### 5.2.3 *Testing the impact of the intervention by teacher*

As shown in Figure 5.4, a teacher-by-teacher analysis shows that for all the teachers except one (Teacher C), the group receiving the intervention obtained a higher post-self-efficacy score than the control group.

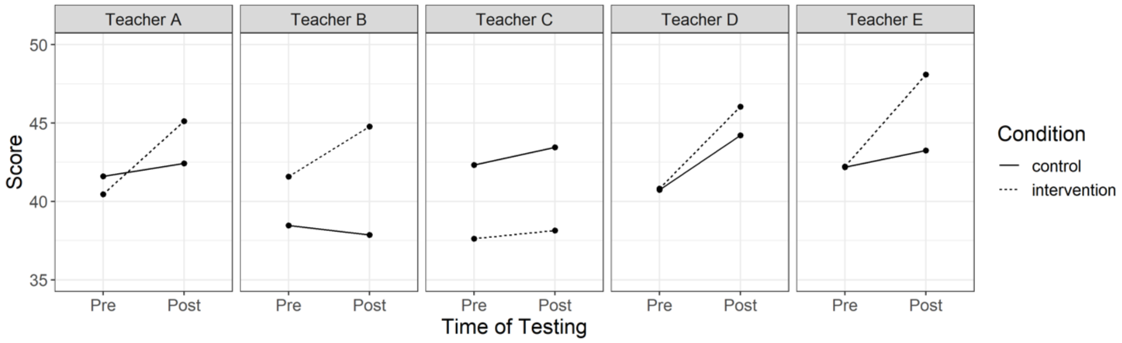


Figure 5-4 Pre- and post-score self-Efficacy scores of students in the experimental and control condition by teacher.

The decline in self-efficacy among teacher C's group raises the possibility of teacher effects, or differences between students of this and other classes, which will be addressed further in Chapter 6.

### 5.2.4 *Comparing the effect of the FC intervention on the high and low self-efficacy students in the experimental group.*

We also explored whether the intervention produced greater gains in students with high than in low self-efficacy students. To do so, the researcher first categorised participants into low, average and high self-efficacy based on their performance on the pre-intervention self-efficacy scale. Low self-efficacy students were defined as students in the lower quartile of the distribution, students with High self-efficacy were the students in the highest quartile, and average students were any participants in the second and third quartiles. Comparison of pre-test post-test gain between Low and High self-efficacy students showed a significant difference (High: M=1.19, SD=3.75; Low: M= 6.64, SD=9.72, t (70) =3.133, p=.003) as shown in Table 5.10, suggesting that students who start with low self-efficacy may benefit from the intervention of the FC.

Table 5-10 Descriptive results for comparing high and low students' self-efficacy in the intervention group.

| | | M | SD | t | p |
|---|---|---|---|---|---|
| Self-efficacy Gain | High Self-efficacy | 1.19 | 3.75 | 3.133 | .003 |
| | Low Self-efficacy | 6.64 | 9.72 | | |

Overall, the results showed that there was a significant difference in the students' self-efficacy scores between the flipped group and the traditional group. These results suggest that the FC instructional approach could improve students' self-efficacy. In addition, the results showed that the students who started with a low level of self-efficacy tended to finish the implementation with higher scores compared to their peers with higher initial self-efficacy.

## 5.3 Summary

This chapter has presented analyses examining the effect of the FC intervention on students' mathematics proficiency and self-efficacy. Overall, the findings of this study showed a significant improvement in the students' self-efficacy in the FCs, compared with those in traditional classrooms. Furthermore, the data suggested that students who start with low self-efficacy may obtain a particular benefit from the intervention. Although students' mathematics proficiency showed no significant difference, overall, between students who learned maths with the implementation of FC instruction and their peers taught in the traditional approach group, there was clearly no sign that it was harmful, which is promising. Moreover, comparison at the teacher level showed significant improvement for four of the five participating teachers, raising the possibility that the post-test performance was influenced by teachers or differences among students. Chapter Seven will present a detailed discussion of all of these findings. First, however, the perception findings from students and teachers' interviews will be presented.

# Chapter 6 : Students' and teachers' perceptions of their experience of the FC implementation

Whereas the aim of the quantitative data presented in the previous chapter was to investigate the effect of the FC instructional approach on students' mathematical proficiency and self-efficacy, this chapter sets out to evaluate the FC implementation based on the perceptions of the students' questionnaires feedback and teachers' interviews. Hence, the first section of this chapter presents the findings of the students' perceptions towards their experience of the FC approach; this questionnaire was only distributed to the intervention group. Then, the semi-structured interviews were conducted with the five participating teachers, who were interviewed after the intervention was completed, to elicit theirs views on their experience with teaching in the FC, to interpret the quantitative findings and to identify the possible advantages and challenges of the FC design adopted in this study. Therefore, the qualitative study aimed to offer a more in-depth analysis of the issues to highlight the impact of the FC instruction on students' learning, and teachers' willingness and perceived ability to implement it in the future. At the end of this chapter, the researcher presents evaluation of the FC implementation. The analysis of implementation processes aims at answering questions such as why the implementing variability exists, how settings' characteristics and the participants interact with intervention's characteristics, how the factors improve or prevent implementation within a real-life setting.

## 6.1 RQ3: What are the participating students' perceptions toward their experience in learning mathematics with the flipped class model?

In this part of the study, an examination of the students' perceptions of their experience with the FC is presented, and carried out after the period of teaching for the flipped group. The questionnaires were designed to capture perceptions on two key dimensions: flipped video and flipped class. The agreement levels (strongly agree and agree) with individual statements were grouped under the term agree and the disagreement levels (strongly disagree and agree) were grouped under the term disagree. The following sections will discuss these dimensions in full.

### *6.1.1 Students' perceptions of the video lectures*

Students were asked for their opinions about their perceptions of learning from video lectures at home to prepare themselves for in-class activities. This scale used 19 items comprising four sub-scales: (a) video preference (three items), (b) video value (seven items), (c) technical aspects of accessing videos (six items) and (d) viewing frequency (three items) adopted from Sletten (2015).

The results indicated that students generally had positive perceptions toward their experience of learning from video lectures. This can be evidenced by the overall score of the scale, which was (M=3.95 out of 5, SD=0.12). Generally, responses to the videos were favourable; no item had a mean less than 3 and 9 items had means higher than 4. The statements which received the highest agreement were: 'I like the fact that I can re-watch lectures any time so I can gain a deeper understanding of the material' and 'The ability to rewind the video lecture helps me learn', from the value of the video subscale (M= 4.48 out of 5, SD= 0.87 and M=4.41 out of 5, SD= 0.81, respectively). Regarding the more technical aspects of FC, the strongest average agreement was found on the statement, "The video lectures for this course are easy to use" (M= 4.11 out of 5, SD= 1.09). However, almost half of the students, 52.20%, indicated a neutral view (32.40%) or disagreement (15.50%) with the statement, "There are opportunities to ask questions on the assigned lecture if I need clarification on the material" (M= 3.61, SD= 1.06), suggesting that students might need more opportunities to interact with their teacher. In addition, nearly a third of the students indicated that they encountered technical difficulties when trying to watch the video lectures (M= 3.88, SD= 1.20). This could be attributed to problems with internet connection at home.

It is important to note that there was a high percentage of neutral responses to many of the items. Only five items had fewer than 10% neutral responses. For item 3, "I often wish lectures were during class time so I could better understand the material", more than a quarter of responses were neutral, and for item 12, "There are opportunities to ask questions on the assigned lecture if I need clarification on the material", approximately a third had neutral responses. By examining the students' perceptions sub-scales, it is clear that the Viewing Frequency subscale had the highest agreement level (79.30%) among students, followed by the Value of Video sub-scale (75.40%). Lower agreement was expressed towards the other sub-scales, Technical Aspects of Accessing Videos, and Preference for the Video, both of which got nearly the same percentage (69.70% and

65.40% respectively). In addition, the subscale, Preference for Videos had a high level of neutral responses. For full descriptive statistics, see Table 6.1 and Table 6.3 below.

Table 6-1 Students' perceptions of the flipped video.

| Statements | Agree | Neutral | Disagree | Mean | SD |
|---|---|---|---|---|---|
| | % | % | % | | |
| **Preference for video** | | | | | |
| 1-I prefer watching lectures on my own time over having | 68.30 | 21.80 | 9.80 | 4.04 | 1.11 |
| 2-I find watching lectures on my own is a better way to learn material than if lectures are during a class time. | 66.20 | 18.30 | 15.50 | 3.70 | 1.05 |
| 3- I often wish lectures were during class time so I could better understand the material. | 61.90 | 27.50 | 10.60 | 3.70 | 0.96 |
| Value of video | | | | | |
| 4-I enjoy being able to view the lecture prior to class as opposed to live in-class lectures. | 69.00 | 16.20 | 14.80 | 3.81 | 1.05 |
| 5-I find that individual access to lectures has increased my desire to learn the material | 61.20 | 21.10 | 17.60 | 3.65 | 1.04 |
| 6-Video lectures greatly enhance my learning. | 76.80 | 16.20 | 7.00 | 4.12 | 0.92 |
| 7. I like the fact that I can re-watch lectures any time so I can gain a deeper understanding of the material. | 88.70 | 4.20 | 7.00 | 4.48 | 0.87 |
| 8. The ability to rewind the video lecture helps me learn. | 90.10 | 4.20 | 5.60 | 4.41 | 0.81 |
| 9-I find it easy to take notes while I watch the video lectures. | 67.60 | 16.90 | 15.50 | 3.82 | 1.04 |
| 10-The ability to rewind the video lecture helps me take notes on the material. | 74.7 | 16.90 | 8.50 | 4.08 | 0.96 |
| **Technical aspects of accessing videos** | | | | | |
| 11-I am able to ask questions on the assigned lecture during class time. | 72.50 | 20.40 | 7.00 | 3.99 | 0.95 |
| 12-There are opportunities to ask questions on the assigned lecture if I need clarification on the material | 52.20 | 32.40 | 15.50 | 3.61 | 1.06 |
| 13-I am comfortable using video lectures for learning. | 69.70 | 18.30 | 11.90 | 3.82 | 1.12 |
| 14-The video lectures for this course are easy to access. | 73.30 | 11.30 | 15.50 | 4.01 | 1.19 |
| 15. The video lectures for this course are easy to use. | 78.20 | 7.70 | 14.10 | 4.11 | 1.09 |
| 16-I encounter technical difficulties when trying to watch the video lectures for this course. | 71.80 | 7.00 | 21.10 | 3.88 | 1.20 |
| **Viewing frequency** | | | | | |
| 17. I always watch the assigned lectures. | 72.50 | 19.70 | 7.70 | 3.94 | 0.98 |
| 18. I usually rewind and re-watch parts (or entire) lecture to study for this course | 85.30 | 9.90 | 4.90 | 4.37 | 0.92 |

| Statements | Agree | Neutral | Disagree | Mean | SD |
|---|---|---|---|---|---|
| | % | % | % | | |
| 19- I do not view the lectures before class although I am supposed to. | 80.30 | 12.70 | 7.00 | 4.23 | 1.01 |
| Overall | | | | 3.95 | 0.12 |

### *6.1.2 Students' perceptions of the flipped classroom*

In this part of the questionnaire, students were asked about their perceptions of in-class activities during the experimental period. This scale used 11 items reflecting different aspects of classroom activities.

Generally, responses to the flipped classroom were favourable; no item had a mean less than 3 and five items had means higher than 4. In line with the general trend, most of the students positively rated the two statements, 'I find that in-class activities make class more useful' (M= 4.27, SD= 0.89) and 'Interactive, applied in-class activities greatly enhance my learning' (M= 4.53, SD= 0.69). Most of the students also indicated that they either "strongly agreed" or "agreed" that they participated and engaged in in-class activities when the flipped classroom was implemented (33.80% and 46.50% respectively: combined 80.30%). Furthermore, a similar number of students indicated that they either "strongly agreed" or "agreed" that discussing with classmates helped them to learn (44.40% and 32.40% respectively; combined 76.80%). However, there was, again, a high level of neutral responses. Only one item had lower than 10% neutral, while item 9 had more than a third of students (37%) who were unsure about the statement, 'I find this class engages me in critical thinking and problem solving'. By examining the students' perceptions of the flipped classroom sub-scales, it is clear that nearly 80% of students appreciated the active learning opportunities offered by the implementation of the FC approach, while almost one-third were unsure of whether the flipped classroom enhanced their learning. For full descriptive statistics, see Table 6.2 and Table 6.3 below.

Table 6-2 Students' perceptions of the flipped classroom.

| Statements | Frequency (%) | | | Descriptive | |
|---|---|---|---|---|---|
| | Agree | Neutral | Disagree | Mean | SD |
| **Value of active learning** | | | | | |
| 1- I participate and engage in in-class discussions. | 72.50 | 19.70 | 7.70 | 3.96 | 0.97 |
| 2- I participate and engage in in-class activities. | 80.30 | 15.50 | 4.02 | 4.08 | 0.85 |
| 3- I find that in-class activities make class less boring. | 71.90 | 16.20 | 11.90 | 3.97 | 1.14 |
| 4. I find that in-class activities make class more useful. | 83.10 | 10.60 | 6.30 | 4.27 | 0.89 |
| 5- Discussing with classmates helps me learn. | 76.80 | 14.80 | 8.40 | 4.11 | 1.01 |
| 6. Interactive, applied in-class activities greatly enhance my learning. | 90.20 | 9.20 | 0.70 | 4.53 | 0.69 |
| 7. The teacher makes meaningful connections between the topics in the lecture videos and the in-class activity. | 73.90 | 16.20 | 9.90 | 3.98 | 0.99 |
| **Learning enhancement** | | | | | |
| 8. This course as a whole has been a valuable learning experience. | 81.00 | 10.60 | 8.40 | 4.20 | 1.04 |
| 9- I feel this class increases my engagement in collaborative decision-making | 64.80 | 25.40 | 9.80 | 3.84 | 1.06 |
| 10. I would take another flipped course. | 70.40 | 21.80 | 7.70 | 3.99 | 1.05 |
| 11- I find this class engages me in critical thinking and problem solving. | 57.10 | 37.00 | 5.60 | 3.80 | 0.96 |
| Overall | | | | 4.07 | 0.12 |

Table 6-3 Students' perceptions by sub-scale**.**

| **Dimensions** | **Subscale** | **Frequency (%)** | | | **Descriptive** | |
|---|---|---|---|---|---|---|
| | | Agree | Neutral | Disagree | Mean | SD |
| **Flipped video perceptions** | Preference for Video | 65.40 | 22.50 | 11.90 | 3.81 | 0.08 |
| | Value of Video | 75.40 | 13.60 | 10.80 | 3.78 | 0.15 |
| | Technical aspects of accessing videos | 69.70 | 18.30 | 11.90 | 3.90 | 1.10 |
| | Viewing Frequency | 79.30 | 14.10 | 6.50 | 4.18 | 0.05 |
| **Active learning perceptions** | Value of Active Learning | 78.39 | 14.60 | 7.01 | 4.13 | 0.14 |
| | Learning Enhancement | 68.33 | 23.70 | 7.88 | 3.96 | 0.05 |

Overall, the perceptions of the entire cohort of students showed a trend towards perceiving positive effects of the FC, as shown by their high level of agreement with the statement: ‘This course as a whole has been a valuable learning experience’ (81% of the students either agreed or strongly agreed with the statement, M= 4.20, SD= 1.04). Similarly, 70% of the students agreed or strongly agreed with ‘I would take another flipped course’ (M= 3.99, SD= 1.05). For full descriptive statistics, see Table 6.1 above. To conclude, the students demonstrated a tendency to view FC favourably. Students favoured the use of video lectures and their features to consolidate their mathematics learning. Students also appreciated the active learning opportunities offered by the implementation of the FC approach. However, some students indicated that they encountered technical difficulties when trying to watch the video lectures as a result of poor internet connection at home. In addition, they indicated that they might need more opportunities to interact with their teacher in the out of class activities.

## 6.2 RQ4: What are the participating teachers’ perceptions toward their experience of the FC model?

The five teachers (referred to as teacher A, B, C, D, and E) who participated in the interviews represented varying levels of experience and self-professed comfort with technology. They were all female, full-time high school mathematics teachers with a broad knowledge of teaching (from 7 to 18 years of teaching practice, mean = 12.4). Teacher C, who had 18 years of teaching experience, described herself as from the old school. Teachers A, B and D were quite similar in their teaching experience, with 14, 10 and 12 years, respectively. Teacher E had seven years of experience and expressed excitement for working with the FC and a conviction that there should be some changes in teaching mathematics to keep up with the student’ needs and the development in educational technology. None of the teachers was familiar with the FC and they had not previously implemented it in their teaching practice. Questions for teachers focused on the FC’s two primary components and the design principles that guided the study implementation. This included classroom routines and lesson planning, perceptions of instructional effectiveness, reflection on teaching and learning, the model’s main advantages, and the possible challenges. Four major themes were identified including: (1) the benefits of in-class activities in the FC; (2) the benefits of out-of-class activities in the FC; (3) general advantages of the approach; and (4) the challenges the FC presents. Table 6.4 illustrates the final themes of teachers’ interviews.

Table 6-4 Themes, categories and codes.

| Theme | Sub-themes | Codes |
|---|---|---|
| The benefits of in-class activities in the FC | Increased interaction | More time with students<br>Opportunities for more feedback<br>Encouraging group participation<br>Students-to-students communication |
| | Pre-assessment benefits for teachers | Checking students' understanding<br>Informing teachers' in-class activity design<br>Encouraging students' preparation |
| The benefits of out of class activities in the FC | The value of the videos | Facilitate understanding<br>Learning resources<br>Flexibility |
| | The benefits of online follow-up exercises | Enriching practice<br>Preparation for in-class activities |
| | The value of the learning management system | Tracking students' performance<br>Organizing out-of- class learning |
| General advantages of the approach | Increased active learning | Encouraging group learning<br>Encourage peer learning<br>Encouraging self-learning |
| | Differentiated learning | Support for lower achievers<br>Accommodating different learning needs<br>Stretching higher achievers |
| | Teaching efficiency | FC good to increase content coverage in maths<br>Comfortable teaching experience |
| Challenges to FC implementation | Student-related | Lack of student motivation<br>Lack of parental support |
| | Teacher-related | Increased workload<br>Lack of time<br>Lack of familiarity with the FC<br>Teachers' beliefs |

| Theme | Sub-themes | Codes |
|---|---|---|
|  | Resource-related | Poor internet connection<br>Lack of equipment(devices)<br>Unsuitability of some existing videos<br>Need support and training |

### *6.2.1 Theme 1: Benefits of in-class activities in the FC*

This theme explains the teachers' views of the possible benefits of the in-class activities in the FC classes. The theme includes two sub-themes, namely, increased interaction and pre-assessment benefits for teachers.

#### 6.2.1.1 Sub-theme: Increased interaction.

This sub-theme describes teachers' reflections on opportunities for increased interaction in the classroom environment, which could be facilitated by the implementation of FC instruction. Interaction in the classroom is defined as the form and content of behaviour or social relationship between teacher and students. Different types of interaction were considered an important part of the classroom process, including student-to-student interaction and student-to-teacher interaction. Generally, all five teachers indicated that the FC approach promoted more opportunities for different modes of interaction in the classroom. All teachers considered that moving direct instruction outside the classroom freed up class time, leaving more time for students and teachers to have discussions and interact with each other. They indicated that in the traditional classroom routine, teaching hours seemed to be insufficient for providing sufficient one-to-one assistance. For example, one teacher mentioned:

> FC helps me to free up the class time to engage with the students' questions... Instead of lecturing for 20 to 25 minutes, we start directly to work with activities. Students are able to participate in the class with peers and groups in a variety of activities (Teacher D).

Three teachers identified another factor that contributes to the increase of classroom interaction in the FC is that the FC approach encourages group participation and student-to student communication. The shift occurs when students attend class and collaborate.

This format encourages cooperative learning amongst students and helps them to learn the right answers as well as explain to peers why the answers are correct.

> Students frequently chat whilst they are working on their worksheets. When I walk around them, they’re chatting and working with their peers and they're teaching someone else how to do it, since they have exposure to the content before class (Teacher A).

> … but with the FC, we are doing things together as a group. Other students formed smaller groups and work together; they check their answers with each other (Teacher B).

> Re-teaching and additional explanations were provided to students based on need with the aid of me or other students (Teacher E).

Furthermore, teachers indicated that the culture of the FC allowed them to observe the learning in real time and have more facetime with their students, by allowing them to move around the room and provide one-to-one instruction and immediate feedback to students. As a result, four teachers reported finding opportunities to give more feedback, as they were available to support and communicate with the students during class time. As teacher A explained:

> The opportunity to give immediate and useful feedback for students. You know, going around students and seeing their work and commenting when possible. I feel my students are even more comfortable when asking questions because they know that I am not in a hurry and I have sufficient time to discuss (Teacher A).

In addition to the teachers being available to provide feedback to students, working with peers and groups empowered another form of peer-to-peer feedback. Teachers asserted that the in-class activities within the FC helped students to receive immediate feedback from peers because they are actively engaging with the content, as teacher E mentioned:

> From the first instant of entering the classroom, my students in my class seem engaged in dialogue and discussion about the content of the videos, they ask each other questions and I see a lot of them seeking help from others… if they need more clarification or if they want to share ideas on the mathematics problems that they usually work on during class, they usually do not ask me first. They prefer to ask their peers and if they [still] do not understand, they can ask me (Teacher E).

The overarching claim which can be gained from the sub-theme is that most teachers benefitted from the shift in the classroom environment by having enough class time to practise more mathematical content with students. The teachers appreciated the change in the classroom dynamic that gave students more opportunities to collaborate with peers and groups to further facilitate and consolidate their learning. The majority of teachers perceived that teaching in the FC helped them to be more approachable, offering more feedback opportunities for students, increasing constructive teacher individual feedback and student peer feedback, which they considered an essential element of improving the learning process. Consistent and regular feedback is crucial in order for new practices to be maintained and reinforced.

#### 6.2.1.2 Sub-theme: pre-assessment benefits for teachers.

This sub-theme represents the advantages for teachers of assigning pre-assessment activities at the beginning of the face-to-face session. Four teachers agreed that students would have varying levels of understanding and comprehension after having completed the out-of-class work. Therefore, teachers should assess their understanding before class time to help them approach their in-class activities. This could be achieved by designing a pre-assessment at the beginning of the face-to-face session, which could help them to check students' understanding of the content before the class session.

> For me, I think I like assessment and quizzes because it gave me an overview of how much students understand the materials presented in the video, you know... I used this technique in the traditional classroom as well, as it is important to recall the information before starting working on different activities in the class session (Teacher C).

> It [pre-assessment] saves my time; by doing so I can identify what every student knows, understands and is able to do with the upcoming class activities (Teacher B).

Three out of the five teachers identified another benefit that contributed to the essential role of having pre-assessment at the beginning of the class session. They indicated that this feature could help to inform their in-class design, since the design of the in-class activities was based on dividing the class into two groups, a *re-teaching group* and an *exploration group*. The students' performance on the pre-assessment would help teachers to divide students into the appropriate groups, which was easier for them than just depending on the students' performance in the out of class activities. For example, two teachers indicated:

> I think pre-assessment makes it easier for me to identify and divide students into two groups based on their understanding and quiz results. In addition, it

> helps me to manage the in-class activities better, based on their performance (Teacher A).
>
> It [pre-assessment] helps me to know how I will work with them through it by focusing my instruction. In addition, it helps to divide the students into the proposed groups and to identify which group will work together and which group I will lead, to re-teach them and ensure each one's individual performance (Teacher B).

Additionally, two teachers (C and E), indicated that this benefit was more likely to encourage students to prepare for the face-to-face session, than if they relied only on the students' performance on the out-of-class activities (video lectures and online quizzes). Although these are an important component of the FC, and should be adopted in any flipped classroom implementation to increase effectiveness, some students might not do them properly. As teacher E commented:

> Some students need some sort of supervision, so if they know that there will be a pre-assessment at the beginning of the class and this will be supervised by the teacher and have grades; this could encourage them to watch the video and answer the quiz in a more concentrated way, rather than just doing the pre-class activity hurry just to show me that they have done their homework (Teacher E).

Teacher A indicated that she usually displayed visual slides highlighting the key points of the videos before the pre-assessment, to refresh students' memories.

> I usually start sessions by presenting just like three to four slides of the main point of the videos so students can remember easily the video content and I found my students like this way (Teacher A).

To conclude, the teachers believed that pre-assessment should be an integral part of the FC implementation and they saw it as an important indicator of students' mastery of the lesson contained within the video. This helped them to manage the in-class activities based on the students' performance and understand the areas of misunderstanding among students before engaging in class activities. Additionally, designing pre-assessment with teacher attendance could encourage proper preparation by students.

### *6.2.2 Theme 2: The benefits of out of class activities in the FC*

This theme describes the teachers' views of the possible benefits of the out of class activities in the FC approach. This theme included three sub-themes: the value of the videos, the benefits of online follow-up exercises and the value of the learning management system to enhance students' learning.

#### 6.2.2.1 Sub-theme: the value of the videos.

Videos are considered one of the main aspects of the FC implementation. This sub-theme was prevalent among all the five participating teachers' interviews. All teachers agreed that video lectures in the flipped maths classroom play a vital role in enhancing student learning. Three main benefits were identified by teachers, including that video lectures facilitate students' understanding, that they are a good learning resource, and that they offer a flexible learning experience. All teachers agreed that video lectures could play an essential role in enhancing students' understanding of the content. From a tactical point of view, teachers thought video features could help to enhance understanding, since videos can be replayed and paused, making them ideal self-study tools. The following comments from teachers illustrate this view:

> The feature of video that enables students to rewind, stop and re-watch, all these features help students to consolidate their understanding (Teacher A).
>
> If students are still not very confident with their understanding of a concept, they can go back to the video and watch it again. Some students told me that when they had the test, they went back to all the video lectures and watched them again, which was really valuable to help them understand the materials better (Teacher B).
>
> Videos help students to understand each step because they can stop the video or re-watch it again until they grasp the idea. This is important in maths problems because most of the activities are based on sequential steps (Teacher D).
>
> Students liked that, when they were watching the videos, they were able to stop it, re-watch the content again and again if they needed to more clarification on the topic discussed in the video (Teacher C).

Flexibility is another feature of learning from video lectures. This positive feature was agreed upon by three teachers, who indicated that videos give a great deal of flexibility, since students can pace the lecture according to their needs, which is difficult to achieve in the traditional classroom. FC introduces flexibility by personalising the learning timeframe so learning can occur when learners are free of other obligations.

> My students, for example, told me that they watched the videos at any time during the day, which makes their learning flexible. This has a massive impact on a student's ability to move whenever they feel comfortable with moving

> on, the ability for a student to move on when they are ready to move on (Teacher E).

Teacher A also stated that one of the most powerful advantages of video instruction is the opportunity for students to set their own timetable, which she explained as follows:

> I discussed with my students how they usually do their homework, usually do their homework, watching the video and doing the quiz. Their answers varied, and I had got students who watched the videos right after coming from school, others at different times and interestingly some of them told me that they watched the videos at 11:00 pm and when I asked them why it was so late, they responded, 'It is the perfect time for us as all the house is asleep and the internet is strong because the number of users is less (Teacher A).

Besides the great value of flexibility of time that videos offer to students, flexibility in place is another advantage. Teacher D noticed among her students that learning from videos provided students with the flexibility of time and place.

> One of my students was very excited that the homework had changed to watching videos because her home is far from school, almost an hour by car and she told me, 'Teacher, I do my homework while I am in the car'. Some students mentioned doing their homework on the bus (Teacher D).

Another perceived advantage of videos observed by teachers in their teaching practices is that video lectures are a learning resource for students, so they can go back to them whenever they want. Three teachers agreed on this. One teacher commented:

> Videos are very great learning resources for students. They help them to know these topics immensely (Teacher D).

Revision, also considered by three teachers, is another feature of the video lectures. Students can use these videos to revise the content, which supports and enhances their learning. Teachers C and E reported that their students told them that they used the video lectures for revision:

> So, it [the video] helps them to revise the content for the final exam, which was much appreciated by most of them (Teacher C).

> Students told me that when they had the test, they went back to all the video lectures and watched them again, which was really valuable to help them understand the materials better (Teacher E).

While videos were seen as a good resource for preparing students who attended the classroom to engage with the class activities, they can also be a good resource for absent students. For example, teacher E reported an incident involving one of her students when she was absent from school:

> A student was absent, and she came back to the class the other day and when I asked her about the lessons, she said, ‘I have already watched the videos and done the quiz’, so she did not miss the lesson; she had already got the main content, and she just needed to practise more with her peers (Teacher E).

Overall, this sub-theme indicates that the video lectures were perceived positively among all the participating teachers as helping to enhance students’ learning. Teachers agreed that learning from videos not only offers students greater control over their learning, allowing them to pause and re-watch parts of the videos whenever they are ready to learn, it also helps students with revision. Additionally, teachers suggested that when students watch the video, it is as if they have to relearn everything. They can realise something new that may have been previously missed in class, with an opportunity for learning, wherever and whenever.

#### 6.2.2.2 Sub-theme: The benefits of online follow-up exercises

This sub-theme considers the reflections by the teacher on how quizzes after watching video lectures benefit students’ learning and enhance their knowledge consolidation. As one of the key components of the FC approach is to watch video lectures at home, teachers agreed that integrating quizzes into the videos enriches their practice, and ensures learners’ knowledge retention as well as providing encouragement to students to prepare for the in-class session. Four out of the five teachers considered it important to follow each video lecture with a set of mathematical problem-solving exercises related to the main concept of the video content. They believed that by applying this strategy they could ensure that students practised what they watched, so the students became active in engaging with the materials presented. By doing the practice exercises, students can revise what they have understood from the video and try to clarify anything about which they are uncertain. Teachers expressed their desire for more opportunities for students to practise mathematics problems, as the following comments illustrate:

> Our subject is maths, which requires practising. If students do not practise what they have learned, the information will not stick in their minds. But I am

> really in favour of using questions with immediate feedback, so students can know the correct answer (Teacher A).
>
> I am a mathematician, so I am very familiar with quizzes and it is an important part of maths to practise what they have watched and understand the content better (Teacher D).

Like Teacher A, Teachers B, C and E acknowledged that simply assigning the videos was not enough. Teacher B mentioned that:

> Regular practising is essential in maths. Students should practise what they have learned from the video and this usually is like traditional homework, where I give students a list of problems to solve. So, watching a video is not enough (Teacher B).

Three teachers asserted that completing short quizzes embedded in or following the video lectures increased students' preparation:

> It helps them to be prepared for the class time (Teacher A)
>
> Also, students come to class prepared by the acquisition of prior knowledge (Teacher B).
>
> Another thing I really like about the flipped classroom is that students come to class prepared (Teacher D).

In summary, based on the teachers' responses, it would be beneficial to find a mechanism that improves the chances of students being prepared for the class activities Having an element of online quizzes as assessment based on the video material, taken prior to each class meeting, could help to make the FC more effective. Teachers emphasised that watching the videos alone might not be sufficient, especially with complex subjects such as mathematics that need regular practice at home and in school.

#### 6.2.2.3 The value of the learning management system.

This sub-theme was raised by four teachers. Generally, teachers expressed their favourable reaction towards using the Moodle learning management system in the FC implementation. This web-based technology supports planning, implementation, delivery, tracking and managing of online education, as well as assessing a specific learning process. Four teachers reported that this platform gave them the ability to keep track of students' progress and ensure that they were meeting their performance milestones. Additionally, two teachers indicated another feature that captured their interest, which was organizing out-of- class learning. Most of the teachers (4 out of 5) articulated their appreciation of Moodle's capacity to easily track learner progress and performance. Teachers claimed that this feature was very important in the FC environment, because teachers could easily keep a close eye on the students' performance in the out-of-class activities, identifying any student who was not participating and, on some occasions, sending her a message through the portal to encourage her to do homework. Teachers E and C commented as follows:

> It helps me to track my students' learning online and with its app downloaded in my phone I can monitor their performance and send notifications for some of them if I see they did not do their homework. This helps to encourage my students to perform better on online learning, because they know that I am monitoring them (Teacher E).

> I can track students' learning outside the class by Moodle. It is very good to have such a learning management system to keep you up with students' learning at home (Teacher C).

Furthermore, two teachers, E and D, indicated another feature of Moodle, which is to support students' learning through organizing the learning process. They asserted that Moodle helps teachers plan, deliver, and manage the online materials in the same portal. Since the FC approach works mainly on videos and online quizzes, it is essential to arrange all these materials in the same platform for easy access by students, so they will be able to find all the materials in a proper manner. This could organize and enhance their learning outside the classroom. As teachers D and C pointed out:

> Moodle makes the teaching process more organized and consistent because, it is the place where all the supporting videos, quizzes, course handbook and materials gathered, so students will be direct their learning instead of sending the materials by e-mail or WhatsApp or others… Moodle serves as a linking platform between my students and me, so any announcement I want to share with them, I can send it through it (Teacher D).

> Instead of having your FC content spread out over different media you can store all of your eLearning materials in one location (Teacher C).

Moodle, therefore, allows for more organized, effective FC implementation. The importance of it was emphasised by a number of teachers, who believed that integrating a learning management system improves course management and is conducive to better student and teacher experiences.

### *6.2.3 The advantages of the FC in general*

The flipped instructional model was perceived to have a positive impact on the teaching and learning process from other aspects. This theme represents other general advantages observed by teachers. These include the increase in active learning opportunities and the potential for the FC to help to differentiate learning based on the students' needs.

#### 6.2.3.1 Increased active learning.

Unlike the traditional teaching approach, moving lecturing outside of the classroom in the flipped approach allows a significant portion of time to be spent in engaging students in active learning. An active classroom is one in which students spend much of their time thinking consciously, communicating rather than hearing a teacher passively. It involves solving problems, sharing ideas and receiving input (Prince, 2004). All teachers agreed that increased active learning opportunities were the most fundamental advantage of FC instruction. This includes more room for practice, discussion-based activities, team-based learning, application exercises or other active learning techniques. For example, one of the teachers confirmed that the FC encourages group learning:

> With the flipped classroom, we are doing things together as a group. Other students formed little groups and work together; students came to the class with more opportunities for discussion since they have exposure to the content before class. They work in groups effectively and they check their answers with each other (Teacher D).

Three teachers indicated that the FC could also encourage other aspects of active learning such as encouraging peer-learning through small and large group discussion. Dialogue with peers helps the learner to clarify course material and gain an insight that they may not have acquired on their own. As teacher E mentioned:

> Students frequently chat whilst completing their worksheets. When I walk around them, they're chatting and working with their peers and they're teaching someone else how to do it, since they have exposure to the content before class (Teacher E).

Two other teachers also commented on peer learning:

> One of the strategies that I think works well with the FC is students learning from each other. While I used the same strategy in the traditional classroom, I think it is more effective with the FC because students have prepared for the

> class content. I usually like to divide the students into groups consisting of four students, not more, because my strategy when I give students any maths problem is to negotiate and solve the problem with the person next to you first and then discuss the answer with the whole group, then with the whole class. This gives the advantage of making all students work hard instead of joining the big group and some students depending on others (Teacher A).
>
> Students who required re-teaching and additional explanation could receive it with the aid of other peers (Teacher E).

In addition, three teachers pointed out that this method of teaching could be linked to improved self-learning skills and encouraged students to be independent learners. Since teachers are doing less leading of education and more collaborative work, students have to assume greater responsibility for their learning. This may be an important adaptation for teachers and students to improve self-directed learning skills.

> It [FC] gave me some flexibility in the managing class time. I have seen that students could learn at their own pace, and this is very helpful for advanced students to move ahead of the class (Teacher E).
>
> I allowed students to work at their own pace, alone or in groups, according to their preference…. I see among my students that they are all at a different spot. I have some students who do everything by themselves (Teacher D).

To conclude, this sub-theme sheds light on how the classroom environment has changed in the FC. While the traditional image of a typical maths classroom seems to be concentrated on passive, bored and dependent students, a new image of a more active, dynamic, and collaborative class emerged. Teachers' explanation for this change is that the FC allows conversion of the transmissive lecture for pre-class preparation, and encourages opportunities for different forms of active learning to take place in the classroom, such as increased discussion, collaboration, and peer instruction. This is important because contact between the students facilitates the conversation, exchange and evaluating of ideas that facilitate individual knowledge building. Students need immediate feedback to make sure wrong ideas are confronted and challenged and that no new misunderstanding has been created. During peer collaboration, they can exchange thinking in groups based on capability before returning to their own learning areas to draw on what they have learned. Additionally, such an approach could help to encourage them to be independent learners and take more responsibility for their learning. This not only helps them to move along their learning paths, but it also ensures a range of essential skills is established.

#### 6.2.3.2 Sub-theme: Differentiated learning.

The fundamental principle of differentiated learning is that different students are given different tasks suited to their various levels and learning styles. Tomlinson (2001) defined differentiated instruction as adjusting the curriculum, teaching strategies, and classroom environment so that all students' needs are met. While this idea seems to be difficult in practice, incorporating technological resources in teaching practice could help to make the differentiation possible. Teachers indicated that the FC approach could help, to some degree, to create more opportunities for teachers to apply differentiated learning strategies. Four of the five teachers agreed that the FC could enhance the learning experience of lower achievers. As their responses indicated:

> I am happy to see even low achieving students participate in the group activities effectively, [whereas before] they were just sitting in the classroom quietly (Teacher A).
>
> Because there is another chance to watch and emphasise the content more, they are able to hear the lesson again, repeatedly if necessary (Teacher D).
>
> I think it is more suitable for low performers so they can improve their understanding and ability by doing more training and practice in class (Teacher B).

Three teachers indicated that the FC could help to accommodate different learning needs. Flipped classrooms simplify the application of differentiated learning techniques for students. Even before students attend a class, they are already working on their individual tasks and events. The students will have sufficient independence and flexibility to explore and learn by having final objectives and clear expectations. This view is illustrated by the following comments:

> I allowed the students to work at their own pace, in groups or alone, according to their preference (Teacher D).
>
> I have noticed that the lower performers get advantages from lots of activities covered during class time and practising lots of tasks, as they have time to do with the support of group working (Teacher A).
>
> This really helps me to concentrate on low-performance students and give them lots of support (Teacher E).

> One thing which I love about the FC is easily differentiated instruction. I see among my students; everyone is at a different stage. Some students do everything by themselves, other students who organised themselves into little groups and work together; they check their answers with each other'' (Teacher D).

Furthermore, teachers A and D thought that this method of teaching could support those students who are self-disciplined and have a strong desire to accomplish complicated mathematical concepts and exercises.

> I found plenty of time to engage higher achievers with higher order thinking problem-solving activities because I know that they already grasp the main content from the videos so they will not be held back by other students, while I can manage the rest of the students and support their learning (Teacher A).

> I found my high achieving students like the idea of working alone with the more complex mathematical problems, as they do usually like to work in this manner (Teacher D).

To summarise, the above claims made by teachers show that some elements of FC can create an opportunity for teachers to facilitate differentiated learning. This can be achieved by keeping low performers engaged and ensuring that they are not feeling lost or left behind. Furthermore, it helps higher-performing students by giving them opportunities to practise different mathematical problems, since they tend to want to work independently. In this way, the FC approach potentially addresses the unique needs of all students.

#### 6.2.3.3 Teaching efficiency.

This sub-theme presents other potential perceived benefits of FC from the participants' points of view. Teachers indicated another aspect of the FC instruction that might enhance teaching efficiency in this environment. Three teachers stressed that the FC helped them increase content coverage in the flipped maths classrooms compared with the traditional classroom. This increase in pace may be attributed to having more time in class to practise different mathematical concepts, which enhances content coverage. As mentioned by teachers A and D:

> It [FC] is a good approach for maths because it helps maths teachers to cover as much as possible of the curriculum (Teacher A).

> I noticed an increase in coverage of content materials in my flipped class compared to traditional ones (Teacher D).

Teacher E pointed out how the FC helped with the intensive maths curriculum. She described how, with the traditional approach, she struggled to keep up with her instructional plan, due to lack of time. She indicated that the problem of lack of time in maths classes is a general issue with maths teachers, and adopting the FC could increase the time in class, which in turn increases the chance of practising more maths.

> The maths curriculum is too intense in year 9. There are lots of exercises, practices, and problem-solving activities after each topic, including higher order thinking problems that are impossible to finish working on in one or two lessons with the traditional way of teaching. Some teachers, including me, borrow class time from other teachers, to have enough time to complete some of these problem-solving activities, but after trying the FC, I have got more time in class to work on more content (Teacher E).

Three teachers expressed their joy at finding teaching in the FC group comfortable and less stressful compared to the traditional group. They believed that coming to the class with advance knowledge and expectations of the students' performance with the pre-designed activities could play an important role in enhancing teachers' confidence.

> The flipped classroom relieved me of stress during the class session (Teacher A).
>
> I am more relaxed and confident when I enter the class because I know that most of the students understand what they will learn each day, instead of coming quickly to class for fear of losing any minute, because I know that I need more time to explain the lesson, then doing exercises and so on (Teacher D).
>
> It [FC] puts me in a more relaxed mood, knowing that most of them understand the main contents (Teacher E).

In summary, teachers agreed that the FC could be a promising technique for intensive disciplines such as maths. They argued that the time spent in the traditional classroom is not enough for practising maths. By implementing the FC, the class time with the students and the content would be increased. Accordingly, teachers felt more relaxed and confident about the amount of maths content they could cover in the class, which could enhance teaching efficiency.

### *6.2.4 Challenges to FC implementation*

With the introduction of any new instructional approach into the teaching process, generally, some challenges are associated with its implementation. Since the FC was a new pedagogical approach for both teachers and students who participated in this study, the data from teachers' perceptions revealed the challenges they encountered, which should be taken into consideration by teachers when deciding whether and how to flip the classroom environment. Based on the teachers' interview data, the challenges fall into three categories, including student-related challenges, teacher-related challenges and resource-related challenges.

#### 6.2.4.1 Student-related challenges.

This sub-theme concerns the challenges of implementing the FC related to students. From the findings, it is evident that one of the greatest concerns of the participating teachers was getting students to do the homework ahead of the face-to-face session. "What if students do not do their homework?" as simply stated by teacher C. Students' possible lack of interest in the out of class materials was a matter of concern to all the teachers, as shown in the following examples:

> The flipped classroom method depends heavily on the students themselves. If they do not work as planned it will put lots of pressure on the teachers to motivate them, to manage the in-class time, if a big number of students are not watching the videos, so it is quite challenging (Teacher B).

> The big issue for me is that students are reluctant to watch the videos. I faced this issue with some students. When I asked them why they did not watch the videos and answer the quiz, they simply told me that they forgot to watch the video, or they were too busy and did not have time (Teacher C).

Teacher D was in line with other teachers and went beyond that by reporting her typical experience with her students when she tried new strategies of teaching. She commented:

> Besides that, I am just thinking about ways of encouraging students to do out-of-class tasks. Some may neglect this part, and it will lead to their coming to the class unprepared. What can I do if last evening students have not watched the video, which means they did not have the time for processing that? This happens with my students when I introduce them to some new strategy; they seem enthusiastic at first but after a while they lose their interest (Teacher D).

Teacher B indicated that the problem of lack of commitment and motivation in students is a common problem faced by teachers, not just in the FC but also in the other teaching strategies adopted by teachers. She compared today's students with the previous generation in the following words:

> We used to take our education seriously, but today you feel like the students come to school to have fun and to make friends. Some students even do not have real goals, they come to school because their parents want them to do so (Teacher B).

Additionally, this issue led teacher C to lack confidence in teaching in the FC as she explained:

> I found sometimes that teaching in the FC was not convenient for me or my students. This is because some students came to the class without any preparation and that causes the re-teaching group to dominate the exploring group, which made some disruption to the class management. This led me to adopt re-teaching for the whole class (Teacher C).

In addition, two teachers believed that issues with the lack of parental support may pose challenges for students to be effective learners in the FC approach. This problem includes parental permission. For example, Teacher C reported that some of her students had inadequate home permission for Internet access. Teacher C asserted:

> Some students have to get their parents' permission to use the internet at home. This is because parents are afraid that their daughters will not learn but instead are trying to use social media applications, which they think will waste their time, so they just let them use the internet for certain hours during the day, with their supervision (Teacher C).

This could be attributed to the fact that students' parents came from a background of traditional teaching methods. Therefore, they appreciated the traditional approach and thought that the way they learned was also the best way for their daughters to learn. Teacher B articulated and understood this concern from parents:

> Putting pressure on the students' learning at home is a challenge for successful FC implementation, but I understand the mentality of these parents, because some students may not take things seriously. Instead of preparing for the class, they may be going to another website, such as playing games online or watching materials that are not related to their learning. This puts pressure on the parents to monitor their daughters at home (Teacher B).

Therefore, upon close examination of the responses, it seems that teachers highlighted a possible risk associated with the FC, that students may not do the out-of-class tasks and thus attend the class without any preparation. If this happens, the FC approach's mechanism will not work effectively, which may lead teachers to go back to their traditional teaching approach. In addition, it seems that a supportive home environment is also an important factor that not only plays a role in enhancing students' learning at home, but also has a positive influence on a student's mindset, attitude, and behaviour toward learning in the FC environment.

#### 6.2.4.2 Sub theme: teacher-related challenges.

This sub-theme concerns the challenges of implementing FC related to teachers. Effective flipped instruction requires careful and intentional planning on the part of teachers. Teachers reported some challenges that may affect their adoption of the FC approach in the future. Increased workload and lack of time were at the top of the list. Teachers believed that creating an FC requires a considerable amount of initial work, more than the average classroom model. It can also be tedious and time-consuming to create materials and instructional videos for a flipped class. Teachers considered that planning and preparing for the implementation of a new instructional approach may take time, which could deter teachers. They perceived the lack of time and increased workload as an obstacle to the development of videos and FC implementation, as the following extracts explain:

> I think it [FC] will increase workload. I am enthusiastic now because you created the videos and manage the Moodle site. So, it was easy for me, just designing the in-class activities and monitoring the students' performance. But if I do everything by myself, especially making my own training videos, it's extremely time-consuming (Teacher A).
>
> I also want to add the increased workload for teachers, especially if I will design the videos myself, it is time consuming with the high commitments at school and at home (Teacher E).
>
> If I take the decision to design my own videos, they require time to make; it will take maybe hours to just create a ten-minute video, so it is hard for me. This also will affect my home time, because the production will be at home, which is inconvenient for me and my family (Teacher B).
>
> It [FC] will take time. I mean, the out of class activities, such as finding software to create videos and learning management systems that are free, since making my own videos takes time (Teacher C).

> The obstacle for me is to find the time to do so as I have to give up my personal time for lectures, videos events. I am not paid [for that time] and it can be a concern (Teacher E).

The issue with increased workload and time was largely related to designing the video that was agreed by all teachers, especially as they were female, and they had families to care for at home. The teachers' responses indicated that they did not have time at school to design their FC. In practice, maths teachers may need to make more videos than teachers of other subjects. This is because in a typical maths class a new skill is taught every day and thus, for each lesson, a new video is required. Teacher B commented:

> For example, as we have the broad topic, which is finding Arithmetic operations with rational expressions, there was a series of videos on multiplying and dividing rational expressions, adding and subtracting rational expressions, adding and subtracting rational expressions with like denominators and with unlike denominators, using the greatest common denominator and adding and subtracting rational expressions that share no common factor, How could one teacher manage to create all these videos? (Teacher B).

To prevent such problems with video production, teacher A pointed out:

Using videos available online on YouTube or on IEN[1] academy could help in dealing with video creation issues (Teacher A).

Another issue identified by four teachers was the lack of familiarity with the FC and the technology it involved. This can be a challenge, since both the students and the teachers had a long experience of and were comfortable using the conventional lecture format. Four teachers indicated that this approach was quite new for them:

> I am not very familiar with it [FC] (Teacher A).

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[1] "IEN" is a National Education Portal managed by the Minstry of Eucation, Saudi Arabia. ien.edu.sa

> In the beginning, I found it different… because it's a new experience (Teacher C).

> It is quite different from the traditional classroom and for some time I tried to get my head around it because I was also teaching the other class in the traditional way (Teacher B).

Additionally, teachers B and A stressed that knowing the technology is important in order to deliver a quality product in the flipped classroom. It requires some skills that they needed to learn. Some of these skills were mentioned by different teachers as follows:

> I am not very familiar with designing videos and dealing with learning management systems if I adopt the flipped classroom (Teacher A).

> There are skills that we have not encountered before, because the traditional way has been the dominant way of teaching mathematics for ages. The idea is not just creating a video, it is more than that, we need to know recording and editing skills, we might need a camera for recording the video (Teacher B).

Teacher D indicated that since she was not familiar with using technology in her maths classes, she would find an easier way to flip her classes:

> I am not very familiar with technology, so I will use easier ways to flip my class by using, for example, the Whatsapp app to send online videos because it is much easier and does not require much advanced technological skills (Teacher D*)*.

However, the FC model is more than simply creating a few videos for students to watch at home. Rethinking how teachers teach and students learn could pose a challenge. Most Saudi teachers practise the traditional way of teaching and are used to it. They are comfortable with their way of teaching, and they may not have the confidence to try a new teaching approach such as the FC. Two teachers declared that the FC might fit nicely with some subjects and might be suitable for some topics, but not all. The issue of teacher beliefs is presented in the following responses.

> I am not sure if the flipped classroom works well with other subjects, but I can see it might be good to have a try and see the results. I think in science it could be a good approach because it is a hard subject and students should not depend on teachers, so they should come to the class prepared and invest the class time in more practical activities. But with others such as humanities or social science, teachers may prefer the traditional approach more (Teacher A).

Teacher C was the only one of the participating teachers who explicitly stated that she would not consider flipping her classes. When she was asked about the reasons behind that, she commented:

> I would say the FC may have potential for success. However, I am a big fan of traditional teaching. I have been teaching for about 18 years until now and I think this is the best way to teach maths, but this does not mean that maybe other techniques cannot help for other teachers (Teacher C).

Teacher C also indicated that teachers should have a clear reason for introducing FC. She thought teachers should consider whether their own teaching and student learning would profit from flipped classes. If teachers cannot find advantages when answering these questions, she believed, the change to a flipped classroom is not worth doing, and it would be better for teachers to think about doing something else.

For the most part, these narratives reveal concerns from teachers about the possible challenges they may encounter during the implementation of this approach and in their future practice if they want to continue flipping. Generally, teachers work in diverse and complex scenarios and have very different professional learning needs

#### 6.2.4.3 Sub-theme: resource-related challenges.

This sub-theme concerns the challenges of implementing a flipped classroom, related to lack of resources. From the findings, all of the teacher participants viewed access to technology and resources as critical for the flipped classroom method to occur. This was identified as a necessary component, since some students may not complete the out-of-class assignments simply because they do not have a device. All participating teachers assumed that at the high school level most students would have some sort of technology at home, such as mobile phones, iPads, and laptops. However, they were concerned about students from low-income families, whose social circumstances prevented them from having access to a suitable device. In addition, they were concerned that big families could not provide a device for each child, so their daughters used devices shared among all the family members. Teachers E, A and B commented on this issue in the following responses.

> I do not think of challenges specific to maths, but I think there are general challenges across different subjects and disciplines, such as each student should have access to technology (Teacher E).

> There are many challenges I can think of personally, such as lack of resources and technological devices in schools and some students' homes. For example, in my school, we did not have enough technological devices, such as laptops, iPods and computers, for students' use freely at school. We have a computer lab, but students are not allowed to use it unless they have a lesson (Teacher B).
>
> We need to ensure our students have access to the Internet and working computers for them to watch the videos or be prepared for class the next day (Teacher A).

The school could be the only opportunity for students who have no access to technology at home to use a computer for out of class learning. This brings up another issue, which is the lack of funding from the school and the educational department in the district. Teachers suggested that there should be a fund to support flipped classroom implementation. Three teachers identified limited funding as a reason for lack of implementing a new instructional approach. It was discussed by the teachers that the schools did not seem to have the available funds that would enable them to implement flipped learning to its full potential. As teacher D mentioned:

> If the student does not have a device, the school cannot provide devices for students due to the lack of funding, so in such a situation the teacher has to deal with this issue alone, which puts us under pressure (Teacher D).

Another issue identified by teachers was the lack of a good internet connection.

> Lack of internet connection in school or at home, this may cause problems for teachers and students. (Teacher A).
>
> Even if they have the devices, the internet connection may be poor and the flipped classroom requires students to watch videos and as you know, they take time to download and this may be frustrating for some of them, some of the students told me. (Teacher E).

Two teachers (C and E) gave examples of how their schools' poor internet connection forced them to bring their own if they wanted to use some sort of technology in the classroom.

> I would prefer to bring my personal internet connection to avoid any problem with internet connection, which always happen when using the school's internet connection (Teacher C).

> I usually use my own internet connection in school to avoid the problem of losing signal if I use the school internet, because it is not strong enough to accommodate all users (Teacher E).

Teacher C was explicit when she mentioned that she could not take full responsibility if she decided to adopt FC. She asserted that:

> I do not think I will be able to deal with the challenges of the FC by myself, because I cannot compel parents to purchase devices for their daughters. They would blame me. We have some students living in areas of poverty and I cannot put pressure on their families to provide their daughters with such resources. If the implementation of FC came from a high authority, this might convince them (Teacher C).

Apart from that, teacher C mentioned that one of the reasons that deterred her from continuing the FC was financial pressure. She explained:

> Lack of internet connection is one of the reasons why I do not want to flip my classes. It is [too much] financial pressure to provide students who have problems with their internet at home with a pre-paid card, because I will [have to] pay it myself, nobody will help me, and it sounds difficult. I have lots of commitments. The school administration will not help. The Ministry of Education should pay that. If they want us to be creative and use a new teaching approach, they should provide funding (Teacher C).

Another challenge identified by teachers is the unsuitability of some existing videos. Generally speaking, it is practical for teachers to use other videos that are available online, such as videos that may have come from reliable public access sites or even individual channels. This would help teachers who are not willing to design their own videos for the students. However, three participating teachers were concerned about using other videos online. They believed that by designing their own videos, they could tailor them to the needs of their students.

> I prefer to use my own videos because I can be sure about the material presented with my own way of explaining things (Teacher B).
>
> They will be more engaging because at least that will not make a change for students. They hear my voice, which might connect them to the class. If I use videos from the internet, I will pre-screen the videos and also check if other content is used that matches what the students would be working with in class (Teacher A).
>
> I know that I may need to be flexible, if I am using someone else’s videos I may need to be flexible, I know that sometimes I must change them slightly, but they're perfect. I will try to find the best ones. This could help me to reduce the time I needed to spend on generating the content (Teacher D).

However, teacher A indicated there might be some occasions when teachers need to adopt ready to use online videos from reliable sources:

> Some teachers may have to look for videos online because they want to provide students with better visualisation and animations to explain complex and difficult concepts. (Teacher A).

Furthermore, implementation of the FC in school needs support and help for teachers. The findings reveal that teachers seemed to be aware of the possible challenges that might face them or other teachers if they decided to flip their classes. Therefore, they reflected on this by suggesting support and training to guide and help them during the adoption process. Two teachers articulated this need:

> I think we need help and support because such skills were not part of our regular preparation, so we would need intensive training and support (Teacher A).

> We do not have intensive training on flipped learning. I have attended a workshop, but it was more abstract, without practical ways on how to implement it and I need to have someone expert to guide me through the transition from the traditional to the FC. (Teacher E).

Teacher E mentioned an important point that other teachers did not mention. She believed that while it is important to get support and training from the education authority, teachers need to work hard to develop themselves. She argued:

> Teachers have to take the time to develop their knowledge and preparation about the usefulness of flipped learning and its impact on students' learning. (Teacher E).

It is clear from the above extracts that the implementation of the FC can pose some challenges that need to be addressed and negotiated between different stakeholders including teachers, parents, school leaders and the Ministry of Education, to guarantee successful implementation. Teachers raised some issues that concerned them, and they indicated their need for support. They believed such support and school resources should be available for teachers and students at any time to support the successful implementation of the FC. Moreover, they suggested the Ministry of Education should fund the implementation to avoid reluctance from teachers and parents.

### *6.2.5 Summary of the teachers' views*

In general, from the teachers' interviews it can be concluded that the FC provides both opportunities and challenges for both teachers and students. Four of the five teachers were happy to continue with flipped classes and indicated that they would recommend the FC to other teachers. Teachers appreciated the design principles that guided the implementation of our version of the FC. This insight adds to current theoretical knowledge, and perhaps the current study can contribute to the field of the flipped classroom and mathematics education. Useful insights regarding potential benefits of the FC approach to enhance teaching and learning were also offered by the participating teachers' recounting of the valuable impact of video lectures on home learning and the increase in students' interactions and feedback from teachers or peers that occurred during the face-to-face session. All these insights add to an increased understanding of complex mathematics topics in high school settings. The emphasis on the importance of assessment and quizzes was perceived favourably by teachers, indicating that assessment should be an integral part of FC designs. Further, teachers indicated that one of the main benefits of the FC is that it allows more time for active learning and it differentiates and personalises learning that is difficult to introduce into a traditional lecture-oriented classroom. However, teachers highlighted a number of challenges associated with FC implementation. Those challenges include students' lack of interest in the materials presented in the out-of-class activities, which could affect their preparation. Additionally, teachers reported that a number of students had difficulties with downloading videos, which was attributed to their poor internet connection at home. In addition, teachers indicated their need for support and training if they decided to flip their classes, as, without support, the transition to the flipped approach could be problematic for them. In such a situation, the absence of support from administrators and school leaders can add extra complexity to the successful implementation of FC in schools, as it may increase the reluctance from teachers, students and parents.

## 6.3 Evaluation of the Implementation

The findings from the quantitative and qualitative data that were reported in this chapter and the previous one provides a detailed picture of how the teachers and students perceived the FC implementation, based on a variety of instruments, including a mathematics proficiency test, self-efficacy questionnaires, students' perceptions questionnaires and teachers' interviews. The students' and teachers' perceptions data was one of the main sources of information for the evaluation process. In accordance with The Education Endowment Foundation (EEF) guidance (Humphrey et al., 2016), the evaluation of the implementation seeks to explore the relationship between the delivery of the intervention and the impact on students' outcomes. In other words, implementation and process evaluation refers to the generation and review of data in order to investigate how an initiative is implemented, how it works to produce the desired results and how it affects these processes (Lendrum & Humphrey, 2012; Humphrey et al., 2016). Hence, the implementation and process evaluation in this section aimed to assess implementation, mechanism of impact and interpretation, all described in more detail below.

### *6.3.1 Implementation*

In this section, the researcher will draw on the following dimensions and factors affecting implementation: fidelity/adherence, exposure, quality of delivery, participants' responsiveness and programme differentiation (Dane & Schneider, 1998). To reflect on these issues, this section reports on some indicators of implementation assessed through the researcher's observation of some parts of the intervention, data from Moodle and teachers' perceptions of the FC implementation. First, ***fidelity/adherence*** means to what extent the intervention was implemented as intended and if in some instances it was not, why this might be (Dusenbury et al., 2003; Nelson et al., 2012). In general, the implementers did what was expected. Strategies to maximise effective implementation were assured by the provision of training, monitoring, and the fact that some aspects of the implementation were created/ managed by the researcher. If the teachers had to do everything themselves, the adherence might have been different, for example, because of the lack of confidence and skills with technology. To elaborate on this, prior to the implementation, the researcher conducted training sessions for both teachers and students to familiarise them with the FC approach and how their role could be changed. There were two trial sessions for each flipped group before the implementation, and support was provided when needed. Additionally, the researcher tried to keep a close eye on the participating schools by making several visits to each school to ensure that the intervention was being implemented as planned and to solve any technical issues faced by teachers or students. In addition, the researcher observed and managed the Moodle site and had regular access to the online materials and students' performance of the out-of-class activities. The researcher monitored the students' Moodle data form to keep track of compliance and identify those who did not receive the minimum exposure (i.e. noncompliers). This helped to ensure that the students accessed and participated effectively in the online classroom at home. Several meetings with teachers were held, both before and after the study, to encourage buy-in and ongoing support. Any issues observed were negotiated with the teachers. However, there were some instances where some teachers were not doing what was expected and planned. This was observed with two out of five teachers, teacher C and teacher B. Teachers C and B reverted to class teaching due to characteristics of students (lack of motivation) and problems with resources (lack of internet) that impeded some students' participation. In addition, the FC was very different from their usual practices (poor goodness-of-fit), leading to unfamiliarity and resistance, at least for teacher C, who was determinedly 'old school'.

The next criterion, ***exposure,*** refers to whether participants received as much of the intervention as expected. It can be deemed that they did, in the sense that students had the planned number of sessions. Maths lessons of approximately 45 minutes duration were held four days per week, for eight weeks, for both the flipped group and the traditional group. In the out of class activities, students were exposed to the video lectures and online quizzes through the Moodle site. However, some students may not have had exposure to all the videos due to the lack of resources at home. These include a poor internet connection, or parental restriction on their access to the internet, as reportedly applied to a few in teacher C's group. This in turn meant that some teachers felt forced to focus more on direct teaching, so this might have affected students' exposure to other activities in the classroom sessions. Learnes who decided did not complete assigned tasks in the traditional group did not affect the rest of the class; their decision only had an effect on their own knowledge accquisation and not on the class learning environment. However, if the flipped group students did not complete their assignments, they would then not have the basic knowledge of the video contents that would allow them to criticise their peers' work or to expand on their intellectual skills. Lack of preparation by the students might have had a negative effect on the standards of group collaborative activities, as class discussions form an important part of the changed model of instruction. This drawback was experienced in teacher B and C's groups. Another issue was that lack of reliable internet connection at some students' homes may have affected their exposure to the online activities, since some teachers reported some students having problems with internet connection. Indeed, this was one of the main challenges reported by teachers, which could affect the success of the FC approach.

Moving to the ***quality of delivery***, conceived of in terms of how well intervention components were implemented (Durlak & DuPre, 2008), the delivery of the FC instruction in the current study was undertaken as part of regular classroom activity by classroom teachers. Overall, teachers implemented the FC approach as planned. However, since this study involved different schools and teachers, there may have been contextual variables that affected the quality of the intervention delivery. These may have included characteristics of students such as age and socio-economic status and institution characteristics, for example, school type, geographic location and resources. Learning culture may have played an important role in determining the effectiveness of FC. The participating schools were from different parts of the city, with areas of different socio-economic status, which might have affected the delivery of the content. Additionally, the characteristics and attitudes of teachers are both viewed as affecting the delivery quality (Baron & Kenny, 1986). Contextual factors included beliefs about students, teacher roles, their perspectives on the efficacy of the FC approach, and their philosophical assumptions about teaching and learning. For example, teacher C considered herself from the old school and she was very convinced of the superiority of her old teaching practices. This belief could have affected the quality of delivery of teaching for her flipped class. Equally significant, due to the teachers' inexperience in introducing a new instructional technique for the first time, there may have been instances in the FC where teachers did not link the in-class activities to the out-of-class instructional material as coherently as desired. They may have needed more time to adapt to a new approach to teaching. This may have influenced some students' understanding of the course, resulting in reduced benefits, as in the case of teacher C's group, who had lower self-efficacy scores. Different contextual factors have a moderating effect at different points in the intervention process (Detrich, 1999; Baron & Kenny, 1986).

Another important evaluation criterion is ***participant responsiveness,*** referring to the extent to which the intervention recipients are engaged by the activities and content delivered during the implementation (Dusenbury et al., 2003). It was evident from the online class observations on Moodle that most of the students participated effectively with the presented materials. In total, nearly 85% of students accessed the video lectures and 92% accessed the online quizzes. From the teachers' interviews, it was evident that the classroom culture provided plenty of opportunities during the lesson for students to share what they had learned at home. The increased time available in the class was among the main benefits identified by teachers that made the class more effective for student learning. This in turn facilitated different styles of classroom learning, as evidenced by group activities, the valuable support from peers and teachers who were more willing and available to answer and discuss students' concerns immediately in the class session. However, some teachers raised the issue of some students' failure to do the required preparation at home, which affected their participation in the active learning opportunities in the class session.

The criterion ***programme differentiation*** refers to the degree to which intervention practices can be differentiated from current practices**,** which is critical in understanding what has caused any improvement in outcomes (Dusenbury et al., 2003). The flipped and traditional groups were distinct in terms of the instructional teaching delivery in the maths course. The researcher tried to ensure that students did not share materials or talk about their activities with friends and neighbours in the other group. In addition, teachers were asked to keep their teaching activities as separate at possible. Despite the fact that precautions were in place to keep the flipped group apart from the traditional group, there may have been some instances of students sharing materials with each other. There was a possibility that traditional group students had access to supplementary support materials, such as the instructional videos outside of class. Similarly, students in the flipped group may not have used all of the tools available to help them learn mathematical concepts; there seemed to be evidence of this with teacher B's flipped group. It should also be noted that there is a possibility of contamination between groups because of having the same teacher for the experiment and control group within each school.

### *6.3.2 Mechanism of impact*

Generally, two key areas were identified as having the likelihood of successful implementation. These two key areas were the FC resources and active learning strategies. The resources that the researcher designed for this study were perceived positively by both teachers and students. These resources included the video lectures, Moodle platform and assessment. Teachers commented positively on the video lectures and how they considered them valuable learning resources to enhance students' learning. The affordances of videos, such as flexibility, were mentioned by both teachers and students. In fact, students indicated these features as major reasons why they valued the

FC approach. Flexibility encourages personalising the learning timeframe, whereby students can learn wherever and whenever they are ready to learn. As confirmed by teachers, using videos as a resource facilitated students' understanding for those students who needed more time to understand the content by doing revision before the exam or those who were absent from class sessions. Students appreciated the easy to use and well-designed video lectures; a very high percentage of students, 90%, indicated that the ability to rewind the video lecture helped them to learn.

Another resource was the use of Moodle as an online management system used to accomplish and facilitate the smooth FC implementation. According to the teachers there were two key benefits from using Moodle in the FC, namely, the platform helped them to track their students' learning of the out-of-class materials, and it organized the learning environment, which in turn enhanced students' and teachers' positive experience of the course. In addition, having the Moodle app helped students and teachers to access the learning materials very quickly from their phones, which made it easier for teachers to regularly check their students' out of class performance and help students to access materials efficiently.

Furthermore, the inclusion of different forms of assessment during the implementation of FC helped both teachers and students. From the teachers' point of view, the assessment provided a good source of information on the students' understanding of the out-of-class activities, which in turn influenced their planning by giving them a clear picture before coming to the class session so they could modify their teaching practices based on the results of the quizzes. Teachers accessed online databases to see how successfully their students performed at home. The details provided in the pre-assessment enabled teachers to schedule their activities to support areas where homework had been poorly understood. Besides that, the pre- assessment before class helped them to organize the class into the proposed groups (exploration and re-teaching), which in turn helped them and their students to work with the group that suited their level of understanding of the content presented in the video lectures. Furthermore, teachers were able to schedule differentiated activities that were appropriate for each student, resulting in a more personalized teaching experience. Teachers said that the classroom work groups were more versatile. Based on information obtained, they could split their class into small groups to reach smaller groups of students and provide support to the students who needed it most. Those assessments also encouraged students to prepare for the in-class activities and could enrich their practice of mathematical problems.

An increase in active learning opportunities provided in the FC approach was the second element identified by teachers as making the intervention successful. Indeed, all teachers agreed that increased active learning opportunities was the most fundamental advantage of FC instruction. From students' questionnaires, it was clear that students appreciated the active learning opportunities created due to implementation of the FC. Teachers identified changes in the classroom environment in the FC group in terms of increased interactions among students, and between teachers and students. There was more time to discuss, collaborate, and engage in more mathematical content because of the way the class time was freed up by moving direct lectures outside the classroom. Teachers also commented that group and peer learning were much more effective in the FC group because pre-exposure to the materials before coming to the class helped students to be active members of the class. All these different learning modes encouraged consistent, immediate feedback from both teachers and students, which in turn enhanced the students' learning experience.

### *6.3.3 Interpretation*

The researcher can be moderately to highly confident that the impact seen was due to the FC implementation. Overall, teachers and students regarded their experience of the FC as positive. Four of the five teachers were happy to continue with flipped classes and indicated that they would recommend the FC to other teachers. 81% of the students agreed that this course as a whole had been a valuable learning experience. In addition, based on the quantitative data collected, apart from teacher B's students, whose group showed lower maths proficiency compared to the other four groups, the FC seemed to work well for four out of five teachers in terms of improving mathematics proficiency. One reason for this difference in outcomes in teacher B's flipped class could have been an instructional tension inside the FC as some students did not do the pre-class work of watching videos, and so required a lot of re-teaching. This could have affected the students' post-test performance. In terms of self-efficacy, four out of five teachers showed improvement in their groups' post-self-efficacy scores. Teachers A, B, D, and E all showed improvement in their students' self-efficacy scores, but this was not the case for teacher C's group. Self-efficacy is different from mathematics proficiency. It is an emotional state, and it is affected by social support (or lack of it), not just the FC. The quantitative results showed that teacher C's groups started with much lower self-efficacy than other groups, and particularly for the experimental group. Since this was evidenced in the pre-test, it cannot be due to the impact of the FC. In fact, both experimental and control groups had a slight increase in self-efficacy across the intervention, almost in parallel, but the initial disadvantage for the FC group was not overcome. Teacher C's implementation of the FC approach could have been affected by various factors. The most likely reasons for the low self-efficacy even at the start could be the teacher's negative attitude and students' lack of motivation towards learning maths. In addition, based on the qualitative data from teacher C's interview, the new teaching approach in the classroom created discomfort for the students. This increased tension as the FC instructional method was new to them. Discomfort may have been caused by the absence of guidance and instructions, which are frequently provided in a conventional classroom. In addition, this could be linked to the point that teacher C took pride in being old school and hence, compared to the other teachers, valued the traditional learning approach more. Moreover, teacher C's resistance to change was epitomized by her insistence that the traditional model of learning is the best system for teaching maths. Contextual factors such as teachers' beliefs could affect teachers' adoption of a new teaching strategy and may lead to less effective implementation of the FC approach and influence students' confidence in learning. In addition, teacher C faced the problem of some students coming to the classroom without preparation. As a result, teacher C argued that class management was made more difficult when the re-teaching group appeared to dominate the group of students who were in the exploration phase. Consequently, due to the imbalance, she had felt forced to deliver the lesson again and revert to the direct lecture approach for teaching the whole class. This repetition of lessons may have undermined students' self-confidence as it emphasized their failure to understand the materials presented. It also reduced the opportunity for more active learning experiences and more interaction and feedback, which could have affected students' understanding and confidence in maths.

Importantly, teachers in this study indicated two types of challenges they faced during the FC implementation in the current study, and other challenges they thought they might face if they decided to continue flipping their classes in the future. The two main challenges during this study were students' lack of motivation to watch out of class activities and poor internet connection in some students' homes. Despite the constant emphasis on effective participation in out of class activities by the teachers, the teachers indicated that a low level of student motivation to do their task might affect the mechanism of the in-class activities, which in turn would affect the potential overall benefits of the FC approach. Students' willingness to take responsibility for their learning is essential because if students do not participate, the teacher would revert to using the lecture format instead, as happened with teacher C's group. Second, the internet connection at students' homes may influence the students' preparation for the class activities. Since much of the online content is based on video lectures, downloading them was an issue for some students without a strong and reliable home internet connection. Therefore, this study showed that students' behaviours may affect the effectiveness of the FC implementation. Students who took responsibility for preparing for the in-class activities showed improvement in their learning outcomes (mathematics proficiency and self-efficacy) - this could apply in three teachers' groups, A, D, and E. On the other hand, some students' behaviours hindered the successful effect of the FC approach, such as coming to the class session without any preparation as happened with teacher B and C groups. The results added to the argument that teachers have a similar likelihood as students to import behaviours which are affected by their cognition about learning and teaching; this could be true for teacher C.

In conclusion, the evidence from the researchers' observation and teachers' interviews showed, overall, that the proposed FC was well delivered, and behaviour on the Moodle platform and in-class sessions mirrored the main components of a flipped learning approach. However, implementation issues can differ over time (Dusenbury et al., 2003) and fidelity levels can deteriorate, or improve, because it takes longer to introduce and implement an intervention in some teachers or schools (Bickman et al., 2009). Because this intervention was carried out as a research project, it was assumed and expected that the implementation would be performed exactly as planned, in all participating schools. The adaptations made by teachers B and C were viewed as a lack of fidelity in the implementation and as a possible reason for lower outcomes in the schools concerned. However, Lendrum and Humphrey (2012) view the adaptation of programmes at the level of individual teachers or schools as inevitable and suggest that they can sometimes be a positive factor, enabling programme sustainability in the face of local contextual factors. In this study, the implementation may have been influenced by differences between schools and catchment areas, in resources, parental support and others, but the study design did not take account of such factors or explore to what extent programme adaptation is acceptable or even necessary, and how it affects outcomes. As this study has shown, a variety of student, teacher, school and location factors can affect the implementation of the FC. These issues need to be explored more fully and carefully considered in any attempt to roll out the FC approach more widely.

## 6.4 Summary

This chapter presented the results of the students' and teachers' perceptions of their experience of the FC approach in teaching and learning mathematics. Overall, their experiences were positive and there are some promising results regarding the potential effects of the FC approach for the teaching and learning process. The chapter ended with evaluation of the implementation of the FC approach in the current study, which aimed to investigate whether or not the intervention worked and in what way, and what factors contributing to this result. In general, the intervention was favourably perceived and linked to improvements in mathematics proficiency (for all groups except teacher B's) and self-efficacy (for all groups except teacher C's). However, various contextual factors were suggested that could affect the quality of FC implementation and, hence, its outcomes. The issues raised in this chapter will be discussed further in the light of relevant literature in Chapter Seven.

# Chapter 7 : Discussion

This chapter presents in-depth interpretations of the findings presented in the previous chapters. The first section discusses findings derived from mathematics proficiency tests, while the second interprets further quantitative data obtained from students' self-efficacy questionnaires. The last two sections present a discussion of the quantitative data collected through a questionnaire regarding students' perceptions towards their experience with the FC implementation, followed by the results of the qualitative data obtained from interviews with the participating teachers about their perceptions of the FC implementation and possible potential benefits and challenges associated with its implementation. Lastly, consideration is given to the possible implications of the Covid - 19 pandemic for the FC implementation. The discussion in each section addresses the research questions and connects the findings to the existing FC literature and the theoretical framework that guides this study.

## 7.1 How does mathematical proficiency compare between students who learn mathematics with the flipped class model and students who learn mathematics with the traditional class model?

This study found that students receiving the FC instruction showed higher maths proficiency compared to those receiving traditional instruction, but that the effect was not statistically significant. This finding is in line with previous studies revealing a small impact of FC, such as Clark (2015), Love et al. (2014), Overmyer (2014), Petrillo (2016), Vang (2017), Yong et al. (2015), and Ziegelmeier and Topaz (2015), and not entirely inconsistent with the meta-analytic average of Lo et al. (2017) since the confidence interval of our effect size (-0.09 to 0.22) overlapped with that of their averaged estimate (0.30 SDs; 95% CI: 0.16 to 0.44). Interestingly, the resulting effect is the same as the average estimate of all the educational interventions tested in the rigorous randomized controlled trials commissioned by the US-based National Center for Educational Evaluation and Regional Assistance (NCEE) and the UK-based Education Endowment Foundation (Lortie-Forgues & Inglis, 2019). There was no evidence that the impact varied between the different sub-sections of the achievement test or that the intervention's impact was influenced by the students' pre-intervention mathematics proficiency.

FC students performed at least as well as, if not better than, the students given traditional instruction. Thus, the FC approach encourages a shift in classroom culture that can give students experience of engagement in a wider range of mathematical activities, but it does not guarantee better student learning over the traditional approach. Even so, it should be noted that despite the fact that the FC had no direct effect on test scores, the teacher interviews showed that the FC students had more time in the class to authentically engage with the material, so facilitating teamwork, communication and idea exploration. Students were prepared to handle the content in this way, since they had already seen the videos before class and thus gained a general understanding of the concepts. This differs from the culture of the traditional approach in which direct instruction was the means of teaching delivery. The students had positive perceptions toward FC as a means of enhancing their learning. Most importantly, the findings of this study demonstrate that regardless of the teaching approach, the FC approach causes no harm to students' learning. The novelty of the approach for both students and teachers and some aspects of the experimental design might have contributed to the lack of statistical significance in the result, as detailed below.

A number of contextual aspects of the current study might help to explain why the impact of the intervention on mathematics proficiency was lower than anticipated. First, the intervention lasted only six weeks, excluding initial training and the last week, which was for performing tests and questionnaires, which is a short period of time for students to adjust to a new approach, which requires independence and use of technology (Whillier & Lystad, 2015). These are considerable changes considering that traditional teaching in Saudi Arabia relies heavily on rote learning and memorization. Indeed, in in the majority of cases, the work of students depends on the guidelines from the teacher (Allamnakhrah, 2013). A longer intervention may bring about different results. Every teacher and student in this study was new to flipped instruction. Hence, within this specific context, we might need more time to see significant results in achievement level. The course outcomes could be affected by the previous experience of the FC approach (Lo et al., 2017). In other words, the experience of students who have learned through flipped methods may be different from those who have never experienced such methods before. Previous experience with the FC emphasizes the student-centred environment, which puts more focus on students' learning. When students become familiar with this environment, they become very self-sufficient and take the learning into their own hands (Ziegelmeier &

Topaz, 2015). This has been found to lead them to become competent learners (Bergmann & Sams, 2012). In addition, familiarity with the FC helps teachers as well; if teachers become familiar with this approach, this will help them to improve their instructional design on a regular basis, and this may lead to statistically significant differences in student learning and attitudes (Yong et al., 2015).

Implementing a FC for a longer period would be likely to increase the comfort level of teachers and students and it may help in reducing the novelty effect of the new approach. Mason et al. (2013) suggested that the FC needed to be implemented for a whole term in order for the full benefit to be obtained. Additionally, it is worth noting that each participating teacher had to teach using both FC (in the intervention classroom) and traditional teaching (for the control classroom). Although this enabled us to minimize teachers' influence in our analysis, it imposed an additional burden on teachers, which might have affected their teaching and, in turn, students' performance. Also, Saudi teachers' limited familiarity with the intervention and the technology involved (Alzahrani, 2019) could have exacerbated this effect – teachers' familiarity with a teaching method being an important determinant of students' learning and attitudes (Yong et al., 2015). In addition, the fact that teachers were teaching in both conditions might have led to contamination of the control group, potentially reducing the impact of FC in our analyses. Additionally, in this study we measured students' achievement using standardized tests, which typically produce smaller effect sizes and are less sensitive to the changes that occur during the intervention than teacher-designed tests (Sénéchal & Young, 2008). Using an outcome measure more aligned with the intervention could have enabled us to detect more subtle effects of FC teaching but would have reduced the external validity of the study. An additional important factor to mention is the study's context. Saudi Arabia has a relatively low average mathematics achievement (368 points) (TIMSS, 2015) compared, for example, to Hong Kong (594). It is strongly thought that the situational context – for example, the background of students or the school's location – where any interventions are introduced will influence the chances of success (Bell, 2014).

It is worth noting that the analysis of student performance for each teacher individually showed that teacher B's flipped group achieved lower proficiency scores than those of other teachers (see Section 5.1.2). It is shown that in teacher B's classes, the traditional group achieved better than the flipped group. This impacted the score for the cohort as a whole. This means that the FC showed improvement in three out of five schools, (A, D, and E), while teacher C's classes showed similar improvement in her traditional and flipped groups. This result may raise the possibility that students' characteristics or circumstances impacted the performance of class B. As she declared in her interview, teacher B faced some students' failure to do the required preparation and they needed a lot of re-teaching of some maths concepts. This issue of students' limited preparation before class time was documented in the literature as the most commonly reported problem in the FC implementation. The effect of the FC can be dependent on how well students are motivated to study in advance (van Alten et al., 2020). If a student does not study at home, they then may have a lower performance in classroom activities, which may reduce the advantages of the FC (Al-Zahrani, 2015). Therefore, this lack of preparation may have impacted teacher B's group learning in three ways: not getting the support of learning provided by the videos, not doing as many practical/ enrichment activities, and not covering as much of the curriculum, which would affect post-test performance. However, since no data was obtained which related to classroom practices, it is not possible to provide a clear explanation of this result.

In general, FC students in this study did better than the traditional classroom students, even though, averaged over the whole cohort, the achievement increases were not high enough to be statistically meaningful, they were promising.

## 7.2 How does mathematical self-efficacy compare between students who learn mathematics with the flipped class model and students who learn mathematics with the traditional class model?

In terms of the students' self-efficacy, the findings for schools A, B, D and E showed significant differences between the flipped group and the traditional instruction group, consistent with the findings of a growing number of studies, suggesting that the FC has a positive impact on students' self-efficacy (e.g., Kenna, 2014; Wiginton, 2013; Yorganci, 2020). The better performance of the intervention group was observed in both sub-sections of the self-efficacy questionnaires and that students who started with low self-efficacy benefited from the FC intervention more than those with higher initial scores. Because self-efficacy is someone's belief or expectation regarding their ability to complete a task or achieve a particular objective (Bandura 1986), the inference is that previous practice and instantaneous feedback from teachers and peers during mathematics tasks encourages students to form positive beliefs about their competence in mathematics.

Based on comments from the teachers, the researcher identified two primary factors that could contribute to this increase in the students' self-efficacy, attributed to the improved quality of student-teacher and student-student interactions, more feedback and active learning opportunities during class activities. The change in the classroom environment from direct lecture promotes more time for greater interaction between teachers and students, which could have a strong influence on the student-teacher relationship throughout the process (O'Flaherty & Phillips, 2015). Teachers mentioned that they became more available for more students to provide further clarification and feedback. This enhanced interaction could optimize the use of class time and help teachers and learners to cover more of the maths content, especially more complicated problems, in the flipped class compared to the traditional one, In the traditional class, little in-class time was available for in-class activities. Doing more of these activities in the FC could have given students more time to engage with different maths problems with the support of either teachers or other students. This interpretation would be consistent with social cognitive theory (Bandura, 1986) which suggests that altering the learning environment and giving students more possibilities in the difficult maths curriculum can help raise their academic achievement, thereby improving their self-efficacy. This change in self-efficacy will, in turn, lead to a change in conduct through motivation and effort that affects the learning environment. This is important since new teaching approaches often produce a sense of unease in students who are accustomed to the traditional approach to the lecture (Love et al., 2014; O'Flaherty & Phillips, 2015).

Another factor considered by teachers was related to the increased opportunities for active learning during in-class time, which was one of the main advantages of the FC from the teachers' perspectives. In the flipped environment, students are encouraged to work with their peers and participate in group discussion. In consequence, greater feelings of connection to their classmates and their teacher are likely to result in greater efforts to apply the ideals that were taught in a particular course. They enable students to observe peers who are successfully working through challenges and problems, and this could build the students' confidence that they are able to solve similar problems (Bandura, 1997; Schunk, 1991). Providing students with instant, authentic, constructive, encouraging feedback can motivate students to work hard to accomplish tasks and lead to increased autonomy and higher self-efficacy (Margolis & McCabe, 2006). Therefore, this study indicates that the FC could enhance the quality of interaction that students have with their teacher and with other students, for example, receiving comments from others, communicating with other students, answering student queries, discussing and commenting on ideas and group activities. All these interactions could have a favourable impact on self-efficacy, consistent with Bandura's (1997) assertion that verbal persuasion, and observing success in others, are two crucial factors influencing students' confidence in completing a task. In short, this finding showed that teachers managed to facilitate more involved and active participation by students in FCs in accordance with the constructivist approach, which enabled them to build their own knowledge through social interaction and collaboration. By engaging with their teachers and working with their peers in class, students may improve their own mathematical thought (Billings, 1997; Vygotsky 1978).

However, this was not the case with teacher C's FC group, which had lower self-efficacy scores than her traditional one (see Section 5.2.3). The qualitative data from teacher C could explain this finding. Teacher C indicated that she did not find the FC methods convenient because some students attended class without any preparation, which caused the *re-teaching* group to dominate the *exploring* group. This disrupted the class management in the flipped group, which led teacher C to adopt re-teaching for the whole class. Thus, her class may have perceived negativity regarding their failure with the FC. In addition, they had less opportunity to receive encouraging feedback from their peers. While a similar problem of unprepared students (especially with some complicated maths topics), was reported by another teacher (teacher B), teacher C, more than the other participating teachers, showed discomfort with the FC approach and she stated that because she was used to teaching with the traditional approach and her students were familiar with it, she would not continue flipping her class. This highlighted that teachers and students may not be equally receptive to new ways of teaching (Elmaadaway, 2018). Some teachers become accustomed to their normal teaching routine and they become resistant to change (Howard, & Mozejko, 2015). This behaviour can cause both students and teachers to be frustrated and this may lead to poor quality of the teacher-student interaction (Bergmann & Sams, 2012). Deviation from the norm (different styles of lesson presentation) sometimes causes students to feel unsettled. A sense of feeling uncomfortable within new learning structures is still an issue in the FC (Strayer, 2012). Another factor that may contribute to this discomfort, is the lack of parental support at home, which may lead to a lack of students' motivation to learn at home. A variety of research evidence shows that the home environment and parental involvement play a critical role in students' growth and efficacy (Castro et al., 2015). According to the responses in teacher C's interview, some students faced parental restriction of their internet access at home, which affected their preparation. This issue was reported in a 2016 study which found that students may not have much insufficient opportunity to use digital devices for out-of-class activities, due to parental opposition to their spending too much time using technology (Wang, 2016). However, research shows that when parents are supportive toward flipped learning, children are more likely to have positive attitudes (Oyola, 2016). The lack of parental support will be discussed in detail (see section 7.4.2.1).

Despite this, even though students in FC groups did not achieve significantly higher than the traditional instruction groups, the improved self-efficacy in four of the five classes demonstrates the possibility of progression for the future learning of mathematics. The strong confidence of students in their ability to learn mathematics assists them in constructing objectives so that they can complete online lectures, participate in group-based mathematics learning activities, and direct their learning activities (Winne & Hadwin, 2012). The researcher considers the improvement observed in self-efficacy to be particularly promising, considering the strong link that this construct has with other important academic outcomes such as students' motivation and the increased interest in STEM subjects (e.g., Winne & Hadwin, 2012).

## 7.3 Students' Perceptions of the FC Intervention

Concerning the students' perceptions toward their experience of learning in the FC approach, overall, the participating students were generally satisfied with the video lectures. Students appeared to appreciate that they could control the pace and frequency of viewing the instruction material prior to class. The most widely agreed reason for them valuing this pedagogical approach was identified as the ability to re-watch video lectures at any time to help them to gain a greater understanding. These results are in line with the findings of previous researchers including Lo et al. (2018), and Lopes and Soares (2018), among others. For example, González-Gómez et al. (2016) reported that almost 97% of students in their study thought that watching video lessons before classes was useful in helping them to achieve their proposed learning objectives. According to Muir (2020), students' ability to pause and repeat the lecture as much as needed allows them to learn more and increase their motivation to engage with the approach. Providing video lectures to deal with more routine aspects allowed students to monitor and review material or to "pause and rewind" the videos, which are other features frequently mentioned in the literature (e.g. Lo et al., 2017). This could help minimize cognitive burden by providing better support for students in learning material through learner-controlled video lectures. There was also strong agreement on the ease of use and accessibility of the video lectures and that the video lectures enhanced students' learning. This study shows that most students agreed that the videos designed by the researcher were easy to use, supporting the suggestion that it is convenient, effective, and easily accessible for students to watch videos as a means of preparation in the FC model. This affordance, especially, met the needs of autonomy and competence of students (Ryan & Deci, 2000) when they reviewed the mathematical material and gained skills in the topic, while the approach's accessibility and comfort allowed students to keep track of their learning and learn at their own pace without impacting the progress of other students with each topic. This positivity towards the video lectures may be attributed to the systematic steps that the researcher followed in creating the videos based on the video production guidelines of Guo et al. (2014) and Mayer's (2014) Cognitive Theory of Multimedia Learning (CTML), which provides guidelines for designing educationally effective multimedia materials. For example, the videos were designed to meet specific learning goals and guidance was followed on the structure of the videos in terms of length and content. Besides, the content was reviewed by all five participating teachers, which increased its validity and appropriateness. Further, using the Moodle app downloaded to the students' phones supported the learning process by making access to the out-of-class materials easy, flexible, and effective. The emphasis on the video design reflects the importance of design features documented in the literature, since some studies reported negative perceptions from students towards video design, which affected their overall performance. For example, it has previously been reported that students have had problems with excessively long videos, causing them to feel disengaged (Schultz et al. 2014). Also, the audio quality of some videos was low, which made listening to the teacher difficult for students (Moraros et al., 2015). In response to these issues, Al-Zahrani (2015) pointed to the importance of teachers designing instructional videos for K-12 students carefully and argued that videos should be carefully prepared to encourage greater participation and satisfaction among students. The effectiveness of the videos in the present study can be attributed to the care taken over such factors, and the efforts made to ensure that the videos were of excellent quality.

Furthermore, students also perceived in-class activities positively. Students perceived them as a useful way to enhance their learning, with most of them agreeing that the interactive, in-class activities applied greatly enhanced their learning. Eighty percent of the students indicated that they participated and engaged in the FC in-class activities. This may be attributable to the effective use of class time to engage students in different activities with the help of their teachers and peers. Further, this may be due to the greater amount of immediate feedback provided by teachers, since practice without immediate feedback can lead to frustration (Hattie & Gan, 2011). These results support those of Chen et al. (2014), Davies et al. (2013) Lo et al. (2018), and Song (2020) suggesting that more time to practise in the classroom and more feedback from teachers are major advantages of the FC approach, compared to traditional lectures.

It is worth noting that not all aspects of students' experience were positive. Most importantly, students indicated the lack of interaction with teachers at home if they needed more clarification on the presented materials. The only complaint about the video lectures in this study was that students could not ask questions about the video content if they needed more clarification, since teachers were not physically present when students watched the online pre-class lectures. In addition, although teachers provided online support for students through the Moodle platform, this seems not to have been enough for some students. This issue was also documented by Bhagat et al. (2016). This suggests that students in the current study needed more opportunities for interaction with their teachers in the out-of-class activities while they were watching the videos. This could have helped them to clarify immediately any ambiguity and uncertainty related to the materials presented in the videos. Interactive video lessons and online discussion forums are online communication tools (Sun et al., 2018) which provide opportunities for teachers and students to facilitate better engagement with the video content and enhance discussions. A study conducted by Chong et al. (2019) in China showed that interactive video lectures contributed to the improvement of conceptual understanding of the students in the flipped classes compared to those in traditional classrooms. A further issue with technology was found in the present research, namely, that some students experienced technical problems when viewing video material online. These issues could be individual to a particular student and relate to a lack of internet access or computer malfunction. This issue has been reported extensively in different studies from different contexts, such as Chen et al. (2016), Clark (2015), and Wang (2016), and more specifically, in the Saudi context, for example, Elmaadaway (2018) and Alzahrani (2015).

Additionally, in the present study, although the flexibility and convenience of access to the video lectures were confirmed as a potential advantage of the FC approach by students, a result consistent with earlier studies (Wanner & Palmer, 2015; Thai et al., 2020), nevertheless, this convenience did not translate into a strong agreement that video lectures were an efficient replacement for lectures. This is shown by the high level of neutral responses to items in the preference for videos subscale. For example, a quarter of students were not sure whether they preferred watching videos or teachers lecturing. These mixed feelings may reflect students' need for more support, due to the novelty of the FC and their lack of familiarity with it. Some students may need time to adapt to making greater independent effort to manage out-of-class learning and take responsibility for their own learning, especially in the Saudi context (Elmaadaway, 2018). These results are in line with Cilli-Turner (2015), who found that some students who enjoyed learning using the FC approach did not report that it was their preferred leaning method. Another possible reason why some students may not favour the FC approach concerns the design of the in-class activities, if full FC instruction was not implemented, with mini-lectures led by the teacher for students who did not watch the out-of-class component for various reasons or did not understand the content. Those students may still not be fully prepared to take full responsibility for their own learning, and they need support from the teacher. Evidence to support this claim was evident in the survey, when students showed a low level of agreement that individual access to lectures had increased their desire to learn the out-of-class materials.

Overall, the perceptions of the whole cohort of students demonstrated a trend towards perceiving positive effects of the FC, with most of the students in agreement that this course as a whole had been a valuable learning experience. Three-quarters of the students indicated their desire to take another flipped course. These results are in line with studies such as Zainuddin and Attaran (2016), which found that most maths students favoured the FC over traditional teaching. However, they are somewhat inconsistent with the results of Braun et al. (2014), who found that only a quarter of maths students preferred the FC to the traditional teaching method. Thus, some researchers (Lo & Hew, 2017) argue that it is vital to concentrate on careful selection of classroom teaching approaches and the creation of better active learning techniques within FC instruction, than to devote significant time and energy to developing online videos and other out-of-class materials. Although the current study did not find a correlation between students' perceptions of the FC and their achievement, the students in the study enjoyed learning mathematics with the flipped format. The positive overall impression of the course could have strengthened students' internal motivation and encouraged them to succeed (Xie et al., 2011). These positive findings are especially promising, considering the documented tendency of students to dislike changes in teaching methods (Chen et al., 2014).

## 7.4 Teachers' perceptions toward their experience of the FC implementation

This section presents teachers' perceptions of the implementation of the FC approach in mathematics education. Their perceptions are presented in two main themes: the potential benefits of the FC implementation and the challenges associated with the FC implementation. Generally, the qualitative results indicated that teachers agreed that the FC is likely to affect students' learning positively, and they perceived its effectiveness for enhancing their teaching practice in mathematics classrooms. These positive perceptions of the FC among teachers are consistent with those reported in previous research (Long et al., 2016; Wanner & Palmer, 2015). Despite that, teachers expressed some concerns and challenges associated with its implementation. The following sub-sections will present more details.

### *7.4.1 Potential benefits of the FC implementation*

In this section, the potential benefits of the FC based on the teachers' perceptions are presented in relation to the two main components of the FC, namely, the in-class activities and the out-of-class activities. These perceived benefits include the following: video lectures enhance students' learning, the value of assessment and the learning management system, the increase in active learning opportunities and interaction, and the potential of the FC to encourage differentiated learning.

#### 7.4.1.1 Video lectures enhance students’ learning.

The key purpose of the out-of-class learning components were to recall previously covered context materials, add some basic information, and prepare students for interactive in-class work. One of the important components of the FC is using videos as a medium of learning outside the classroom. Those videos are used as a means of introducing students to the basic information on a topic before they come to the class sessions and engage in more complex activities. According to the teachers, video can bring a variety of benefits to students, including improving cognitive and psychomotor aspects of students learning. The cognitive side is the recall and reinforcement of learning skills. Teachers stated that the videos could enable students' understanding by helping them prepare for the assigned tasks, which may improve their retention. At the same time, the psychomotor aspects, which are difficult to practise, can be done repeatedly through individual learning, enabling students to monitor their learning. Teachers indicated that the ability of students to access the videos at their convenience enabled them to re-watch, rewind, and pause material as needed. This is particularly useful in learning mathematics, especially in complex mathematical problem-solving activities that require more time for students to assimilate the content (Lo & Hew, 2017).

For these reasons, videos in the FC give students more flexibility in their learning, which in turn could enhance their understanding. This finding corroborates the results of Long et al. (2016), who suggested that pre-class videos help to improve convenience and to strengthen the conceptual comprehension of students. Teachers, according to Evans (2014), have noted that videos can be used to aid students’ learning in the clarification of complicated ideas and difficult concepts because students can watch videos many times to improve their capabilities by improving understanding. Teachers use videos to present new lessons, but students can also utilise them as a learning aid to supplement their learning. Teachers have argued, for example, that videos allow students to revisit previous lectures (Long et al. 2016) and can provide additional support for individuals requiring special skills or students who have been absent due to illness (Herreid & Schiller, 2013).

Further, teachers argued that videos help students avoid the shame of asking questions in class by allowing them to go back and watch the material. Students may use videos to unpack complex mathematical processes, obtain accurate and valuable information and reinterpret the information to make it understandable to themselves. Their concerns were reduced, and their work quality and output improved (Lopes & Soares, 2018). Furthermore, watching and reviewing videos allows students to track their own learning, which may facilitate the transfer of responsibility for learning, and eventually encourage further learning.

#### 7.4.1.2 The value of assessment in the FC.

Despite the essential role of pre-class exposure to video lectures, teachers indicated that the videos in themselves are neither essential nor sufficient. They asserted that FC requires more than just simply a pre-class video experience. Their concerns came from the belief that in mathematics learning, watching a video is not sufficient for students to properly consolidate their understanding and they need some sort of quiz activities to ensure their full engagement with the content presented. Therefore, the teachers emphasised the essential role of assessments in the flipped approach, including online follow-up exercises after watching video lectures and pre-assessment at the beginning of each flipped class. Their view, consistent with Lo et al. (2018), was that these quizzes are essential for preparing students to be ready to collaborate in in-class activities.

The teachers believed that engaging with pre-class activities is crucial in order to establish foundational knowledge that allows students to take advantage of the active learning opportunities that occur in the face-to-face sessions. Their views coincide with the suggestion by FC researchers such as Bishop and Verleger (2013) that creating tests has the benefit of encouraging students to finish the necessary work before class, so introducing quizzes would increase their understanding and help them to learn. Therefore, students should take full responsibility for their own learning and take full advantage of the materials presented on the videos and quizzes; by doing so, they will be able to function more effectively in the class activities. The benefits of adopting quizzes have previously been reported in the literature. According to Van Alten et al. (2019), the FC achieved higher learning outcomes when quizzes were added to their design. This is in accordance with Bloom’s taxonomy (Bloom, 1956) of thinking skills; the FC allows students to access the lower-order cognitive skills involving remembering and understanding in their own time at home and provides the opportunity for them to practise knowledge in class time by engaging with their teacher and peers in more challenging tasks, involving higher-order cognitive skills, including applying, analysing and evaluating. On this basis, a policy of introducing a quiz before class events was implemented in order for teachers to monitor students' video viewing and ensure that they had had sufficient opportunity to experience new course materials prior to attending class in person. Since this current study provided instant computerized feedback to students following their completion of out-of-class quizzes, students could check their answers and correct any inaccurate first responses (Epstein et al., 2002). This feature was appreciated by most of the teachers, and they highlighted the importance of designing quizzes with immediate feedback because it is critical for students to know whether they have answered a question correctly. This helps them to avoid frustration and encourages their confidence in their performance in the out-of-class activities, which in turn helps them to come to the class session with a high level of self-efficacy. Immediate feedback helps students actively construct knowledge.

Another type of assessment emphasised by teachers in this study was pre-class assessment before the in-class activities took place. Teachers appreciated the benefits of in-class quizzes at the beginning of the face-to-face sessions as these helped them to recognize how well students understood the pre-class materials. This result is consistent with that of Lo et al. (2018), where the three teachers who participated in their study from different disciplines, maths, computer science and physics, favoured such quizzes. It also supports Kim et al. (2014) in their assertion that in-class quizzes completed by students to prove their FC readiness are essential tools that assist both the teacher and students in assessing classroom comprehension.  Assessment results aided teachers in recognizing students' areas of competence and any need for additional knowledge. This is in line with Merrill's (2002) activation principle; students' learning was promoted because they were better able to recall the necessary basic concepts and skills, which provide a firm ground for the construction of knowledge. In addition, the teachers emphasised that the students' performance in pre-assessment could inform their in-class practice, in accordance with the principle that activation of pre-class learning. Students' understanding of flipped mathematics is critically important in developing their understanding of mathematics (Lo & Hew, 2017). A key benefit of such assessment is the potential to encourage students to have a greater degree of confidence in their ability to learn maths. Bandura (1986) contended that feeling good about yourself has a lot to do with succeeding. Students' mathematical trust can be built up by selecting and structuring online lectures and quizzes that suit their mathematics learning level so that they experience success early on, and confidence to learn advanced topics later is developed.

#### 7.4.1.3 Learning management system benefits FC.

Another aspect of the FC design adopted in the current study that was perceived favourably by teachers was the use of the Moodle LMS as a platform for the out of class activities. Using such a platform to organize the out-of-class component can help to design a good learning experience for both teachers and students. Teachers agreed that Moodle facilitates interaction with students and content, as well as convenient access to online course materials, and helped in the management of various activities associated with teaching and learning. It offers a flexible and convenient learning environment, as students could watch the course videos on the Moodle app using their smartphones, which encouraged mobile-friendly learners. The majority of the students enjoyed interacting with online materials via their mobile phones. This result supports Strayer's (2012) claim that in a FC using an LMS platform, students are able to download course materials posted on the LMS platform or emailed to them. By doing so, students engage in a variety of activities in class, such as sharing their thoughts and communicating with others in order to improve their comprehension of the downloaded course material (Strayer 2012). This result is also consistent with Kuh's (2009) finding that academic institutions can promote a successful learning culture by developing platforms that improve both student-staff interactions and student-to-student collaborative learning, eventually improving students' learning interest and achievement.

Tracking students' performance was another benefit of Moodle identified by teachers. Teachers claimed that this feature was very important in the FC environment because teachers could easily keep a close eye on the students' performance in the out-of-class activities, identifying any student who was not participating and, if necessary, sending her a message through the portal to encourage her to do her homework. The value of using a learning management system to track students' online behaviour was emphasised by Lo et al. (2017). It solves the problem noticed with some research such as Muir and Geiger (2016) and Sahin et al. (2015), these findings depended on the self-reported learning effort data of students, and so is not verifiable and dose not provide objective information that can be used for inform teachers' decisions. In contrast, by using online data from Moodle or another LMS, teachers can get a better understanding of students' performance in the out-of-class activities. Teachers in this study asserted that when designing an FC, teachers should carefully evaluate how instruction and course material would be delivered to students. Integrating an LMS improves course management and is conducive to better students' and teachers' experiences.

#### 7.4.1.4 FC increases active learning opportunities.

Teachers in this study experienced a high level of active learning opportunities in the classroom practices, which helped them to implement different learning modes. Active learning has emerged in numerous different studies as an important feature in FC implementation that enhances students' learning (Bergmann & Sams, 2012; Bishop & Verleger, 2013; Chen et al., 2016; Jensen et al., 2015). One of the main reasons why the FC method worked so well for the teachers in this study is that it moved some of the rote learning practice outside of and prior to class sessions, freeing up precious face-to-face class time for applied learning pursuits. This reflects a change in the learning culture, characterized by the transition of teaching from a centred teacher to a centred student. It is important to note that there is a significant difference between classes where the emphasis is on teaching and classes where the emphasis is on learning. In a student-centred classroom, the emphasis is on learning rather than presentation, and students work collaboratively in small groups to address tasks. Students in the current study were encouraged to take an active role in discovering, sharing, and co-constructing information in the FC, for example, by participation in classroom activities. In addition, this study suggests that the participating teachers recognized effective group learning activities and considered the FC as a good approach to encourage students' participation in group work. This could be because students came to the class with pre-existing knowledge of the main topic, which gave them the motivation and confidence to participate with other students in the group activities, instead of being left behind. This is in alignment with the findings of previous studies examining why students were more engaged in active learning opportunities in the FC environment (Missildine et al. 2013; Roehl et al., 2013; Jensen et al., 2015). It was found from this quantitative data that students had a high level of agreement that the learning activities in the class were interactive, and greatly enhanced their learning. The teachers in this study confirmed that students in the FC group seemed to have more opportunities for discussion, checking their answers with each other, arguing with other students, and working effectively in groups. The findings are consistent with previous research in mathematics classrooms (Cronhjort et al., 2018; Lo et al., 2018; Wilson et al., 2013; Yorganci, 2020). Teachers reported, consistent with Gillies et al. (2003) that group learning offered richer opportunities and inspiration for learning and encouraged a collaborative environment. This in turn, promotes more knowledge sharing, more support among group members, more innovative thinking, and more peer impact, leading to greater productivity (Cockrell et al., 2000).

Peer learning is another identified feature of the implementation of the FC approach. According to the teachers, the FC could facilitate peer instruction since students are more comfortable when they work with their peers in the FC classes compared with the traditional classes. When students of various abilities get together to better grasp a piece of work, they are helping each other to succeed. Peer learning is an immersive form of teaching that promotes in-class interactivity to involve students and discuss subjects that are challenging for them (Mazur, 2013). By allowing students to explore topics in class, the FC promotes peer learning. However, for the method to function optimally, students must come to class with a basic understanding of the concepts. In collaboration with competent, generous, and capable peers, students will teach each other (Vygotsky, 1978). The design of in-class activities may support peer learning, since the students in this study were divided into two groups, a re-teaching group and an exploration group, and students were grouped with others who had the same level of understanding of the out-of-class materials. This could help to create a good environment and confidence among students and help them to work together to achieve their course objectives. This way of learning helps students to be more involved, which is beneficial to their education and makes them better able to make practical use of their knowledge and skills than conventional learners. The essential role of peer learning in the FC environment is emphasised in the literature. For example, a recent study by Lo and Hew (2020) found that increased peer participation in the flipped class increased students' mathematical achievement and cognitive involvement. Thus, the FC creates a structure that is very complementary to the constructivist learning environment. Students may shape their own learning experiences at home by watching, listening to, or reading lectures and content-specific material. The exercises organized by the teachers help them to connect with their peers and process data more thoroughly and apply the skills that they developed at home when they return to class the next day. The teacher is around to help students confirm or correct their interpretations in this process. The findings are in line with the work of McCollum et al. (2017), who found that students in the FC demonstrated better relationships with their peers. As a result, they gained greater knowledge and appreciation for learning, which stimulated them to pursue even more learning. In the current study, the students' appreciation of the FC experience was evident in the high agreement with the item suggesting that the FC course as a whole had been a valuable learning experience for students.

The FC design in this study still employed lectures of a kind. These lectures were in the form of mini lectures for those who did not understand the key content of the videos and were assigned to the re-teaching group based on their pre-assessment performance. Whilst this did not entirely reflect a constructivist-based classroom, compared to traditional teaching, it allowed for more student dialogue and hands-on activities during class, all of which are constructivist-based teaching concepts (Seimears et al., 2012). Data from the current study also supports previous research suggesting that short in-class lectures are still needed for explaining the more complicated concepts and to support struggling students (Van Altin et al., 2019; Lo et al., 2018; McLaughlinet al., 2013). For example, van Alten et al. (2019) found that student satisfaction was higher in FCs that included lecture activities than in FCs that did not include lecture activities. Teachers in the present study indicated that some students attended class without being prepared for various reasons such as technical problems downloading videos, so it was helpful for them to take part in a small group with other students in a similar situation and engage with the content in more detail, with direct teaching. In a more interactive setting, the participating teacher may illustrate and expand on these materials. With more time to learn difficult things in the classroom, the teachers were also able to provide much easier direct guidance in the classroom.

#### 7.4.1.5 FC increases interaction.

Teachers appreciated the advantages that the FC offered to maximize the class time, prepare students for class activities and increase interactions among students and between teachers and students. Teachers emphasised that different forms of interaction could be facilitated by the FC environment, including teacher-students, student-teacher and student-student interaction. The teacher's behaviour in asking questions, giving directions, acknowledging feelings, praising or supporting, accepting or using student ideas, and criticizing or justifying authority may be seen as contact between teacher and students. Students' behaviour, such as students' talk-response and students' talk-initiation, revealed the student-teacher relationship. Many researchers argue that the more the initiative comes from students in classroom interaction, the more learning takes place (Clark, 2015; Ziegelmeier & Topaz, 2015). Interaction among students is equally significant, as it allows students to practise newly introduced items in a lively and encouraging environment. Students see pair practice as a constraint-free operation, one that is not under the teacher's supervision. They feel as though they are in the real world, which increases their enthusiasm, self-confidence, and self-efficacy. As a result, a student’s efforts to ask a question, either to the teacher or to their peers, is likely to promote a learning environment in which both the initiator and responder benefit from the conversation. The personal contact between the teacher and the students was far more common and rewarding than in the traditional class. Chen et al. (2015) reported that the use of the FC method enables teachers to spend more time with students and to understand better their moods, styles of learning, and individual requirements.

As there are greater opportunities for group collaboration with their peers, and on a one-to-one interaction with the teacher, the FC provides teachers with the ability to turn the classroom into a more engaging and animated environment. The FC places a strong focus on the growth of students' learning skills and capabilities. Students improve their personal and interpersonal skills, capabilities and dispositions, and think creatively and objectively by being involved in active learning contexts. In contrast to a conventional mathematics class, the FC model encourages teachers and students to get more involved both in and out of the classroom. These results are similar to those of Lo et al. (2018), Bruan et al. (2014) and Mason et al. (2013), suggesting that by reducing lecture time and increasing student interaction time, teachers can involve students in more critical thinking, constructivist-based practices. The enhanced contact between teachers and students is an additional advantage of the FC. The teacher serves in a constructivist classroom as a student guide by asking open-ended questions and facilitating dialogue by tasks; teachers must be able to relinquish classroom authority and encourage student autonomy and initiative.

Additionally, the teachers in this study agreed that the FC enhances opportunities for feedback. The increased interaction in the FC opens windows for effective feedback from teachers, who are no longer confined to the front of the classroom, as the 'sage on the stage', since the lectures are delivered via video. Unfortunately, in a typical classroom, students only get a few minutes of clear, individual input each day (Siegle, 2014). Flipping the classroom allows teachers to devote more time to providing students with the targeted input they need for optimal academic development. They can move around the classroom and answer questions as the 'guide on the side'. In this way, teachers are able to give more insightful feedback, identify student misunderstandings at an early stage and provide prompt clarification, as they engage with students immediately after they have learned the course content (Kim et al., 2014). Having students engage with the basic knowledge of the subject before class, by watching videos, helps teachers incorporate more advanced activities and provide instant feedback in class, facilitating successful knowledge transfer. Continual, immediate, and detailed feedback is required, as students are conscious of their limitations and strengths.

#### 7.4.1.6 FC could encourage differentiated learning.

Based on the perceptions of the teachers in this study, in a traditional classroom, it can be difficult to fulfil the needs of all students, but the teachers perceived that these differing needs could be met in FC instruction. There are several possible explanations for the differentiated instruction that happened in the FC classroom in this study. First, Gilboy et al. (2015) point out that access to knowledge in various formats and the inclusion of different learning activities support the various preferences of students, enhancing their learning experience. This speculation is supported by the teachers' views in this study. They perceived that students' exposure to various learning activities in different formats online or in the face-to-face sessions, helped them to understand the mathematical content presented in a more comprehensive and a differentiated environment. In addition, it seems that as a result, the teachers could design the classroom activities deliberately in line with several levels of student performance (Altemueller & Lindquist, 2017). That is, the teacher could perform various activities allowing students to work with the same material, basic insights and skills, yet with different levels of complexity and ability in the FC. In this study, students were able to advance at their own speed, with teachers providing extra material to enhance the student learning experience and quickly monitoring those who required less repetition (Siegle, 2014). To elaborate, teachers asserted that students could watch the videos or perform the activities in accordance with their own needs and preferences. Higher achievers were not held back by low achievers, since the class design could help them to practise more complex mathematics content with the aid of the teacher's presence. Lower achievers also benefited from the repetition from the teacher and from working on different activities with the support of their peers and teachers. The teachers were able to offer immediate feedback on learning and differentiate their teaching and materials according to the needs and timing of the students. The design of the in-class activities promoted the differentiated instruction in the FC. This study applied different classroom management strategies, in which students were divided into two groups, each group with different learning abilities and the teachers came to class with sufficient knowledge about their students' understanding of the content because of the assessment being carried out before engaging in the in-class activities.

What is interesting is that teachers indicated that the low achievers could be particularly helped by being in the FC group, confirming previous results by Bhagat et al. (2016) and Nouri (2016). This could be attributed to the low achievers' greater confidence gained from the use of video as a tool for learning, which helped them to have more chance to learn at their own speed. This interpretation is in line with Nouri's (2016) finding that, out of 240 university students, low performers were slightly more favourable than high performers in their attitudes towards using videos as learning tools. It was suggested that, whereas in conentioal teaching, students who received no educational encouragement at home struggling with homework tasks involving the highest levels of Bloom's taxonomy of thinking skills without assistance. In contrast, with the FC, they had relatively straightforward tasks at home and could perform activities regarding higher-level skills with the assistance of their teachers and peers. This could improve low achievers' confidence while working on the mathematics activities in the classroom. The quantitative results of this study support this claim, since they showed that students who started with lower levels of self-efficacy tended to finish the FC intervention with higher levels of self-efficacy compared to the high achievers.

Another important point made by the teachers in this study is that they believed this method of teaching could support those students who are self-disciplined and have a strong desire to master complicated mathematical concepts and exercises. Teachers found plenty of time to engage higher achievers with higher-order thinking, and problem-solving activities because they knew that they had already grasped the main content from the videos so they would not be held back by other students. Indeed, higher achievers or faster learners were no longer bored in the classrooms, waiting for their classmates to catch up, but instead could participate in advanced classroom activities. Students feel empowered when they complete higher-level assignments with their teachers, because, now, students determine important knowledge, correlate it to experiences in real life and share it with their peers (Kivunja, 2015). Thus, the FC gave students the freedom to learn at their own pace. Students who needed to repeat materials had discretion over how many times they used the re-teaching options. Certain students could benefit from the availability of additional enriching content. Students who learned at a quicker rate, on the other hand, benefited from enrichment as well as the opportunity to stay ahead of the group. The more able students could skip the parts they already knew, while struggling students were able to revisit the videos frequently.

Furthermore, the online part of the FC is considered an important feature that supports self-learning by enabling independent learning to happen effectively and simply, by providing students with independence and flexibility, and allowing them to take more control of their learning (Enfield, 2013; McLean et al., 2016). Teachers indicated that students in the flipped group showed a sense of independence during the intervention and confirmed that the FC could help students to be self-learners. Giving students the opportunity to learn the basic materials outside the classroom allowed them to express themselves and provided them with invaluable, rich, independent learning content, which enabled them to direct their own learning. Some aspects of the study design were particularly effective at enhancing students' self-learning, such as the online quizzes that investigated students' self-learning success (Cohen & Sasson,2016). These results are consistent with Lo et al. (2018) and show that FC learning can support students in intentional knowledge building and the use of successful learning strategies. In addition, it could be argued that this type of learning strategy, implemented in the FC, offers a strong framework for learners to track and assess the most suitable learning strategies for their personal learning processes. The results indicated, however, that pre-class learning activities must achieve specific objectives and allow pace-based self-interest in order to maximize attention and effort. Although teachers provide differentiation in order to support students, students themselves need to be responsible for their own learning and make sure that they take time so that this can happen (Carbaugh & Doubet, 2015; Sun et al., 2018)

#### 7.4.1.7 FC enhances teaching efficiency.

It seems that the positive effects of the FC approach on teaching practice may have extended to enhancing teaching efficiency in the mathematics classrooms. This was evident when teachers specified the FC helped them increase content coverage in the flipped maths classroom compared with the traditional classroom. As ICT is authentically incorporated into mathematics instruction, it becomes successful and useful in content delivery (Burns, 2007). In FC groups, all lectures were given online by Moodle and could thus be used more efficiently than in conventional classrooms, since moving this component online freed up class time for other purposes. Mathematics at secondary school level is very intense, and it can take a long time to engage with the materials. In Saudi schools, mathematics lessons are generally 45 minutes long, making it difficult for a teacher to attend to all learners in a particular lesson and to practise different mathematical concepts in the allocated timeframe. Teachers explained how they struggled with the lack of time in the traditional classroom and how this problem was reduced in the FC community, as they had more time in class, enabling them to do more mathematics practices. The previous findings are confirmed by the qualitative data:  the FC is one type of active learning that provides a solution to the problem of curriculum coverage by moving lessons out of the classroom in the form of homework, so in class time is used for content execution and processing (Clark, 2015).

Another important point expressed by teachers is that teaching in the FC group was more comfortable and less stressful than in the traditional group, because they were less concerned with establishing and following the educational plan. This finding is consistent with the views of teachers participating in other studies such as Ziegelmeier and Topaz (2015). The finding shows that teaching in the FC was perceived as much easier and less rushed than attempting to cover the material in the conventional course. During the flipped session, students seemed more interested. Additionally, teachers believed that coming to the class with advance knowledge and expectations of the students' performance with the pre-designed activities could play an important role in enhancing teachers' confidence, which in turn may be reflected in their teaching practices in the classroom activities.

### *7.4.2 Challenges to FC implementation*

While the teachers did not indicate any negative aspect of the FC approach, they all agreed that the approach poses some challenges that might affect its implementation. It is notable that teachers in this study indicated that they faced two types of challenges, challenges that faced them during the FC implementation in the current study. They also mentioned other challenges they thought they might face if they decided to flip their classes in the future. Teachers asserted that students' lack of motivation of towards the out of class materials, and lack of a robust infrastructure, including internet connection, could affect students' preparation for the class activities. In addition, lack of time and increased workload, lack of familiarity with the FC, and the need for support and training could affect the teachers' willingness to implement this approach in their teaching practice. The following sections will shed light on all these challenges in detail.

#### 7.4.2.1 Students' lack of motivation.

In most previous studies, it was found that the advantages of the FC approach depended on the students' ability to attend classes well prepared for successful in-class learning. The results of this study support the results of previous literature, which found that some students lack the motivation to do pre-class work. The explanations offered for this negligence, however, differ from one study to another. Some studies have suggested that students were not properly prepared for the FC approach (Porcaro et al., 2016), while other studies demonstrated that there was weakness in the design of the course resources and materials (e.g., Alzahrani, 2015). In addition, students need guidelines and help at home (Wanner & Palmer, 2015; Chen et al., 2016). In this study, however, the teachers attributed the students' lack of motivation to three possible reasons, namely, lack of motivation towards studying maths, students not being well prepared to learn and take responsibility for their learning as independent learners and lack of parental support at home. This finding is consistent with some previous research including Van Sickle (2016) and Sletten (2017). Previous writers have described Saudi Arabia's K-12 education system as teacher-centred, with an overemphasis on rote memorization (Rugh, 2002). Indeed, high school students are accustomed to memorizing information and are required to produce textbook-style answers in written exams. In contrast to Western learning methods, independent problem-solving methods and innovations in group work are rarely promoted. Additionally, in Saudi Arabia teachers and textbooks are considered the main sources of information and are often the only sources.

Allamnakhrah (2013) characterized Saudi Arabia's conventional teaching philosophy as one where students must memorise information without reflecting, synthesising and analysing. As a result, students do not normally have to think deeply, check and generate responses, and are not accustomed to exerting effort to respond to higher intellectual demands, as required by the FC. Being accustomed to an atmosphere governed by teachers could deter learners' autonomy. These conclusions highlight the cultural considerations raised by incorporation of technology, particularly the cultural position of teachers in Saudi schools, alongside conventional didactic education, which still establishes teachers as the authoritative figure in the classroom organization. Other participants suggested that the prescribed curriculum did not properly foster the critical thinking and problem-solving skills necessary to learning. In this environment, learners have little freedom or autonomy in the learning process, so becoming self-regulated learners is difficult for them.

Another important reason that could contribute to some students' lack of motivation in this study is the age of the students. Most of the research that has been done in high school settings indicated that students' low level of motivation was a challenge to the FC. This makes it worth considering the lower cognitive development of high school students compared to undergraduate students (Piaget, 1964). Bryce and Whitebread (2012) argued that older students value tasks more than younger students, and the metacognitive skills and abilities of older students are different from those of younger students due to their previous experiences. It is probable that less advanced, younger students who are less cognitively developed require greater teacher guidance; therefore, the FC's more student-directed approach may be ineffective at increasing their level of motivation. Students in secondary schools may lack the autonomy to learn the content effectively (Jensen et al., 2018). Research reveals that many students are less than ready for FC training; first-year university students were less ready to learn than those in their third year (Hao, 2016). These findings led Hao (2016) to identify specific qualities such as self-directed learning skills that need to be practised to better prepare students for the student-centred nature of the FC environment.

Additionally, teachers indicated that the lack of parental support may pose challenges for students to be effective learners in the FC. Students whose home environment is not supportive may lack motivation. A variety of research evidence shows that the home environment and parental involvement play a critical role in students' growth and efficacy (Castro et al., 2015). Parental encouragement could have a huge impact on expanding the FC model (Wei et al., 2020). However, there is some evidence in the literature that some parents are not comfortable with the method (Collins, 2017; D'addato & Miller, 2016) as they consider viewing videos at home to be unacceptable. This lack of understanding means doing homework or studying may not be encouraged by parents (Goodnough & Murphy, 2017). Some parents in this study restricted their daughters' access to the internet at home, which posed a unique challenge for students' learning at home. According to the teachers, this was because most of the parents came from a background in which traditional teaching methods were predominant in teaching and learning. Hence, they had been not exposed to ICT at home during their school days. Their understanding of the FC was restricted due to their limited understanding of technology. Such parents appreciated the traditional teacher-centred approach and thought that the way they had learned, by reading and writing from textbooks and handouts, was also the best way for their daughters to learn.

This finding is consistent with previous authors' arguments that some parents can see technology as disruptive for students and as an instrument that can divert their attention from the content. This concept was discussed in the literature by contrasting the understanding of so-called "digital immigrant" parents, with that of "digital natives", which Prensky (2001) describes as the new generation of young people born into the digital age, and more able to adjust to their environment. However, they retain, to some extent, the old-fashioned way of doing certain things (Prensky, 2001). While watching video lectures and answering quizzes as homework may not take more than half an hour to finish, some students may not take things seriously, which may lead to some parents being uncomfortable with the FC learning environment, as their children may be interacting with technology most of the time. Bittman et al., (2011) have noted that behavioural changes resulting from technology use could lead to misunderstandings between digital natives and immigrants. This lack of awareness by parents was the consequence of the constant use of technology and of the distinction between using technology for educational, recreational, and social purposes. Instead of students preparing for the class, they may be surfing the net or playing games online, which puts their parents under pressure to supervise and control their learning. This underlines a lack of understanding of the FC by parents who may believe that the teacher does not teach their child and students are merely searching for random knowledge on the Internet. Therefore, digital immigrant parents need more knowledge in order to better help their children understand the FC (Medone, 2019). Parental engagement and supervision are critical during out-of-class student education activities (Wei et al., 2020). Those issues were evidenced extensively during the covid-19 pandemic, and Mann et al. (2020) concluded that students in Saudi Arabia are unlikely to have easy access to a computer and internet connection at home.

#### 7.4.2.2 Lack of robust infrastructure.

Availability of a robust infrastructure is a primary consideration when making adecision to implement a FC in an environment of resource scarcity. Most low-achieving countries suffer from an old-fashioned education infrastructure and limited availability of required resources (Westbrook et al., 2014). At the students' level, the results showed that all of the students who participated in the study had access to either a computer, laptop or mobile phone, the latter being the most common. This was not surprising, given the fact that the participants were high school students and they owned mobile devices. Using mobile phones was much appreciated by students as it gave them confidence and flexibility. However, teachers raised concerns that some students may have to share technological devices with other family members because of the lack of different forms of devices, which raises the issue of access to learning at home. School students must have access to computers, technology, and a high-quality internet connection to be able to access a FC. There are some issues associated with access to technology for students from lower-income families because they might not have the necessary funds (Li, 2018). Additionally, some areas have a poor internet connection so they cannot stream videos, which would clearly inhibit flipped learning (Milman, 2012).

At the school level, there were teacher worries about the lack of necessary facilities for use by teachers and students (such as laptop computers, tablets, and mobile devices). The researcher was very keen to choose schools that represented the current state of typical Saudi schools, instead of choosing those with particularly good technological infrastructure, which are usually either international or private schools, although some public schools are fortunate in this respect. In fact, in this study, only two classrooms out of ten had access to an interactive whiteboard, and most schools did not have enough technological devices such as laptops, iPods, and computers for students' use. Schools lacked technological devices that were available to be used freely by students who had problems with access at home. Teachers indicated that the computer lab was the only place that students could use computers or laptops, and they needed permission from the school administration or computer teacher whenever they wanted to use it. Without this equipment, it would be difficult to incorporate flipped learning in education. It is important to note that all the participating schools were from different parts of the city, and students were from different socio-economic backgrounds.

Another issue identified by teachers was the lack of a stable internet connection in students' homes. While Saudi Arabia's households are mainly Internet-accessible, there is still a digital divide between the wealthiest households and those with lower incomes. Although the researcher ensured that all students who took part in this study had internet connectivity, some students had to be given a prepaid internet card to enable this. In general, teachers were concerned about those students living in poor or low-income areas, who mentioned having difficulties being able to access the internet because of their location. The issue with internet connection is widely mentioned in other studies examining the effect of the FC in different contexts (Milman 2012; Li, 2018; Şen & Hava, 2020). Teachers highlighted that some students experienced faulty internet connections, which caused downloading the videos to take longer and this sometimes frustrated them. This highlights the need for a strong internet connection, given the fact that the FC depends mainly on online video lectures.  When introducing the FC, video access must run smoothly. Strayer (2012) emphasized that students should not spend more time troubleshooting technology problems than on assignments. In other words, technology must function properly and not hinder students from viewing videos and completing their assignments. Participating teachers even pointed out that they brought their own internet connection to school because the internet connection in school was not strong enough to accommodate all users. Thus, the FC requires additional support to function properly.

The issue of lack of internet connection and technological devices essential to the FC implementation may raise the issue of the digital divide concerning unequal access to technology caused by differences in socio-economic status (Bittman et al., 2011). How to teach in a classroom or district that faces a digital divide is a serious concern. The present study confirmed this as a significant issue. When students lacked digital technology or access at home, this appeared to put extra pressure on the teachers to provide them with such access or persuade their parents to do so, by convincing them of the advantages of the FC approach. Low-income students may particularly struggle with access deficit or internet stress (Chaudhuri, 2005). In the present research, only limited demographic data were collected so it was not possible to ensure that those living in areas of poverty were not impacted by internet access issues, which could then generate online access problems, depending on students' financial circumstances. The study confirms that the FC could inadvertently establish a divide caused by the gap between those who had access to internet connection and devices and those who did not. This digital divide could obviously affect the overall level of comfort and performance of students in the flipped learning environment (Altemueller & Lindquist, 2017). Teachers suggested that school administrations could face this challenge of providing equal opportunities for all students by initiating a project to fund provision of digital devices, which the school could lend out with connectivity to support students’ learning. Closing the digital divide, however, requires much more than purchasing equipment, providing a reliable internet connection, increasing teachers' awareness and skills, using technology and access to digital resources in the community (Riel & Schwarz, 2002). Teachers should take the socioeconomic status of students into account and provide students with IT support in order to facilitate the introduction of flipped classrooms. Teachers, for example, should make more use of digital resources at school (Schultz et al., 2014).

#### 7.4.2.3 Lack of time and increased workload.

Another challenge that might face teachers if they want to implement a FC is the lack of time and increased workload. This study’s finding concurs with other studies in different disciplines in education, that teachers believe that creating an FC requires a considerable amount of initial work, certainly more than the traditional classroom model (Lo & Hew, 2017; Cevikbas & Kaiser 2020). For example, Lo and Hew (2017) found similar results and noted that producing content increased the workload for teachers for both digital and classroom activities. In fact, a mathematics teacher who participated in a recent study by Cevikbas and Kaiser (2020) indicated that she would not consider teaching mathematics using a FC approach. Among the issues she mentioned was the increasing workload from designing videos. While teachers in the current study were provided with all the learning materials, since the researcher created all the video lectures, online materials and managed the Moodle learning management system, teachers were concerned about the likely increase in their workload if they decided to continue flipping their classes. Designing video lectures and dealing with the technology involved was one of teachers' main concerns, because such skills were not part of their regular training. Designing videos needs technical skills which teachers would need to learn in order to create high quality educational videos that suit their students' learning needs (Kim et al., 2014). Such skills include how to design videos using specific software, recording and editing skills, and the video transfer process. It is worth noting that mathematics may require the creation of more videos than other disciplines. Teachers indicated that in maths, they might need to create more videos for each topic compared to other disciplines, due to the nature of mathematics, where teachers had to teach new concepts in each class. Even though there are many videos available online for teachers, teachers indicated that they would need to spend time evaluating all those videos and perhaps making changes by editing those videos or adding some elements to them to make them suitable for their students. The use of videos posted on various online platforms, not screened by any mathematician, can pose problems concerning the validity of the material (Schultz et al., 2014). It should also be noted that the teachers in this study were all female and were concerned that an increased workload would affect their ability to care for their families and fulfil other responsibilities at home. Therefore, they felt that adopting the FC and having to undertake additional work such as tracking the online environment and preparing materials for in-class and out-of-class activities could negatively affect their home environment and put them under pressure. The teachers believed it was onerous to work from home and be constantly connected with the students' outside learning.

#### 7.4.2.4 Lack of FC familiarity and teachers' beliefs.

While teachers had indicated earlier that they felt comfortable teaching in the FC, the uncertainty of teaching in FCs for the first time made them quite unsure about their future plans to adopt the FC approach. Further, one teacher indicated explicitly that she would not continue flipping her classes.  One possible explanation for this hesitancy among teachers might lie in their perceived deficit in the requisite technological skills for FC implementation.  Indeed, teachers' lack of technological skills led some of them to indicate that they would continue flipping their classes, but they would use a more acceptable alternative to Moodle such as WhatsApp, which would not require a high level of IT skills.

While teachers in the current study expressed a lack of confidence in using advanced technology in their teaching practice, in a previous study, teachers in university settings in the same context expressed greater confidence (Alshathri & Male, 2019). This could be attributed to the more advanced development of technology implementation in higher education in Saudi Arabia, compared to K12 settings, and therefore it is not surprising that teachers in K12 education expressed less confidence in flipped learning. Another possible reason is that teachers were unfamiliar with reversing the teaching environment from a teacher-centred approach to a student-centred approach. Although teachers were acquainted with student-centred teaching methods, they were also using direct teaching methods in their courses and the students were accustomed to a teacher-centred environment for learning mathematics. Therefore, teachers may need more time to adapt to the change in the learning environment and see themselves as facilitators of learning, not providers and they may find it difficult to adopt a culture of learning centred on the student, who becomes the centre of teaching and learning in the flipped environment. Pedagogical changes are a significant demand, because of the teacher-centred, rote-learning approaches and other teacher-centred philosophies that continue to dominate low-achieving environments (Thomas, 2013), including Saudi Arabia. Smith and Hudson (2016) confirm that even when teachers working in low-achieving areas recognize the difference between teacher and learner-centred approaches, their cultural beliefs and conceptualizations of knowledge may present a substantial barrier to change. Putting it simply, teachers may be inadequately prepared to handle the benefits of the FC in their everyday practice, because they cannot overcome their intrinsic commitment to didactic teaching and rote memorization that define teacher-centred philosophies in the classroom. In this respect, the findings resonate with much of the literature on flipped learning. For example, in another context, specifically Taiwan, it was reported that, despite a gradual appreciation of the FC, teachers still needed more time to change their instructional habits from those found in traditional classrooms to those more fitted to a new blended learning design (Chen et al., 2016).

Teachers' teaching practice is informed by many factors, including their knowledge of the discipline and its teaching methods, the empirical trend, the willingness to think openly, and beliefs about good teaching that reflect their perceptions of how students learn. According to the literature, there is a strong relationship between the beliefs of teachers and their teaching practices, which means that their beliefs primarily reflect their teaching philosophy, interpretation, and opinions, which also affect their classroom actions (Nespor, 1987; Levin & Wadmany, 2006; Stipek et al., 2001). The views of teachers can therefore be barriers to renewing their teaching practice or help to support such a renewal. There is perhaps some evidence of this in this study, since teacher C was not comfortable with the FC instruction because it was different from her usual teaching style. Teachers' teaching approaches are unique and reflect their personalities and beliefs (Levin & Wadmany, 2006). As a result, they mirror the individual and their perspective of the students' requirements. Keeping this in mind, what works well for one teacher may not work well for another. From a pedagogical perspective, three teachers in this study indicated their enthusiasm for the FC approach, while two did not. From her responses in the interviews, it is clear that teacher C was very accustomed to her traditional teaching approach and so were her students. Besides, she reported having a problem with classroom management due to students' lack of preparation, which led her to go back to the traditional teaching approach.

Moreover, teachers must adhere to strict material and testing timetables, which makes it difficult for them to implement FCs without approval and help from educational stakeholders. FC implementation without approval from the school administration and parents might produce an unfavorable reaction from different parties, which would put a lot of pressure on teachers to manage the huge transformation in the learning environment. These worries point to the fact that teachers are not free to devise their own teaching approach, at least in countries with a strong centralized educational administration. In all, this factor shows that the transformation from conventional to progressive teaching methods such as the FC can be challenged by the prevalence of deeply entrenched views. Among other things, the need for changes to the current principles and beliefs of education stakeholders is an impediment (Cevikbas & Kaiser 2020).

#### 7.4.2.5 Need for support and training.

Although Saudi Arabia has not been left behind in the growth of ICT and has invested heavily in ICT for education, the success has sometimes been deceptive – leading to some serious issues for decision-makers. Al Mulhim (2014) concluded that, despite Saudi Arabia's strong support for technology, there is unfortunately no consistent policy or mechanism for ICT provision and implementation at schools. This study confirms that view, as the results showed that although there was an interest in professional development training among teachers, the training was perceived as somewhat inadequate and not practically effective. Teachers reported that, despite having successfully completed Ministry of Education-provided continuing professional development courses in ICT, in general, they thought of themselves as having only a basic level of technical knowledge. Often, due to a lack of technological resources to enable more inventive technology integration, classroom practice consisted of PowerPoint-style presentations. One teacher indicated that she had once attended a workshop on flipped learning. However, she complained that it was too abstract, and that no practical sessions were provided afterwards. This lack of effective professional development for teachers in the Saudi context has been documented by various authors (Albugami and Ahmed, 2015; Yahya & Ayasrah, 2018). Although the Ministry of Education released huge funds to support teachers' professional development programmes, all these programmes failed to be effective in enhancing their teaching practices, especially in innovations to the classroom environment. Having teachers attend theoretical training sessions without further monitoring, or evaluation of their practices would not help to reinforce the training and convince teachers to adopt changes and may lead to a reduction in motivation to attend such training programmes.

One teacher commented that there should be practical sessions on how to implement the FC and she felt the need to have someone expert to guide her through the transition from the traditional to the FC. Inexperienced teachers may simply not be in a position to implement strategies and innovative approaches such as FCs. Professional development of teachers is a complex field where the knowledge, skills, attitudes, beliefs, or actions of teachers are constantly changing (Fraser et al., 2007). This study reinforced the need to connect professional development with the respective teachers' practices and strategies, and to implement new knowledge and skills in an enhanced environment with the support of professionals. They should then take part in training and learning programmes in order to ready themselves to consider changes and to get ready for improvements and apply suitable methods in classrooms. The continuing professional development practices and programmes in Saudi Arabia are planned centrally and do not consider the experiences and needs of the teacher (Sywelem & Witte, 2013).

This research has shown how critical is the need for education programmes, pre-school education courses, and teacher workshops, and to develop tutorials to ensure quality improvement, which is consistent with other studies such as Alzahrani (2019). Consequently, the school administrators and policymakers need to adopt a shift in pedagogy to encourage creativity and a more student-centred approach. Providing teachers with some freedom may encourage them to be more creative and adopt new teaching approaches such as the FC. In addition, teacher professional development programmes should be launched to train teachers in creating flipped learning environments, since teachers are such a crucial part of successful FCs. There should be greater emphasis on support and training for implementing the intervention when it is introduced into a new context (Bell, 2014).

However, FCs alone cannot solve the myriad of academic problems facing students in different contexts. Murnane and Ganimian (2014) write: “More or better resources do not improve student achievement unless they change children’s daily experiences at school” (p.1). In some contexts, a single intervention will hardly yield a major and sustainable result, because it is not holistic and cannot address the myriad of challenges that children and adults encounter in their daily lives. For example, in South Africa, students need access to technology, and teachers need better professional development opportunities to properly establish the FC (Tanner & Scott, 2015). In Arab countries, such as Jordan and Saudi Arabia, issues related to teacher shortage and their professional expertise must be addressed (Yahya & Ayasrah, 2018). Overall, the FC should be implemented in an environment that fosters teacher-student collaboration and facilitates knowledge exchange inside and outside the classroom setting.

## 7.5 How Covid-19 could help to promote FC implementation

Despite the above challenges, the Covid-19 pandemic has given added impetus to changes such as the FC because of the emergency in the educational system in Saudi Arabia and other parts of the world. The need to curb the pandemic has prompted many governments to introduce rigorous physical proximity controls, restricting teachers’ and students’ freedom to meet in schools as they would usually (Schleicher, 2020). This unplanned rapid transformation from conventional to purely online learning has changed education institutions' methods of offering classes to their students. The normal classrooms have been changed to e-classrooms, which means that educators have changed their entire pedagogical approach to adapt to changing conditions. Based on the discussion above, and given the emergency conditions resulting from the Covid-19 pandemic, shifts from face-to-face approaches to remote teaching have altered roles and responsibilities of teachers, students, and parents. In response to the crisis, the Saudi Arabia approach was guided by the national government, and the local education authorities, school leaders, and teachers were very committed to it (Mann et al., 2020). Teachers have been forced to move to teaching online during the past year. This has meant that teachers have been trying to adjust to the new approach to teaching, learning new skills, especially with using technology in their teaching practices, which has become a requirement not a choice for them. This could change teachers' beliefs about using technology in education after the pandemic is over, and open up more innovative approaches that favour the use of technology as a mediator to support their teaching practices, such as FC instruction. The home environment was also hugely affected by this transition in the teaching and learning process. Parents played an essential role to support their children's learning at home. They became open to learning through technology and facilitated access to devices and internet connection to facilitate their children to participate in online school and support their learning at home. The Ministry of Education has also allocated substantial funds to support this transition by offering devices and training for teachers, as well as promoting open access to educational platforms in Saudi Arabia, free of charge for all educational communities. Although this transition has raised many issues and challenges, such as those previously mentioned in this study, it set the foundation of support for online learning and innovative instructional approaches in Saudi schools, which had not been fully considered before. Therefore, some of the previously reported challenges may be alleviated in the near future. A combination of face-to-face and online learning, "blended learning" is one of several models proposed for the future of the technology-aided classroom. Covid-19 may be the main factor driving this paradigm in schools around the world (Mahaye, 2020; Myung et al., 2020).

## 7.6 Summary

This chapter has presented a discussion of all the study findings in the light of existing theory and current literature. The design principles that were adopted in the current study could inform teachers' practice of the FC in mathematics education and enhance students' learning experience. The effectiveness of the FC in students' learning experience has been evaluated by conducting mixed methods research. Two groups of students were compared, one receiving FC instruction and the other receiving traditional instruction, and their achievement and self-efficacy were reviewed. The results of this study revealed a non-significant improvement in mathematics proficiency and quite a significant gain in self-efficacy in the FC group, compared to the traditional group. It was thus demonstrated that providing students with various opportunities for active learning activities and informative and continuous feedback from teachers or peers in the classroom could contribute to an increase in their confidence in learning maths. Aside from these two variables, the students' perceptions towards their experience of learning mathematics in the FC approach were elicited, along with the teachers' views of their experience of teaching in the FC approach. Students showed positive perceptions toward learning in the FC approach, highlighting the positive effects of out-of-class activities and the in-class learning environment. Moreover, teachers were satisfied with the overall design of the FC and indicated the potential positive effect on students' learning. It was evidence, however, that FC implementation could be affected by the classroom's sociocultural context and its implementation by teachers. Teachers' pedagogical beliefs about teaching and learning, previous experience of technology, their roles and their familiarity with the learners' learning style and preference could affect their approach to FC implementation. All influence the way they implement the FC approach, which could significantly affect the students' learning experience. While teachers indicated that implementing the FC brought various benefits to their teaching practice, they agreed that certain challenges needed consideration in relation to any future implementation of this approach in a similar context. In addition, a brief review was provided of how the Covid-19 pandemic could promote such an approach in the future. The following chapter will tie the study together and draw conclusions by considering the contribution of this research, presenting some implications for theory and practice, and considering the study's limitations and suggestions for future research.

# Chapter 8 : Conclusion and Recommendations

Using a mixed-methods approach, this study was designed to investigate the potential effects of a FC on students' mathematical proficiency and self-efficacy and, in addition, to elicit the perceptions of students and teachers to this approach. Although the results of both the quantitative and qualitative data have been discussed in depth in the previous chapters, the purpose of this chapter is to look back at the goals and objectives of the research and determine how well they were met. In this final chapter, therefore, the following aspects will be addressed. First, a discussion of the contributions of the findings of the study to our understanding of FC implementation. Then the limitations of the research are acknowledged. Following this, implications are considered, based on the findings of the study, the beliefs of the students and teachers who participated, and interpretive inferences about ways to make FC implementation more successful, both in the current case and in others where an acceptable test of fitness has been completed. At the end of the chapter, some suggestions are made for future research on the implementation of the FC in mathematics education and other disciplines that could be applied in variety of contexts.

## 8.1 Contribution to Knowledge

Theoretically, this research contributes to the body of knowledge and continuous debate on the effectiveness of implementing the FC approach in mathematics education, and provides empirical findings about the potential effect of the FC on students' mathematical proficiency and self-efficacy in high school settings. This study also addressed current gaps in our understanding of the effectiveness of the FC on students' mathematics self-efficacy, since there is a dearth of research in this area. The effectiveness of the FC was measured rigorously in high school settings with a large sample and using educationally relevant outcome measures; the study was conducted in different schools and classes and with different teachers. There are currently few studies in high school mathematics, and so this study contributes to the existing knowledge by exploring the link between self-efficacy in learning and the FC instructional approach. Furthermore, this study was carried out in Saudi Arabia, a country with low proficiency in mathematics and limited technological resources. This context differs markedly from those of most previous evaluations of FC. This study therefore makes an important contribution, especially considering that there has been little rigorous evaluation of the effectiveness of FC teaching in low-achieving countries. Another contribution is that this study adds insights from the perspective of the teacher to help them with this approach and understand the commitment involved and how implementation occurs. This research was designed to recognize the challenges and achievements of the FC, which is entirely different from the pedagogical practices traditionally employed by teachers. Other teachers could therefore take advantage of the teacher experience identified in this study to help them to adapt to a new educational model more smoothly. Teachers' perceptions are likely to influence the adoption of the flipped classroom in schools. Therefore, consideration should be given to their opinions to increase the understanding of the strengths and weaknesses of this teaching approach, which could potentially lead to improvements.

Methodologically, the FC design was based on empirical principles created by Lo et al. (2017), and all of the principles were established based on relevant empirical evidence. Most past research did not analyse in detail any particular conceptual frameworks to help teachers with designing their FC (Bishop & Verleger, 2013; Giannakos et al., 2014). Although there have been many studies which have implemented the FC approach in different disciplines, they have not fully defined or examined a conceptual framework which could assist teachers in designing a FC approach (O'Flaherty & Phillips, 2015; Song et al., 2017). The FC designs in past studies were not always clearly reported. To date, there are only two studies that used a novel theoretical framework for implementing FC approaches. Lo and Hew (2017) and Lo et al. (2018) tested the efficacy of an instructional design theory – Merrill's (2002) First Principles of Instruction for FC implementation. Therefore, the FC design employed in this study was based on empirical principles created by Lo et al. (2017), all of which were established based on relevant empirical evidence. Therfore, the current study bridges this gap in the pedagogical literature, taking into account the use of mixed approaches to assess the impact of FC teaching and learning. Additionally, having evaluated the implementation of Lo et al.'s (2017) model in this study as well as the challenges encountered despite using the framework, the researcher concluded that these challenges could have arisen either because particular issues were not adequately covered by the framework or because of the manner of implementation. The researcher therefore suggest that three important points could be added to develop Lo et al.'s (2017) framework in order to overcome some of the challenges faced by teachers and students in the current study. The first possibility would be to give more specific guidance on how to organize active learning strategies such as discussion and collaboration or to ensure PAL. In principle 1 (manage the transition to the flipped classroom for students) in Lo et al.'s (2017) framework, there was an emphasis on preparing students for the out-of-class activities, such as watching the videos and by teaching them note-taking techniques. Although this is important, students also need to be prepared for the in-class activities by teaching them effective discussion and collaboration techniques, especially in situations in which they have been accustomed to taking a passive role in teacher-centred classrooms, as is commonly the case in Saudi Arabia. Since active learning which takes place in the classroom is the key to the FC (Bishop & Verleger, 2013). Lo et al. (2017) failed to emphasise that teaching students how to manage, discuss and collaborate effectively while working on the classroom activities is essential for ensuring that classroom time is spent effectively, which in turn will increase the chance of successful implementation of the FC. By setting ground rules for discussion and collaboration in class activities as recommended by Mercer (1996), teachers could help students to understand their role and participate effectively in class session. Additionally, managing transition may be particularly important in Saudi Arabia. The problem of teachers and students being familiar with a teacher centred dedicated approach (which may contribute to some students' difficulties with self- regulation, and also cause some teachers like teacher C to resist the FC) is associated with high Power Distance (Hofstede, 2011). In cultures with high uncertainty avoidance (Hofstede, 2011) (such as Saudi Arabia) teachers can be expected to show high level of anxiety about implementing a new approach as reflected in this study in teachers comments about the unfamiliarity of FC and their fears about potentially implementing it unaided. High cultural uncertainty a voidance is likely to increase the need for support and guidance for teachers.

Another useful addition to the framework would be to consider parental support, which was neglected by Lo et al. (2017). The majority of the studies included in Lo et al.'s (2017) review were done at university level, but younger students in particular would depend on their parents for access to computers and for permission to use the internet. Some of the difficulties reported by teachers in this study arose because some parents did not understand or support the FC and did not give their children sufficient access to devices and the internet at home. Getting parental support could also help to address the problems encountered by students who lacked the motivation and self-discipline to carry out the pre-class activities. Parents' involvement is essential because there is a great deal of information on the internet, some of which might distract students' concentration, especially those with lower self-regulation. Parents could help students to be responsible for their learning activity and in particular to take control of their own learning pace (Wei et al., 2020). Parents' involvement and supervision has been shown to be very important when students were doing out-of-class learning activities in the FC environment (Wei et al., 2020). There should therefore be more emphasis on the importance of parents' role in supporting their children in the FC environment. The researcher therefore suggest adding another principle to the transition to the FC in Lo et al.'s (2017) framework called Principle 3 (Preparing parents for the transition to the FC). Parents should be informed about the FC and their support could be solicited by, for example, letters to parents, the school's newsletter or magazine, meetings or open days. Additionally, parents could be invited to attend the learning activities to supervise the pupils, watch videos with them and join in the pre-class quiz in order to understand how the FC works and to support students' learning performance.

In the present study, there was also a problem with some students' motivation to do the pre-class preparation (watching the videos). Motivation was mentioned by Lo et al. (2017) under principles 5 and 7, but in the current researcher's view, it would be helpful to have more emphasis on how teachers can increase students' motivation to engage effectively in the FC activities. For example, consideration could be given to making the formative quizzes part of students' assessment grade for the term.  Teachers might also find some ways to reward those who prepare effectively. This could be done by awarding students badges for their performance and recognizing it in their final term grade. This mixed methods study therefore contributes to the literature in terms of increasing our understanding of the effectiveness of FC implementation in mathematics courses. Research into FC is increasing, and the input of K-12 educators shows the need for additional quantitative and qualitative research.

## 8.2 Limitations

Every research project has limitations, particularly when it comes to context and time constraints. This current study was no different and its findings must therefore be interpreted in the light of a number of limitations. One of these concerns' generalisability: this study was conducted within a specific context, namely, Saudi Arabia, and all the participating students and teachers were women. Whether the impact of the FC could be expected to differ for male students is unclear. Some studies have shown that the impact of FC, on achievement at least, tends to be greater for female students (Chiquito et al., 2020; Gross et al., 2015), whereas others have shown no gender difference in the impact of FC (for example, Chen et al., 2016). Whether the current findings can be generalized to male Saudi students is an important question for future researchers to address. Furthermore, the Saudi Arabian context has a number of characteristics that might affect FC implementation.

Throughout the study, there were some limitations in the design and method of analysis. Due to the scope of this research, the findings cannot be generalised or transferred beyond the specific classroom population from which the sample was taken, where teachers decided to experiment with the FC approach in a mathematics course. Because of the restricted study time, only four schools were selected and all of them were in the same city. Because of infrastructural and other differences, the results might have been different in other schools in the same city or other Saudi cities, let alone elsewhere in the world. The results are therefore not generalisable, although contextual information has been provided to assist in judgements on transferability.

Another point to consider is that this study was conducted with teachers and students who were experiencing the FC for the first time, so they were unfamiliar with the approach. This lack of familiarity with flipped learning among both students and teachers is a barrier reported in the literature (Cilli-Turner, 2015; DeSantis et al., 2015; Palmer, 2015). As teachers and students develop their flipped learning skills and adjust to the new teaching and learning culture gradually, some types of difficulties would be likely to decrease significantly, such as challenges to becoming independent learners on the part of students and competence in technology skills on the part of teachers. Hence, the findings of this study cannot be generalised to all implementations of the FC, especially with teachers and students who become accustomed to and develop a high level of confidence with the FC approach. However, this study provides some insights into the issues faced in one particular experiment, and a thick description of the implementation process, so that readers can decide if the findings may be transferable to another context having similar characteristics (Silverman, 2017).

Additionally, the duration of the experiment could be argued to be short, at only six weeks for actual implementation of the FC. The requirement for students to prepare for the forthcoming end of year examinations, it was not possible to prolong the length of the intervention due to curriculum constraints. It is also worth noting that it was necessary to allocate enough time for pre- and post-intervention tests, which contributed to the overall duration of the project. Implementing the FC for a longer period would likely have increased the comfort level of teachers and students and may also have helped in reducing the novelty effect of the new approach. As suggested by Mason et al. (2013), a FC may need to be implemented for a whole term in order for the full benefit to be obtained.

From a methodological perspective, this study made use of questionnaires and semi-structured interviews to generate data about the students' and teachers' perceptions of their experience of the FC implementation. Although these methods generated sufficient data to address the key research questions, it can be argued that the use of other methods could have enriched the data and added greater depth and thicker descriptions. These methods might have included different interview formats or focus group discussions with the students and classroom observations of the teachers. These different methods for data collection may have helped to clear up any ambiguous results in the questionnaire responses and helped to document the teachers' practices in the classroom in order to examine their perceptions and how their perceptions link to their actual practices in the classroom. Furthermore, eliciting students' perceptions of the traditional teaching group could have enabled the researcher to compare the perceptions of the two groups.

This study did not compare the four schools and so did not distinguish between them. Such a comparison would have made it possible to study the differences and similarities between teachers. This could have widened the understanding of how teachers apply the FC as well as help to identify the different kinds of teacher behaviours that either promote or hinder learning in the FC approach. In addition, more demographic data about the students might have helped in interpreting the findings, particularly the results for teacher B, for proficiency, and teacher C for self-efficacy. In addition, students' acquaintance with technology and the internet in the control and intervention groups might have influenced the outcomes of the perception scores.

Another aspect of this study, which might be a limitation in the sense that it suggests the possibility of researcher bias, relates to the qualitative data collected through the teachers' interviews. Different people's experiences and understandings can result in different perceptions of the same phenomenon (Kvale & Brinkmann, 2009). As a result, in order to reduce the risk of researcher bias and improve legitimacy, member checking was used as a way of avoiding data misinterpretation (Creswell, 2014). The researcher of this study is a mathematics high school teacher in the same context as the participants. Therefore, she had been through similar experiences to the teachers of this study. As a maths teacher, the researcher could understand the participants' cultural background, difficulties, and teaching practice and perceptions. However, as she had never implemented the FC before, and she had been absent from schools (studying in the UK) for almost four years, she might be not able to identify all the teaching practices, benefits and challenges of the FC approach according to teachers' narratives. It is worth noting, however, that this does not alter the fact that the interview data results are interpretative rather than definitive.

Another limitation is that there was no delayed post-test evaluation, which might have discovered an effect of the FC approach not currently observed. In addition, the outcome measures employed could not capture all the benefits that the FC might have had on students, such as motivation, engagement and their perceptions of maths. Finally, the study did not include the perspectives and perceptions of other stakeholders, such as parents. Parents are an influential community, and they might have added another dimension to our understanding of FC implementation in schools. As suggested in a later section, this and other areas of interest could be investigated further in future studies. Such possible constraints do not, generally, contradict or diminish the value of the results achieved in this research. These limitations just underline the fact that much work still lies ahead.

### 8.3 Implications for Theory and Practice

Despite the limitations acknowledged above, this study carries important implications for teachers, students, educators, researchers and policy makers. This is practically important since educational systems around the world may consider adding aspects of blended learning to K12 teaching and learning to respond to the demand created by the Covid-19 pandemic. First, the FC was shown to have a positive impact on students' self-efficacy, suggesting that the teaching method can be beneficial for enhancing students' confidence in mathematics. This finding is significant in light of existing research indicating that positive mathematics self-efficacy is a substantial predictor of mathematics academic achievement (Hackett & Betz, 1989; Skaalvik et al., 2015) and has impacts on the decision making of students with regard to their future academic and career choices (Carpenter & Clayton, 2014; Usher & Pajares, 2009). Whilst the link with mathematics proficiency was not clearly demonstrated in this study, the improved self-efficacy is a positive sign that may contribute to engagement, effort, and persistence in mathematics and, hence, influence proficiency in the long term. According to Bandura (1997), experiencing success is one of the key sources of self-efficacy. The implications for teachers adopting the FC is that they could include strategies to enhance students' self-efficacy by providing opportunities for early success, which would help develop students' confidence about learning advanced topics later in the course (Sun et al., 2018). This could be achieved by creating learning activities and quizzes suitable for their level of learning so that all out of class activities are of an introductory nature, so giving students the confidence that they can achieve those tasks independently, which could enhance their participation in such activities. Furthermore, designing rich in class activities that encourage more peer-learning and group activities to give opportunities to students to observe their peers doing tasks (vicarious experience) and receive positive feedback (social persuasion) could increase their self-efficacy.

Additionally, the results of the study indicate that students and teachers had generally positive perceptions towards their experience with the FC approach. Whether the method is perceived favourably by both students and teachers is very important, since negative perceptions could reduce adherence and minimize the potential benefits that the intervention has to offer (Turco & Elliott, 1986). For example, students' perceptions could influence their willingness to perform the out-of-class preparation demanded by the FC approach. In addition, teachers' perceptions are likely to influence decisions on the adoption of the FC in schools; it is thus critical that teachers feel the benefits of such an approach. Consideration should be given to their opinions to increase the understanding of the strengths and weaknesses of this teaching approach, and of the resources and support needed for effective implementation, which could lead to improvements. The interview results provide new information concerning, albeit from a small sample, concerning teachers' perceptions regarding the FC in mathematics classrooms, which could potentially help to inform policy-making by the Ministry of Education in Saudi

Arabia on whether to encourage more teachers to consider this teaching approach, and if they do so, how to get the most benefit from it.

Since this study involved a variety of schools, students and teachers, and outcomes (both proficiency and self-efficacy) differed among the participating groups, an important implication is the insight that contextual factors such as teachers' beliefs, differences between schools, socio-economic status, resources, parental support and others including students' characteristics could affect the implementation of the FC and the likelihood of its success. Different contextual factors will have a moderating effect at different points in the intervention process (Detrich, 1999; Humphrey et al., 2016). Therefore, educators and researchers who are interested in introducing the FC need to focus efforts on considering all those factors and their impact and influence on FC implementation.

The research findings provide no clear evidence of a significant impact of the FC implementation on students' mathematics proficiency. However, although contextual data was not collected for analysis in the study, there were indirect indications of the possible salience of personal and environmental factors, which may account for the differences observed between groups, from which implications may be drawn.

Additionally, the experience of the researcher and the participating teachers in the present study suggest important implications for issues that should be considered when designing a flipped maths classroom, which should be explored in future research. Most importantly, however, consideration should be given to FC design, as simply flipping pre-class and in-class activities may not be sufficient. Because of the great variability in the effect sizes reported in studies, it is important to consider how the FC approach was applied. Based on the principles that inspired this research, the teachers' interviews and interpretation of the quantitative results, several general directions can be suggested for successful FC design. The following suggestions are offered as points for consideration by teachers and policy makers.

First, it is important to manage the transition to the FC for both teachers and students. Teachers need to allocate a sufficient period to convert courses into an FC format. They will need to take time to familiarise students and themselves with what an FC is and to ensure that all the materials are set up correctly, including how to manage the in-class activities and the role of the students in this part of the flipped class. In addition, care is needed in managing the online materials, ensuring that the videos are uploaded correctly and that all the students have access to the online materials. If students have problems with access, including internet problems and a lack of suitable devices, it will be necessary to try to find suitable solutions. Teachers should be prepared to assist students in mastering the new content delivery process. This could be achieved by initiating and maintaining contact with students and parents about the FC implementation. Teachers should provide details about how the methodology differs from the traditional approach, why the change is necessary, and how the roles of students and parents will change. In addition, teachers should introduce students to some important skills of flipped learning, such as taking effective notes from videos. Videos should be played in class prior to actual implementation so helping students make sense of the new format and become familiar with the new methods.

Teachers therefore must make sure that they plan and are prepared for implementing FC as a new teaching practice. They could do this by using online resources, reading about flipped learning and identifying suitable tools and software that they can access and use during FC implementation. This will include software for creating, editing and posting videos, and websites or learning management systems to organize and monitor the online classroom. Teachers in this study emphasised the importance of using a learning management system to manage an online virtual classroom. In this study, Moodle was used, an open-source learning management system, and it was found to be a very useful tool that helped to track and monitor the students' progress, helped teachers to design in-class activities based on the students' performance and ensured consistency between different classes. This was the first step and an essential stage that contributed to the success of the implementation. Furthermore, maintaining face-to-face time and incorporating quizzes are critical components of a good FC implementation (van Alten et al., 2019).

Because the researcher created and designed the out-of-class learning materials and managed the Moodle site, she spent considerable time in preparation work before the actual implementation. This included designing the course in Moodle and recording, editing and uploading video lectures and other learning resources; tasks, which in other contexts, would have to be done by teachers. In fact, most of the previous research reported the high initial cost of moving to a FC, and that it is very time-consuming for the teacher and this has been identified by teachers as one of the main challenges (Chen, 2016; Wanner & Plamer, 2015; Lo & Hew, 2017; Cevikbas & Kaiser, 2020). Indeed, it was a concern for teachers in this study. Recording videos can be a problem for teachers if they are unfamiliar with the technology. Nonetheless, teachers are encouraged to design their own videos because a video produced by the teacher has a greater impact than one created by someone else. Each teacher has her/his own way of teaching, a specific accent or a particular style of talking, and this keeps students more connected with the teacher. However, if teachers are not willing or able to create videos, they can still implement flipped instruction with the aid of YouTube, Khan Academy or other videos created by other teachers. Teachers should, however, be careful when selecting videos from the internet. They should look for the best videos to suit their students' learning style and use those that are simple and easy to understand. Even though the initial design process takes up a great deal of time, the experience of teachers in this study confirms that when the flipped method is implemented it reduces the amount of time needed for a traditional lecture presentation.

Creating an educational community that promotes flipped learning necessitates a consistent mechanism in the classroom to promote student-centred classrooms and constructive learning opportunities, as well as more input from either the teacher or the students. The results of the study show that, without adequate support and training, it is difficult to change teachers' practices and values in order to follow new teaching practices. As a result, despite having access to technology that could encourage the introduction of modern pedagogical techniques, teachers still tend to use conventional teaching methods. They therefore need support and help from school administrators, policy makers and the Education Ministry itself to help them manage the pressure of flipping their classes. Teachers who flip should be encouraged to use technology in meaningful ways during class; ways that support pedagogy and content delivery across the curriculum. School administrators can assist teachers by offering ongoing professional development workshops and helping teachers to learn about current approaches to teaching with technology, develop online content, and share technology-rich ideas and in-class activities with colleagues.

It is therefore advisable to set strategies to encourage teachers to collaborate with colleagues in order to share good practice for the FC. A potential way to do this would be to develop a platform for teachers to share and exchange the videos that they have made locally to suit the context and the culture of their students. This approach could offer teachers more opportunities to collaborate with their peers and reduce workload. Sharing each other's experiences could help teachers to discover successful behaviours and strategies and ease their adaption to the new approach. Not every teacher has the technological skills required to carry out the task, therefore training sessions whereby teachers can learn from successful teachers in this field will give them the practical skills to produce their own videos. Alzahrani (2019) stated that Saudi teachers have not had the opportunity to collaborate with colleagues, administrators and flipped learning researchers to learn about and adopt flipped learning. Communities of practice could boost creativity and facilitate the transition to new learning approaches, allowing teachers to exchange their knowledge and materials. Without these facilities, teachers will continue to adhere to centralized approaches defined by local authorities, schools and governments, which leave little room for innovation and autonomy. It may be easier for teachers to flip if curriculum designers include provision for elements of flipped learning in the course design, with relevant materials. It is important to recognise that teachers are subject to specific curriculum and examination schedules that have to be followed, so it is difficult for them alone to implement FCs without approval or help from educational stakeholders. FC implementation would need school administrators and policy makers to adopt a shift in pedagogy to encourage creativity and a more student-centred approach. Providing teachers with some freedom could encourage them to be more creative and adopt new teaching approaches such as the FC. In addition, professional development programmes should be launched to train teachers in the successful creation of flipped learning environments, as teachers are a critical component of successful FCs.

Additionally, care should be taken when implementing FC in K12 settings because learners might not have the level of independence required for the intervention to be beneficial. The required skills to thrive in the FC approach will need to be taught to students. It could take time for learners to become fully competent in flipped courses, so delaying any effect of the FC on students' learning. Students have to take responsibility for watching the lectures and preparing for class on their own. It could be problematic for teachers to keep students motivated in an FC, in the same way that they can struggle to keep them motivated with the traditional teaching approach. Implementing FCs requires a collaborative approach in which teachers and students work side-by-side to redesign the learning process and experience its benefits to the fullest. In this complex environment, a FC might simply not produce the desired response among students. More research in other disciplines and educational contexts will therefore be required to formulate effective strategies for the use of FC environments in education.

## 8.4 Future Research

Because there are different cultural and social contexts, it would be worthwhile exploring the impact of the implementation of the FC approach using the same design principles that guided this study in other contexts. It is therefore recommended that a similar study is conducted with a larger sample size, longer-term intervention, mixed genders and in other education subjects and contexts. Additionally, further studies could include additional research to explicitly evaluate other elements of the potential of FC in terms of the enhancement of students' mathematics learning experiences; for instance, the potential for addressing motivation towards mathematics, as well as fostering creative higher-order mathematical skills. It is a possibility that age plays a role in students' performance and further research could attempt to discover any correlations between age, grade levels and content areas that might indicate a more positive impact on achievement. Another promising area for future research could be a focus on finding what features of the classroom make the greatest contributions to stimulating higher gains in students' maths self-efficacy. In order to better understand the longer-term efficacy of FC intervention, it is strongly recommended that a longitudinal study be carried out in the future. Further research could involve carrying out a similar study over several semesters and then comparing the success of students in subsequent courses with the progress of students in FC and traditional groups. As a final area of interest, future researchers could investigate parents' perceptions of their children's learning in an FC context or how students interpret responses from their parents to a flipped maths course.

## 8.5 Overall Conclusion

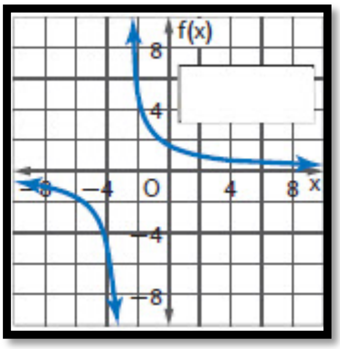
The current study sought to design, implement and evaluate the effectiveness of the FC approach with a view to improving students' mathematical proficiency and self-efficacy.

The findings presented in this thesis yielded no evidence, overall, of a significant effect on students' mathematics proficiency, although there were gains for some groups. However, the FC did show a positive impact on self-efficacy, and the method was perceived positively by both teachers and students, suggesting that this novel teaching method can be beneficial to the development of maths self-efficacy in a range of contexts. This research has clearly demonstrated that the FC approach is not simply adding technology and out-of-class video activities to lessons. Rather, it necessitates that students and teachers flip the methods of teaching and learning. When doing something that deviates from routine and traditional procedures, adjustments must be made on several fronts. The journey to a successful FC is a journey of building capabilities and skills among both teachers and students. Ensuring that teachers and students develop such strengths and skills requires a specific learning environment that fosters a positive learning culture. Furthermore, the effectiveness of FC implementation requires highly motivated students who can take responsibility for their learning. It also requires ambitious policymakers, including school leaders, to strengthen the abilities and skills of their teachers. As well as parents who are supportive towards home learning, an effective implementation of a FC requires a classroom structure able to apply different forms of active learning, strengthening both students' and teachers' communication, and encouraging differentiated learning in the in-class activities. Another crucial point is that a successful FC implementation is one in which policies support the development, of collaboration and dialogue among schools, teachers and students, a properly funded technological infrastructure and professional development. Although the teachers highlighted certain obstacles, most were of the view that the benefits of the FC outweighed the disadvantages. As teachers move their allegiances from a teacher-centred classroom to a student-centred classroom, the FC promises a different future for learning. This shift helps to foster an environment which enhances students' engagement, motivation, collaboration and most importantly, learning outcomes. The future of FC in K12 education is expected to have a strong effect on the learning environment. This should become much clearer when the Covid-19 pandemic is over and educational systems show a willingness to accept the introduction of new technologies in learning, which will encourage the use of the blended learning approach. This will hasten the growing awareness of the need for a new approach to education.

# Appendices

## Appendix A1: Mathematics achievement test (English Version)

Choose the correct answer for each of the following questions.

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 1 | What value(s) of x make $\frac{5x+3}{x^2-9}$ undefined? | | | | | | | |
| | A | -9 | B | -9, 9 | C | 9 | D | -3, 3 |
| 2 | Simplify $\frac{x^3-y^3}{y-x}$ | | | | | | | |
| | A | $-x^2-xy$<br>$-y^2$ | B | $x^2-xy+y^2$ | C | $x^2-xy$<br>$-y^2$ | D | $x^2+xy$<br>$+y^2$ |
| 3 | Simplify $\frac{27x^2y^4}{16yz^3}\cdot\frac{8z}{9xy^3}$ | | | | | | | |
| | A | $\frac{3x}{2z^2}$ | B | $\frac{x}{z^2}$ | C | $\frac{3xy}{2z^2}$ | D | $\frac{3xy^2}{2z^2}$ |
| 4 | Simplify $\frac{x-y}{a+b}\div\frac{x^2-y^2}{a^2-b^2}$ | | | | | | | |
| | A | $\frac{a+b}{x+y}$ | B | $\frac{a-b}{x+y}$ | C | $\frac{a+b}{x-y}$ | D | $\frac{x+y}{a-b}$ |
| 5 | Find the Least common multiple (LCM) for $12a^2b, 15abc, 8b^3c^4$ | | | | | | | |
| | A | $60a^2b^3c^4$ | B | $120a^2b^3c^4$ | C | $120a^2bc$ | D | 120abc |
| 6 | Simplify $\frac{4x}{x^2+9x+18}+\frac{5}{x+6}$ | | | | | | | |
| | A | $\frac{9x+15}{(x+3)(x+6}$ | B | $\frac{9x+15}{(x+3)(x-6)}$ | C | $\frac{9x+3}{(x+3)(x+6}$ | D | $\frac{4x+15}{(x+3)(x+}$ |
| 7 | The domain of the reciprocal function $f(x)=\frac{2}{x-3}$ is | | | | | | | |
| | A | $\{x: x\neq 1\}$ | B | $\{x: x\neq -3\}$ | C | $\{x: x\neq 3\}$ | D | $\{x: x\neq 0\}$ |
| 8 | The vertical asymptote for the function $f(x)=\frac{3}{x+2}+1$ is | | | | | | | |
| | A | $y=-1$ | B | $x=-2$ | C | $y=1$ | D | $x=2$ |
| 9 |  What is the formula for the function represented above? | | | | | | | |

<table>
<tr><td></td><td>A</td><td>$\frac{5}{x+3}$</td><td>B</td><td>$\frac{5}{x-2}+1$</td><td>C</td><td>$\frac{5}{x-3}$</td><td>D</td><td>$\frac{5}{x-4}$</td></tr>
<tr><td rowspan="2">10</td><td colspan="8">The range of the function $f(x) = \frac{3}{x+2} + 1$ is</td></tr>
<tr><td>A</td><td>$R - \{3\}$</td><td>B</td><td>$R - \{-1\}$</td><td>C</td><td>$R - \{1\}$</td><td>D</td><td>$R - \{-2\}$</td></tr>
<tr><td rowspan="2">11</td><td colspan="8">If y varies directly with x and y =15 when x = -5, what is the value of y when x = 7?</td></tr>
<tr><td>A</td><td>-5</td><td>B</td><td>-21</td><td>C</td><td>105</td><td>D</td><td>21</td></tr>
<tr><td rowspan="2">12</td><td colspan="8">The volume of a specific gas v varies directly with its temperature t, and inversely with its pressure p. This relationship is a/an ________ variation.</td></tr>
<tr><td>A</td><td>direct</td><td>B</td><td>inverse</td><td>C</td><td>joint</td><td>D</td><td>combined</td></tr>
<tr><td rowspan="2">13</td><td colspan="8">If x varies inversely with y and x = 24 when y = 4, then the value of x when y = 12 is</td></tr>
<tr><td>A</td><td>8</td><td>B</td><td>72</td><td>C</td><td>-8</td><td>D</td><td>2</td></tr>
<tr><td rowspan="2">14</td><td colspan="8">Which value of $y$ satisfies the equation $\frac{5}{y-2} + 2 = \frac{17}{6}$ ?</td></tr>
<tr><td>A</td><td>7</td><td>B</td><td>6</td><td>C</td><td>8</td><td>D</td><td>5</td></tr>
<tr><td>15</td><td colspan="8">Solve $\frac{3}{x+2} + \frac{1}{x} = 0$ for $x$</td></tr>
<tr><td></td><td>A</td><td>2</td><td>B</td><td>$\frac{1}{2}$</td><td>C</td><td>-2</td><td>D</td><td>$-\frac{1}{2}$</td></tr>
<tr><td rowspan="2">16</td><td colspan="8">The equation that represents joint variation is</td></tr>
<tr><td>A</td><td>xy = 3</td><td>B</td><td>$\frac{x}{yz} = 3$</td><td>C</td><td>$\frac{xy}{z} = 3$</td><td>D</td><td>$x = 3y$</td></tr>
<tr><td rowspan="2">17</td><td colspan="8">The breakpoint of the graphical representation of $f(x) = \frac{x^2+2x-3}{x-1}$ is</td></tr>
<tr><td>A</td><td>$x$ = 3</td><td>B</td><td>$y$ = 0</td><td>C</td><td>$x$ = -3</td><td>D</td><td>$x$ = 1</td></tr>
<tr><td>18</td><td colspan="8">Solve $\frac{2}{x-3} - \frac{4}{x+3} = \frac{8}{x^2-9}$ for $x$</td></tr>
<tr><td></td><td>A</td><td>7</td><td>B</td><td>-1</td><td>C</td><td>5</td><td>D</td><td>1</td></tr>
<tr><td>19</td><td colspan="8"><table><tr><td>x</td><td>14</td><td>28</td><td>56</td><td>112</td></tr><tr><td>y</td><td>3</td><td>1.5</td><td>0.75</td><td>0.375</td></tr></table>The variation represented by this table is</td></tr>
<tr><td></td><td>A</td><td>combined</td><td>B</td><td>inverse</td><td>C</td><td>joint</td><td>D</td><td>direct</td></tr>
<tr><td rowspan="2">20</td><td colspan="8">A passenger plane travels 7,500 miles on a flight<br>What this plane needs to travel this distance in terms of speed, write a function that shows time</td></tr>
<tr><td>A</td><td>$t = \frac{7500}{r}$</td><td>B</td><td>$t = \frac{r}{7500}$</td><td>C</td><td>$t = \frac{1}{7500 - r}$</td><td>D</td><td>$t = 7500r$</td></tr>
<tr><td>21</td><td colspan="8">5,-6,-17,-28,…..<br>Is this sequence</td></tr>
</table>

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | A | arithmetic,<br>r =11 | B | arithmetic,<br>r =10 | C | arithmetic,<br>r = -11 | D | not an arithmetic sequence |
| 22 | 4,8,16,32,…<br>In this geometric sequence the common ratio is | | | | | | | |
| | A | 0 | B | 2 | C | 4 | D | 3 |
| 23 | Find $a_1$ in the geometric sequence when $r = \frac{-1}{2}$ , $a_n = 16$, $s_n = 688$ | | | | | | | |
| | A | 1024 | B | 2038 | C | 514 | D | 2042 |
| 24 | 7,21,63,…<br>The next two terms in this geometric sequence are | | | | | | | |
| | A | 136,576 | B | 189,555 | C | 189,567 | D | 140,459 |
| 25 | The function $f(x) = \frac{x^2}{x-1}$ is undefined if | | | | | | | |
| | A | $x = 3$ | B | $x = 0$ | C | $x = -1$ | D | $x = 1$ |
| 26 | Write 0.48 as a regular fraction | | | | | | | |
| | A | $\frac{9}{16}$ | B | $\frac{22}{50}$ | C | $\frac{1}{2}$ | D | $\frac{13}{19}$ |
| 27 | The domain of the reciprocal function $f(x) = \frac{7}{x-2}$ is | | | | | | | |
| | A | $\{y: y \neq 2\}$ | B | $\{x: x \neq 0\}$ | C | $\{x: x \neq -2\}$ | D | $\{x: x \neq 0\}$ |
| 28 | Find the sum of the infinite geometric series<br>27+18+12+8+... . | | | | | | | |
| | A | 30 | B | 81 | C | 27 | D | 18 |
| 29 | Ali receives a wage of 100 riyals per day and receives an increase in his daily wages 5 riyals every 3 months. How will his daily wages become after 3 years? | | | | | | | |
| | A | 160 | B | 102 | C | 150 | D | 115 |
| 30 | Which of the following is NOT a vertical asymptote of the rational function $f(x) = \frac{1}{x^2-49}$ ? | | | | | | | |
| | A | $y = 0$ | B | $y = 7$ | C | $y = -7$ | D | $y = 1$ |

## Appendix B1: Mathematics Pre-test (English Version)

Choose the correct answer for each of the following questions.

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 1 | The number $-\sqrt{49}$ belongs to the number sets | | | | | | | |
| | A | I, Z | B | R, Q, Z | C | W, N | D | R, Z |
| 2 | The domain of the absolute value of a number is the | | | | | | | |
| | A | Set of natural numbers | B | Set of rational numbers | C | Set of real numbers | D | Set of integers |
| 3 | The multiplicative inverse of $\frac{6}{13}$ is | | | | | | | |
| | A | $\frac{6}{13}$ | B | $\frac{-13}{6}$ | C | $\frac{13}{6}$ | D | $\frac{-6}{13}$ |
| 4 | The degree of the polynomial $8x^5 - 4x^3 + 2x^2 - x - 3$ is | | | | | | | |
| | A | 3 | B | 4 | C | 8 | D | 5 |
| 5 | The rank of the matrix $\begin{bmatrix} -9 & 6 \\ & \end{bmatrix}$ is | | | | | | | |
| | A | -1.1 | B | 1.2 | C | 1.1 | D | 2.1 |
| 6 | The phrase $b^2 - 4ac$ is | | | | | | | |
| | A | polynomial | B | discriminant | C | an equation of a straight line | D | a relativistic equation |
| 7 | The derivative of a square root contains | | | | | | | |
| | A | fifth root | B | Nth root | C | square root | D | cube root |
| 8 | Solve $2^x = 8^3$ for $x$ | | | | | | | |
| | A | 9 | B | 4 | C | 5 | D | 2 |
| 9 | Simplify $\sqrt{-18}$ | | | | | | | |
| | A | $3\sqrt{2}i$ | B | $3\sqrt{2}$ | C | $-3\sqrt{2}i$ | D | $-3\sqrt{2}$ |
| 10 | Simplify $3i\,.\,4i$ | | | | | | | |
| | A | 12 | B | $7\,i$ | C | $-12$ | D | $3\sqrt{2}$ |
| 11 | The greatest common factor of the polynomial $4x^4 - 2x^3 - x^6 + 3$ is | | | | | | | |
| | A | -1 | B | 4 | C | -2 | D | 3 |
| 12 | If $f(x) = 3x^3 - 6x^2 + x$,<br>then $f(3) =$ | | | | | | | |
| | A | 19 | B | 10 | C | 9 | D | 30 |
| 13 | The domain of the function $f(x) = \sqrt{x - 3}$ is | | | | | | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | A | $x \geq 3$ | B | $x \leq 3$ | C | $x \geq -3$ | D | $x \leq -3$ |
| 14 | Simplify $\sqrt[3]{8x^6}$ | | | | | | | |
| | A | $x^2$ | B | $2x^2$ | C | $4x^2$ | D | $3x^2$ |
| 15 | Simplify the square root expression $4\sqrt{8} + 3\sqrt{50}$ | | | | | | | |
| | A | $23\sqrt{2}$ | B | $3\sqrt{8}$ | C | $4\sqrt{58}$ | D | $3\sqrt{50}$ |
| 16 | What values of $x$ make $\frac{(x-3)(x+6)}{(x^2-7x+12)(x^2-36)}$ undefined? | | | | | | | |
| | A | -6,3 | B | -6,6 | C | 4,6 | D | -6,3,4,6 |
| 17 | If $xy = -3$ and $x^2 + y^2 = 10$, what is the value of $(x+y)(x+y)$? | | | | | | | |
| | A | 16 | B | 13 | C | 7 | D | 4 |
| 18 | If y varies directly with x, and y = 15 when x = 5, then the value of y when x = 7 is | | | | | | | |
| | A | 21 | B | 19 | C | 12 | D | 7 |
| 19 | The inverse function of $f(x)\frac{x-3}{5}$ is | | | | | | | |
| | A | $y = \frac{5x+3}{x}$ | B | $y = 5x$ | C | $y = 5x + 3$ | D | $y = 5x + 2$ |
| 20 | The domain of the function $f(x) = \frac{1}{x}$ is | | | | | | | |
| | A | $R - \{1\}$ | B | $R - \{0\}$ | C | $R^+$ | D | $R$ |
| 21 | The breakpoint of the function $\frac{16+x^2}{x-4}$ is | | | | | | | |
| | A | $x = 4$ | B | $x = -16$ | C | $x = -4$ | D | $x = 16$ |
| 22 | Find the least common multiple of $16x, 8x^2, 5yx^3$ | | | | | | | |
| | A | $30x^2y$ | B | $80x^3y^3$ | C | $80xy$ | D | $80xy^3$ |
| 23 | Simplify $\frac{\sqrt{y^8}}{\sqrt{x^6}}$ | | | | | | | |
| | A | $\frac{y^2}{x^3}$ | B | $\frac{y^2}{x^4}$ | C | $\frac{y^4}{x^2}$ | D | $\frac{y^4}{x^3}$ |
| 24 | The equation $2(x+3) = 2x + 6$ has the following property | | | | | | | |
| | A | Commutative | B | Identity | C | Associative | D | Distributive |
| 25 | The rank of the matrix $[-9 \quad 6\ ]$ is | | | | | | | |
| | A | $-1 \times 1$ | B | $2 \times 1$ | C | $1 \times 1$ | D | $1 \times 2$ |
| 26 | The area of the inequality $x < 2$ lies ______ the straight line $x = 2$ | | | | | | | |
| | A | below | B | to the left of | C | above | D | to the right of |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 27 | The additive inverse of $\sqrt{x}$ is | | | | | | | |
| | A | $\frac{1}{\sqrt{5}}$ | B | $\frac{\sqrt{5}}{5}$ | C | $-\sqrt{5}$ | D | $\sqrt{-5}$ |
| 28 | The relation $x$ = 5 is graphically represented as | | | | | | | |
| | A | $x = 5$, vertical line | B | $y = 5$, vertical line | C | $x = 5$, horizontal line | D | $y = 5$, horizontal line |
| 29 | The following $\begin{bmatrix}1 & 0\\0 & 1\end{bmatrix}$ is a | | | | | | | |
| | A | unit matrix | B | zero matrix | C | column matrix | D | row matrix |
| 30 | If $y = \frac{x}{5}$, then $y$ has a/an _____ relationship with $x$ | | | | | | | |
| | A | combined variation | B | inverse variation | C | joint variation | D | direct variation |

## Appendix A2: Mathematics Pre-test (Arabic Version)

اختاري الإجابة الصحيحة فيما يأتي :

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 1 | العدد $\sqrt{49}-$ ينتمي لمجموعة الاعداد | | | | | | | |
| | A | $R, Z$ | B | $R, Q, Z$ | C | $W, N$ | D | $I, Z$ |
| 2 | مجال دالة القيمة المطلقة | | | | | | | |
| | A | مجموعة الأعداد الصحيحة | B | مجموعة الأعداد الحقيقة غير السالبة | C | مجوعة الأعداد الحقيقة | D | مجموعة الأعداد السالبة |
| 3 | النظير الضربي للعدد $\frac{6}{13}$ | | | | | | | |
| | A | $\frac{-6}{13}$ | B | $\frac{-13}{6}$ | C | $\frac{13}{6}$ | D | $\frac{6}{13}$ |
| 4 | درجة كثيرة الحدود $8x^5 - 4x^3 + 2x^2 - x - 3$ هو ............ | | | | | | | |
| | A | 3 | B | 4 | C | 8 | D | 5 |
| 5 | رتبة المصفوفة $[-9 \quad 6]$ | | | | | | | |
| | A | $2 \times 1$ | B | $1 \times 2$ | C | $1 \times 1$ | D | $-1 \times 1$ |
| 6 | تسمى العبارة<br>$b^2 - 4ac$ | | | | | | | |
| | A | المعادله النسبيه | B | المميز | C | معادله المستقيم | D | كثيرة حدود |
| 7 | متباينة الجذر التربيعي هي متباينه تحتوي على: | | | | | | | |
| | A | الجذر التكعيبي | B | الجذر النوني | C | الجذر التربيعي | D | الجذر الخامس |
| 8 | $2^x = 8^3$ | | | | | | | |
| | A | 9 | B | 4 | C | 5 | D | 2 |
| 9 | $\sqrt{-18}$ | | | | | | | |
| | A | $3\sqrt{2}i$ | B | $-3\sqrt{2}i$ | C | $3\sqrt{2}$ | D | $-3\sqrt{2}$ |
| 10 | $3i\ .\ 4i$ | | | | | | | |
| | A | 12 | B | $7\,i$ | C | $-12$ | D | $3\sqrt{2}$ |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 11 | العامل الرئيس لكثيرة الحدود $+ 34x^4 - 2x^3 - x^6$ | | | | | | | |
| | A | $-1$ | B | $-2$ | C | 4 | D | 3 |
| 12 | إذا كان $f(x) = 3x^3 - 6x^2 + x$ فإن $f(3)$ | | | | | | | |
| | A | 19 | B | 9 | C | 10 | D | 30 |
| 13 | مجال الدالة $f(x) = \sqrt{x-3}$ | | | | | | | |
| | A | $x \geq 3$ | B | $x \geq -3$ | C | $x \leq 3$ | D | $x \leq -3$ |
| 14 | $\sqrt[3]{8x^6}$ | | | | | | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | A | $3x^2$ | B | $2x^2$ | C | $4x^2$ | D | $x^2$ |
| 15 | تبسيط العبارة الجذرية $4\sqrt{8}+3\sqrt{50}$ | | | | | | | |
| | A | $23\sqrt{2}$ | B | $4\sqrt{58}$ | C | $3\sqrt{8}$ | D | $3\sqrt{50}$ |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 16 | حدد قيم x التي تجعل العبارة $\frac{(x-3)(x+6)}{(x^2-7x+12)(x^2-36)}$ غير معرفة . | | | | | | | |
| | A | -6,3 | B | 4,6 | C | -6,6 | D | -6,3,4,6 |
| 17 | ماقيمة العبارة$(x+y)(x+y)$ إذاكانت $xy=-3, x^2+y^2=10$ | | | | | | | |
| | A | 16 | B | 7 | C | 13 | D | 4 |
| 18 | إذا كانت y تتغير طردياً مع x , وكانت y=15 عندما x=5 فإن قيمة y عندما x=7 تساوي. | | | | | | | |
| | A | 21 | B | 19 | C | 12 | D | 7 |
| 19 | الدالة العكسيه للدالة $f(x)\frac{x-3}{5}$ | | | | | | | |
| | A | $y=5x+2$ | B | $y=5x$ | C | $y=5x+3$ | D | $y=\frac{x+3}{x}$ |
| 20 | مجال الدالة $f(x)=\frac{1}{x}$ هو | | | | | | | |
| | A | R | B | R-{0} | C | $R^+$ | D | R-{1} |

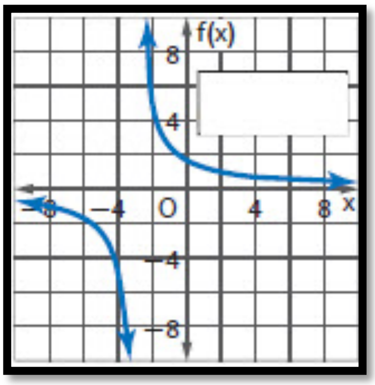
| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 21 | الدالة $\frac{16+x^2}{x-4}$ لها نقطة انفصال عندما: | | | | | | | |
| | A | $x=4$ | B | $x=-4$ | C | $x=-16$ | D | $x=16$ |
| 22 | المضاعف المشترك الاصغر لكثيرات الحدود الاتيه:$,5yx^3 16x, 8x^2$ | | | | | | | |
| | A | $80xy^3$ | B | $80x^3y^3$ | C | $80xy$ | D | $30x^2y$ |
| 23 | $\frac{\sqrt{y^8}}{\sqrt{x^6}}$ تبسيطها | | | | | | | |
| | A | $\frac{y^2}{x^3}$ | B | $\frac{y^4}{x^2}$ | C | $\frac{y^2}{x^4}$ | D | $\frac{y^4}{x^3}$ |
| 24 | الخاصية الموضحة $2(x+3)=2x+6$ | | | | | | | |
| | A | الخاصية التبديلية | B | الخاصية التجميعية | C | خاصية الانغلاق | D | خاصية التوزيع |
| 25 | رتبة المصفوفة $\begin{bmatrix} -9 & 6 \end{bmatrix}$ | | | | | | | |
| | A | $2\times1$ | B | $1\times1$ | C | $1\times2$ | D | $-1\times1$ |
| 26 | منطقة حل المتباينة $x<2$ هي المنطقه التي تقع ........ المستقيم $x=2$ | | | | | | | |
| | A | يمين | B | يسار | C | أعلى | D | أسفل |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 27 | النظير الجمعي للعدد $\sqrt{x}$ هو العدد | | | | | | | |
| | A | $\sqrt{-5}$ | B | $\frac{\sqrt{5}}{5}$ | C | $-\sqrt{5}$ | D | $\frac{1}{\sqrt{5}}$ |
| 28 | العلاقة $x = 5$ تمثل بيانياً | | | | | | | |
| | A | خط رأسي $x = 5$ | B | خط أفقي $x = 5$ | C | خط رأسي عند $y = 5$ | D | خط أفقي عند $y = 5$ |
| 29 | تسمى المصفوفة التالية $\begin{bmatrix}1 & 0\\0 & 1\end{bmatrix}=$ | | | | | | | |
| | A | مصفوفه الوحدة | B | مصفوفه صف | C | مصفوفه صفريه | D | مصفوفه عمود |
| 30 | إذاكانت $y = \frac{x}{5}$ فإن $y$ تتغير تغيراً.......... مع $x$. | | | | | | | |
| | A | طردياً | B | عكسياً | C | مركباً | D | مشتركاً |

## Appendix B2: Mathematics Achievement Test (Arabic Version)

إختاري الإجابة الصحيحة لكل عبارة من العبارات التالية :

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1 | قيم $x$ التي تجعل العبارة $\frac{5x+3}{x^2-9}$ غير معرفة هي | | | | | | |
| A | -9 | B | 9 | C | -9 , 9 | D | -3 , 3 |
| 2 | تبسيط العبارة $\frac{x^3-y^3}{y-x}$ هو | | | | | | |
| A | $-x^2-xy-y^2$ | B | $x^2-xy-y^2$ | C | $x^2-xy+y^2$ | D | $x^2+xy+y^2$ |
| 3 | تبسيط العبارة $\frac{27x^2y^4}{16yz^3}\cdot\frac{8z}{9xy^3}$ يكون | | | | | | |
| A | $\frac{3x}{2z^2}$ | B | $\frac{x}{z^2}$ | C | $\frac{3xy}{2z^2}$ | D | $\frac{3xy^2}{2z^2}$ |
| 4 | تبسيط العبارة $\frac{x-y}{a+b}\div\frac{x^2-y^2}{a^2-b^2}$ يكون | | | | | | |
| A | $\frac{x+y}{a-b}$ | B | $\frac{a-b}{x+y}$ | C | $\frac{a+b}{x-y}$ | D | $\frac{a+b}{x+y}$ |
| 5 | LCM للحدود $12a^2b,15abc,8b^3c^4$ | | | | | | |
| A | 120 abc | B | $120a^2b^3c^4$ | C | $120a^2bc$ | D | $60\ a^2b^3c^4$ |
| 6 | تبسيط العبارة $\frac{4x}{x^2+9x+18}+\frac{5}{x+6}$ يكون | | | | | | |
| A | $\frac{4x+15}{(x+3)(x+6)}$ | B | $\frac{9x+3}{(x+3)(x+6)}$ | C | $\frac{9x+15}{(x+3)(x-6)}$ | D | $\frac{9x+15}{(x+3)(x+6)}$ |
| 7 | مجال دالة المقلوب الاتية $f(x)=\frac{2}{x-3}$ | | | | | | |
| A | $\{x: x\neq 0\}$ | B | $\{x: x\neq -3\}$ | C | $\{x: x\neq 3\}$ | D | $\{x: x\neq 1\}$ |
| 8 | خط التقارب الرأسي للدالة $f(x)=\frac{3}{x+2}+1$ هو | | | | | | |
| A | $x=2$ | B | $x=-2$ | C | $y=1$ | D | $y=-1$ |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 9 |  <br>الدالة الممثلة بالشكل الاتي تكون معادلتها هي | | | | | | |
| A | $\frac{5}{x+3}$ | B | $\frac{5}{x-3}$ | C | $\frac{5}{x-2}+1$ | D | $\frac{5}{x-4}$ |
| 10 | مدى الدالة $f(x) = \frac{3}{x+2} + 1$ | | | | | | |
| A | $R-\{-2\}$ | B | $R-\{-1\}$ | C | $R-\{1\}$ | D | $R-\{3\}$ |
| 11 | إذا كانت $y$ تتغيَّر طرديا مع $x$ ، وكانت $y = 15$ عندما $x = -5$ ، فإن قيمة $y$ عندما$x = 7$ . | | | | | | |
| A | 21 | B | -21 | C | 105 | D | -5 |
| 12 | يتغيَّر حجم غاز معين $v$ طرديا مع درجة حرارته $t$ ، و عكسيا مع ضغطه $p$ فإن هذه العلاقة تمثل تغيرا | | | | | | |
| A | طرديا | B | مشتركا | C | عكسيا | D | مركبا |
| 13 | إذا كانت $x$ تتغير عكسيا مع $y$ وكانت $x = 24$ عندما $y = 4$ فإن قيمة $x$ عندما $y = 12$ هي | | | | | | |
| A | 8 | B | -8 | C | 72 | D | 2 |
| 14 | قيمة $y$ التي تحقق المعادلة $\frac{5}{y-2}+2=\frac{17}{6}$ تكون | | | | | | |
| A | 5 | B | 6 | C | 8 | D | 7 |
| 15 | حل المعادلة $\frac{3}{x+2}+\frac{1}{x}=0$ | | | | | | |
| A | 2 | B | -2 | C | $\frac{1}{2}$ | D | $-\frac{1}{2}$ |
| 16 | المعادلة التي تمثل تغيرا مشتركا من المعادلات التالية هي | | | | | | |
| A | $x = 3y$ | B | $\frac{x}{yz} = 3$ | C | $\frac{xy}{z} = 3$ | D | $xy = 3$ |
| 17 | نقطة الانفصال للتمثيل البياني للدالة $f(x) = \frac{x^2+2x-3}{x-1}$ عندما | | | | | | |

<table>
<tr><td>A</td><td>X=3</td><td>B</td><td>X=-3</td><td>C</td><td>Y=0</td><td>D</td><td>X=1</td></tr>
<tr><td>18</td><td colspan="7">حل المعادلة $\frac{2}{x-3}-\frac{4}{x+3}=\frac{8}{x^2-9}$</td></tr>
<tr><td>A</td><td>1</td><td>B</td><td>-1</td><td>C</td><td>5</td><td>D</td><td>7</td></tr>
<tr><td>19</td><td colspan="7">التغير الممثل بالجدول
<table>
<tr><td>112</td><td>56</td><td>28</td><td>14</td><td>x</td></tr>
<tr><td>0.375</td><td>0.75</td><td>1.5</td><td>3</td><td>y</td></tr>
</table>
المجاور هو</td></tr>
<tr><td>A</td><td>طردي</td><td>B</td><td>عكسي</td><td>C</td><td>مشترك</td><td>D</td><td>غير ذلك</td></tr>
<tr><td>20</td><td colspan="7">تقطع طائرة ركاب مسافة 7500 ميل في إحدى الرحلات.<br>اكتب داله تبين الزمنt الذي تحتاج إليه هذة الطائرة لتقطع هذة المسافة بدلاله السرعة r</td></tr>
<tr><td>A</td><td>$t=\frac{7500}{r}$</td><td>B</td><td>$t=\frac{r}{7500}$</td><td>C</td><td>$t=\frac{1}{7500-r}$</td><td>D</td><td>$t=7500r$</td></tr>
<tr><td>21</td><td colspan="7">هل المتتابعة الاتية حسابية 5,-6,-17,-28,…..</td></tr>
<tr><td>A</td><td>حسابية و آساسها<br>-11</td><td>B</td><td>ليست حسابية</td><td>C</td><td>حسابية و آساسها<br>-10</td><td>D</td><td>حسابية و أساسها 11</td></tr>
<tr><td>22</td><td colspan="7">في المتسلسلة الهندسية 4,8,16,32,… الأساس r يساوي..</td></tr>
<tr><td>A</td><td>2</td><td>B</td><td>4</td><td>C</td><td>3</td><td>D</td><td>0</td></tr>
<tr><td>23</td><td colspan="7">أوجدي $a_1$ في المتسلسله الهندسية التي $a_n=16, s_n = 688r = -\frac{1}{2}$ ,</td></tr>
<tr><td>A</td><td>1024</td><td>B</td><td>2038</td><td>C</td><td>514</td><td>D</td><td>2042</td></tr>
<tr><td>24</td><td colspan="7">الحدين التاليين في المتتابعة الهندسية 7,21,63,….. هما...</td></tr>
<tr><td>A</td><td>140,459</td><td>B</td><td>189,555</td><td>C</td><td>189,567</td><td>D</td><td>136,576</td></tr>
<tr><td>25</td><td colspan="7">يوجد للدالة $f(x)=\frac{x^2}{x-1}$ صفر عندما ...</td></tr>
<tr><td>A</td><td>$x=1$</td><td>B</td><td>$x=0$</td><td>C</td><td>$x=-1$</td><td>D</td><td>$x=3$</td></tr>
<tr><td>26</td><td colspan="7">أكتبي العدد 0.48 على صورة كسر إعتيادي</td></tr>
<tr><td>A</td><td>$\frac{9}{16}$</td><td>B</td><td>$\frac{22}{50}$</td><td>C</td><td>$\frac{1}{2}$</td><td>D</td><td>$\frac{13}{19}$</td></tr>
</table>

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 27 | مجال دالة المقلوب التالية $f(x)=\frac{7}{x-2}$ | | | | | | |
| A | $\{x: x\neq 2\}$ | B | $\{x: x\neq -2\}$ | C | $\{x: x\neq 0\}$ | D | $\{y: y\neq 0\}$ |
| 28 | أوجدي مجموع السلاسل الهندسية اللانهائية<br>27+18+12+8+..... | | | | | | |
| A | 30 | B | 81 | C | 27 | D | 18 |
| 29 | يتقاضى عليٌّ نظير عمله أجرة مقدارها 100 ريال يوميا ويحصل على زيادة على أجرته اليومية مقدارها 5 ريالات كل 3 شهور. فكم تصبح أجرته اليومية بعد مرور 3 سنوات؟ | | | | | | |
| A | 160 ريال | B | 102 ريال | C | 150 ريال | D | 115 ريال |
| 30 | آي مما يأتي ليس خط تقارب للدالة النسبية $f(x)=\frac{1}{x^2-49}$ | | | | | | |
| A | $y=0$ | B | $y=-7$ | C | $y=7$ | D | $y=1$ |

مع تمنياتي لكم بالتوفيق والنجاح

## Appendix C1: ICT Questionnaire (English Version)

**Dear Students**

This short questionnaire aims to collect information about accessibility to technology and the internet at home. For the purpose of this research, please read the following questions carefully and attempt to answer them correctly, and state any issue that you might face with using such technology at home.

Student name……

School name…….

1) Do you have any of the following devices in the house?
   a. Computer
   b. Laptop
   c. iPad
   d. Mobile

2) Can you use these devices freely at home; when answering no, please explain what kinds of problems and why?
   a. Yes
   b. No, explain more………

3) Do you have a good internet connection at home?
   a. Yes
   b. No

4) Can you watch video clips like YouTube and others? Write down any problem that you have in this regard.
   a. Yes
   b. No

Any problem with watching videos at home…….

Thank you for your time and for the information you have provided.

## Appendix C2 : ICT Questionnaire (Arabic Version)

**عزيزتي الطالبة**

يهدف هذا الاستبيان القصير إلى جمع بعض المعلومات حول إمكانية الوصول إلى التكنولوجيا والإنترنت في المنزل. لغرض هذا البحث يرجى قراءة الأسئلة التالية بعناية ومحاولة الإجابة عليها بشكل صحيح وذكر أي مشكلة قد تواجهينها عند استخدام هذه التكنولوجيا في المنزل.

إسم الطالبة:

إسم المدرسة:

هل يوجد في المنزل أي من الأجهزة التالية؟

أ. حاسب مكتبي

ب. حاسوب محمول

ج. آيباد

د. جهاز جوال

هل يمكنك استخدام هذه الأجهزة بحرية في المنزل عند الإجابة بـ"لا" ، يرجى توضيح أنواع المشكلات ولماذا؟

أ. نعم

ب. لا ، لماذا..

هل لديك اتصال جيد بالإنترنت في المنزل؟

أ. نعم

ب. لا

هل يمكنك مشاهدة مقاطع الفيديو مثل يوتيوب وغيرها؟ اكتبي أي مشكلة لديك في هذا الصدد؟

أ. نعم

ب. لا

مالسبب....

شكرا لك على وقتك وعلى المعلومات التي قدمتها

## Appendix D1: Mathematical Self-Efficacy Questionnaire (English Version)

In order to better understand what you think and feel about your flipped maths classroom, please respond to each of the following statements on a scale of 1 (Definitely false) to 5 (Definitely true). Below is an explanation of the meaning of the options to choose from:

1. Definitely False (totally disagree with this statement)
2. Probably False (I am somewhat against this statement)
3. Neither True nor False (I neither agree nor disagrss with this statement)
4. Probably True (I somewhat agree with this statement)

5. Definitely True (I fully agree with this statement).

| Items | Definitely True | Probably True | Neither True nor False | Probably False | Definitely False |
|---|---|---|---|---|---|
| 1. I make excellent grades on maths | | | | | |
| 2. I have always been successful with maths | | | | | |
| 3. Even when I study very hard, I do poorly in maths | | | | | |
| 4. I got good grades in maths on my last report card | | | | | |
| 5. I do well on maths assignments | | | | | |
| 6. I do well on even the most difficult maths assignments | | | | | |
| 7. My maths teachers have told that I am good at learning math | | | | | |
| 8. People have told me that I have a talent for maths | | | | | |
| 9. Adults in my family have told me what a good maths student I | | | | | |
| 10. I have been praised for my ability in maths | | | | | |
| 11. Other students have told me that I'm good at learning maths | | | | | |
| 12. My classmates like to work with me in maths because they think I'm good at it | | | | | |

## Appendix D2 : Mathematical Self-Efficacy Questionnaire (Arabic Version)

### المقياس التالي يهدفُ إلى التعرّف على رأيك فِي مدى قدرتك الذَّاتية لتعلم الرياضيات

(فضلًا اِقْرَئِي كل عبارة بعناية، ثم ضعي علامة في المكان الذي يعبر عن وجهة نظرك تجاه كل منها، فضلًا اختاري إجابةً واحدة لكل عبارة)

فيما يلي تفسير لمعنى الخيارات المطلوب الإختيار منها:

أرفض بشدة (أنا ضد هذة العبارة تمامًا)، لا أوافق (لا أوافق تمامًا على هذة العبارة)، غير متأكد (لا أوافق ولا أرفض هذة العبارة)، أوافق (إلى حد ما، أنا أتفق مع هذة العبارة)، أوافق بشدة (أتفق تمامًا مع هذة العبارة)

| م | | موافق بشدة | موافق | غير متأكد | غير موافق | غير موافق بشدة |
|---|---|---|---|---|---|---|
| 1- | أحصل على درجات ممتازة في اختبارات الرياضيات. | | | | | |
| 2- | أنا دائمًا ناجحُة في الرياضيات. | | | | | |
| 3- | على الرَّغم من أنني مجتهدة في مذاكرة الرياضيات فإنَّ أدائي ما زال ضعيفًا فيها. | | | | | |
| 4- | حصلت على درجة عالية في الرياضيات في آخر تقرير لي. | | | | | |
| 5- | أنَا جيدٌة في أداء المهام والتمارين الرياضية. | | | | | |
| 6- | أنا جيدٌة حتى في التمارين والأسئلة الرياضية الأكثر صعوبة. | | | | | |
| 7- | معلمتي أَخبرتني بأنني جيدة في تعلم الرياضيات. | | | | | |
| 8- | هناك أناس أخبروني بأن لديَّ مهارة في حل المسائل الرياضية. | | | | | |
| 9- | عائلتي أخبرتني بأنني طالبة رياضيات جيدة. | | | | | |
| 10- | لقد حصلت على جائزة تفوق في الرياضيات. | | | | | |
| 11- | زميلاتي في الصف أخبروني بأنني جيدة في الرياضيات. | | | | | |
| 12- | زميلاتي في الصف يحبون أن أحل معهم المسائل الرياضية، لأنَّهم يعتقدون بأنني جيدة في الرياضيات. | | | | | |
| 13- | أشعر بأن لغة الرياضيات لغة معقدة عند محاولتي حل أي مسألة رياضية. | | | | | |
| 14- | أنا أفهم معظم ما يطرح في حصة الرياضيات. | | | | | |
| 15- | أعرف أن للرياضيات لغتها الخاصة التي يمكن فَهمها. | | | | | |

### Appendix E1: Students' Perception of the FC Questionnaire (English Version)

The following scale aims to identify your opinion of the effectiveness of the flipped classroom strategy, in addition to the appropriateness of using it in learning mathematics. Please read each item carefully and then place a mark in the place that expresses your view towards each of them, please choose only one answer. Below is an explanation of the meaning of the options to choose from:

1. Strongly disagree (I am absolutely against this statement).
2. Disagree (I do not fully agree with this statement).
3. Neutral (I did not agree nor disagree with this statement).
4. Agree (to a certain extent, I concur with this statement).
5. Strongly agree (I absolutely concur with this statement).

### Flipped Video Perceptions

| | Items | Strongly Agree | Agree | Neutral | Disagree | Strongly Disagree |
|---|---|---|---|---|---|---|
| 1 | I prefer watching lectures on my own time over having lectures during class time. | | | | | |
| 2 | I find watching lectures on my own is a better way to learn material than if lectures are during class time. | | | | | |
| 3 | I often wish lectures were during class time so I could better understand the material. | | | | | |
| 4 | I enjoy being able to view the lecture prior to class as opposed to live in-class lectures. | | | | | |
| 5 | I find that individual access to lectures has increased my desire to learn the material. | | | | | |
| 6 | Video lectures greatly enhance my learning. | | | | | |
| 7 | I like the fact that I can re-watch lectures any time so I can gain a deeper understanding of the material. | | | | | |
| 8 | The ability to rewind the video lecture helps me learn. | | | | | |
| 9 | I find it easy to take notes while I watch the video lectures. | | | | | |
| 10 | The ability to rewind the video lecture helps me take notes on the material. | | | | | |

|  | Items | Strongly Agree | Agree | Neutral | Disagree | Strongly Disagree |
|---|---|---|---|---|---|---|
| 11 | There are opportunities to ask questions on the assigned lecture if I need clarification on the material |  |  |  |  |  |
| 12 | I am comfortable using video lectures for learning. |  |  |  |  |  |
| 13 | The video lectures for this course are easy to access. |  |  |  |  |  |
| 14 | The video lectures for this course are easy to use. |  |  |  |  |  |
| 15 | I encounter technical difficulties when trying to watch the video lectures for this course. |  |  |  |  |  |
| 17 | I do not view the lectures before class although I am supposed to. |  |  |  |  |  |
| 18 | I always watch the assigned lectures. |  |  |  |  |  |
| 19 | I usually rewind and re-watch parts (or entire) lecture to study for this course. |  |  |  |  |  |

## Flipped Class Perceptions

|  | Items | Strongly Agree | Agree | Neutral | Disagree | Strongly Disagree |
|---|---|---|---|---|---|---|
| 1 | I participate and engage in in-class discussions. |  |  |  |  |  |
| 2 | I participate and engage in in-class activities. |  |  |  |  |  |
| 3 | I find that in-class activities make class less boring. |  |  |  |  |  |
| 4 | I find that in-class activities make class more useful. |  |  |  |  |  |
| 5 | Discussing with classmates helps me learn. |  |  |  |  |  |
| 6 | Interactive, applied in-class activities greatly enhance my learning. |  |  |  |  |  |

|  | Items | Strongly Agree | Agree | Neutral | Disagree | Strongly Disagree |
|---|---|---|---|---|---|---|
| 7 | The instructor makes meaningful connections between the topics in the lecture videos and the in-class activity. |  |  |  |  |  |
| 8 | This course as a whole has been a valuable learning experience. |  |  |  |  |  |
| 9 | I would take another flipped course. |  |  |  |  |  |
| 10 | I feel this class increases my engagement in collaborative decision-making. |  |  |  |  |  |
| 11 | I find this class engages me in critical thinking and problem solving. |  |  |  |  |  |

## Appendix E2: Students' Perception of the FC Questionnaire (Arabic Version)

**المقياس التالي يهدف إلى التعرّف على رأيك في مدى فاعلية استراتيجية الصف المقلوب، بالإضافةِ إلى مدى مُلائمة استخدامها في تعلم مادة الرياضيات.**

(فَضلًا اِقْرَئِي كل عبارة بعناية ثم ضعي علامة في المكان الذي يعبر عن وجهة نظرك تجاه كل منها، فضلًا اختاري إجابة واحدة لكل عبارة).

فيما يلي تفسير لمعنى الخيارات المطلوب الإختيار منها:

أرفض بشدة (أنا ضد هذة العبارة تمامًا)

لا أوافق (إلى حد ما لا أوافق على هذة العبارة)

غير متأكد (لا أوافق ولا أرفض هذة العبارة)

أوافق (إلى حد ما ، أنا أتفق مع هذة العبارة)

أوافق بشدة (أتفق تمامًا مع هذة العبارة)

**(1) الأثر التعليمي لاستخدام الفيديو في استراتيجية الصفوف المقلوبة:**

| م | الأثر التعليمي لاستخدام الفيديو في استراتيجية الصفوف المقلوبة | موافق بشدة | موافق | غير متأكد | غير موافق | غير موافق بشدة |
|---|---|---|---|---|---|---|
| 1- | أنا أفضل مشاهدة المحاضرات في الوقت الخاص بي على وجود محاضرات خلال وقت الدرس. | | | | | |
| 2- | أجد أن مشاهدة المحاضرات بمفردي طريقةٌ أفضل لتعلم المواد، أكثر مما لو كانت المحاضرات خلال الفصل الدراسي. | | | | | |
| 3- | غالبًا ما كنت أتمنى أن تكون المحاضرات أثناء الفصل الدراسي حتى أتمكن من فَهم المادة بشكل أفضل. | | | | | |
| 4- | أنا أستمتعُ بالقدرةِ على مشاهدة المحاضرة قبل الفصل، بدلًا من المحاضرات الحية في الصف. | | | | | |
| 5- | أجد أنَّ الوصول الفردي إلى المحاضرات زاد رغبتي في تعلم المادة. | | | | | |
| 6- | مُحاضرات الفيديو تعزز -إلى حدٍّ كبيرٍ- تعليمي. | | | | | |
| 7- | أعجبني أنَّه يمكنني إعادة مشاهدة المحاضرات في أي وقت؛ حتَّى أتمكن من الحصول على فَهمٍ أعمق للمادة. | | | | | |
| 8- | تساعد القدرة على إرجاع محاضرة الفيديو على التعلم. | | | | | |

| م | الأثر التعليمي لاستخدام الفيديو في استراتيجية الصفوف المقلوبة | موافق بشدة | موافق | غير متأكد | غير موافق | غير موافق بشدة |
|---|---|---|---|---|---|---|
| 9- | أجد أنَّه من السهل تدوين الملاحظات أثناء مشاهدة محاضرات الفيديو. | | | | | |
| 10- | تُساعد القدرة على إرجاع محاضرة الفيديو على تدوين ملاحظات حول المادة. | | | | | |
| 11- | هناك فرص لطرح الأسئلة على محتوى الفيديو إذا كنت بحاجة لتوضيح ذلك. | | | | | |
| 12- | أنا مرتاحٌ باستخدام محاضرات الفيديو للتعلم. | | | | | |
| 13- | مِن السهل الوصول إلى محاضرةِ الفيديو. | | | | | |
| 14- | محاضرة الفيديو للدروس التي تعلمناها سهلة الاستخدام. | | | | | |
| 15- | أواجه صعوبات فنية عند محاولة مشاهدة محاضرات الفيديو. | | | | | |
| 16- | أنا لا أرى محاضرات الفيديو قبل الفصل، رُغم أنني من المفترض أنْ أُحضّرَ الدرس، وذلك بمشاهدات تلك الفيديوهات. | | | | | |
| 17- | أنا دائما أشاهد محاضرات الفيديو يوميًّا. | | | | | |
| 18- | أنا عادة أُعيد وأُعيد مشاهدة أجزاء (أو كامل) محاضرة الفيديو. | | | | | |
| 19- | عادة ما أشاهد فقط أجزاء من محاضرات الفيديو. | | | | | |

(2) **أثر تطبيق استراتيجية الصف المقلوب على الأنشطة داخل الصف:**

| م | أثر تطبيق استراتيجية الصف المقلوب على الأنشطة داخل الصف | موافق بشدة | موافق | غير متأكد | غير موافق | غير موافق بشدة |
|---|---|---|---|---|---|---|
| 1- | أشارك بفاعلية في مناقشات الصف. | | | | | |
| 2- | أشارك وأمارس الأنشطة داخل الصف. | | | | | |
| 3- | أجد أن تنوع الأنشطة داخل الفصل يجعل الصف أقل مللًا. | | | | | |
| 4- | أجد أن الأنشطة داخل الفصل تجعل الصف أكثر فائدة. | | | | | |
| 5- | تُساعدني المناقشة مع زملائي في التعلم. | | | | | |
| 6- | إنَّ الأنشطة التفاعلية والتطبيقية في الفصل الدراسي تعزز إلى حدٍّ كبير تعليمي. | | | | | |
| 7- | تقوم المعلمة بعمل روابط ذات معنى بين المواضيع في مقاطع الفيديو والنشاط داخل الفصل. | | | | | |
| 8- | استراتيجية الصف المقلوب كانت تجربة تعليمية قيّمة. | | | | | |
| 9- | أتمنى أنَّ أتعلم بطريقة الصف المقلوب مرة أخرى. | | | | | |
| 10- | أشعر أنَّ هذا الصف يزيدُ مِن مُشاركتي في صنعِ القرار التعاوني. | | | | | |
| 11- | هذا الصف ساعدني في تعلم التفكير النقدي وحل المشكلات. | | | | | |

**ختامًا:**

**أتقدم بخالص شكري وتقديري إلى كل مَن شارك في هذا الاستبيان في سبيل خدمة البحث العلمي**

**وأسأله تعالى أن يجزيه خيرَ الجزاء ويمكن كتابة أي ملاحظة أدناه:**

.............................................................................

.............................................................

**Appendix F1: Interview Questions (English Version)**

## Interview Guiding Questions

**Date:** **Interview Start Time**:

**Teacher Name**: **Interview End Time**:

### Introduction

Hi, my name is Badriah, and I am a PhD student at the University of York, researching the effect of the flipped classroom on students' learning experience. I want to thank you for taking the time to talk with me today. The aim of this interview is to gain a deep understanding of your experiences of teaching mathematics with the implementation of the flipped classroom instructional approach during the previous weeks. The interview will be recorded, and your identity will remain anonymous. You will also have the opportunity to comment on the written record of your interview.

Do you have any questions for me before we begin?

The potential topics for the interview:

1. Can you describe your flipped maths class during the implementation of the flipped classroom?
2. What do you think about using video lectures to support teaching or learning?
3. What impact do you think video lectures have on students' learning? Achievements?
4. How could the designs of the activities both in class and out of class have an impact on students' learning?
5. In your opinion, how effective is the flipped classroom model in your classroom?
6. Could you tell me how you, as a teacher, have benefited from the approach? What have you gained by flipping your class? Has it changed the way you teach? Positively and/or negatively?
7. What do you consider have been the main challenges of the approach? Prompt with: problems with students? Any technical problems? Identified any gaps in the approach or need for extra training?
8. What is your further suggestion for improving the flipped classroom approach in the future?
9. Do you like this model? Will you continue flipping your classroom? Why or why not?
10. If you decide to flip your class in the future, would you prefer using existing videos on the internet or design your own videos?
11. Will you recommend the flipped classroom to other teachers in the school?
12. Any general comments you would like to make?

Thank you very much for your time and your participation in the interview.

## Appendix F2 : Interview Questions (Arabic version)

### أسئلة توجيهية للمقابلة

**التاريخ:** **وقت بدء المقابلة:**

**إسم المعلمه:** **وقت انتهاء المقابلة:**

**مقدمة**

مرحبًا، أنا بدرية القرني، طالبة دكتوراة في جامعة يورك. أُجري بحثًا حول تأثير استراتيجية الصف المقلوب على التجربة التعليمية للطالبات. أودّ أن أشكرك على وقتك اللذي خصصته لأجري معك المقابلة اليوم. الهدف من هذه المقابلة هو الفهم العميق لتجربتك في تدريس مادة الرياضيات من خلال تطبيق استراتيجية الصف المقلوب خلال الأسابيع السابقة. سيتم تسجيل المقابلة، ولن يتم الإفصاح عن هويتك، وستتاح لك الفرصة أيضًا للتعليق على التفريغ الصوتي لمقابلتك.

هل لديك أيّ أسئلة قبل البدء؟

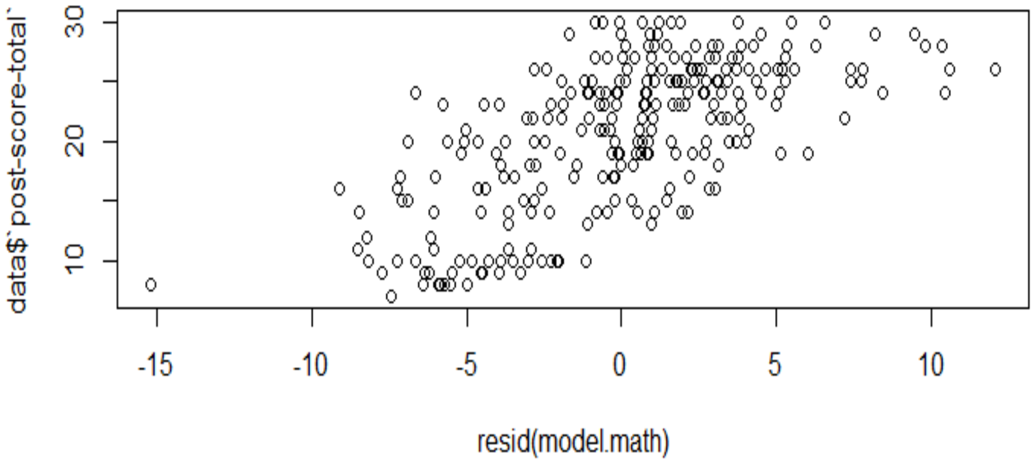
1. صِفي استراتيجية الصف المقلوب التي طبقتيها في تدريس الرياضيات؟
2. ما رأيك في استخدام محاضرات الفيديو لدعم التدريس أو التعلم؟
3. ما تأثير محاضرات الفيديو على مشاركة الطالبات في أنشطه الفصل؟
4. كيف يمكن أن يؤثر تصميم الأنشطة داخل الفصل وخارجه على تعلم الطالبات؟
5. برأيك، ما مدى فاعلية نموذج الصف المقلوب في فصلك الدراسي؟
6. هل يمكن أن تخبريني كيف استفدتي من هذه الاستراتيجية كمعلمهٍ؟ ما الذي اكتسبته من قلب صفك الدراسي؟ هل غيّرأسلوبك في التدريس؟ إيجابًا و/ أم سلبًا؟
7. باعتقادك، ما هي التحديات الرئيسية لهذه الاستراتيجية؟ (توجيه للإجابة: مشكلات مع الطالبات؟ أيّ مشاكل فنية؟ هل اكتشفتي أيّ ثغراتٍ في الاستراتيجية أو حاجةٍ إلى تدريب إضافي؟)
8. هل لديك اقتراحٌ آخرٌ لتحسين استراتيجية الفصل المقلوب في المستقبل؟
9. هل أعجبك هذا النموذج؟ هل ستستمرين في قلب فصلك؟ نعم أم لا؟ ولماذا؟
10. إذا قررتي قلب فصلك في المستقبل، هل تفضّلين استخدام الفيديوهات الموجودة على الإنترنت أم إعداد الفيديوهات بنفسك؟
11. هل توصين باستراتيجية الصف المقلوب لمعلمات اخريات في المدرسة؟
12. هل لديك أيّ تعليقات عامة تودين الحديث عنها؟

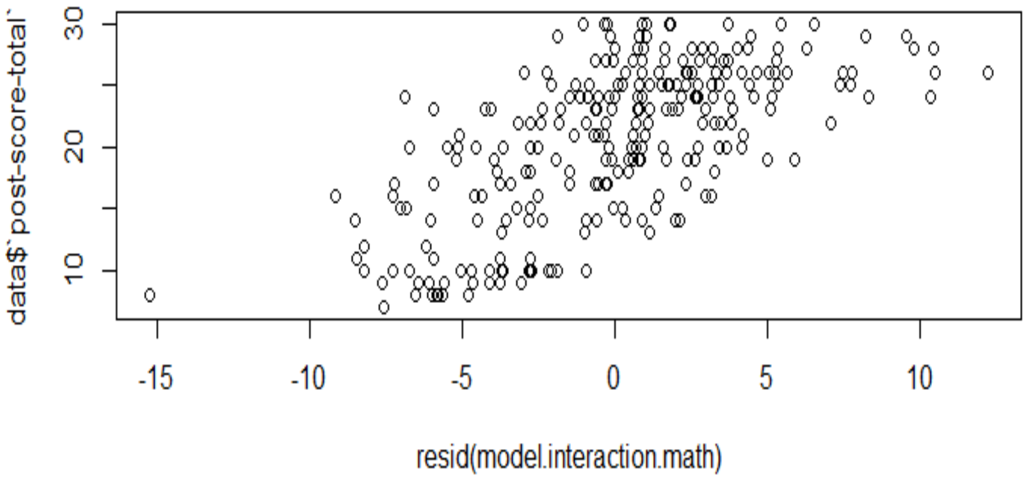
شكرًا جزيلًا على وقتك ومشاركتك في المقابلة

## Appendix G1: Assumptions of the Mixed Effects Model

There are main three assumptions which should be met for application of the mixed effect model, namely: linearity, homogeneity of variance, and normality of residuals (Bates et al., 2014). The data for this study were checked to ensure that these assumptions were not violated. Below the tests of, linearity, homogeneity of variance, and normality of residuals will be discussed and tested.

Firstly, the **linearity** assumption was tested by plotting the residuals of the model on the X- axis and a dependent variable on the Y-axis. All graphs revealed randomly distributed data (see the following figures below).





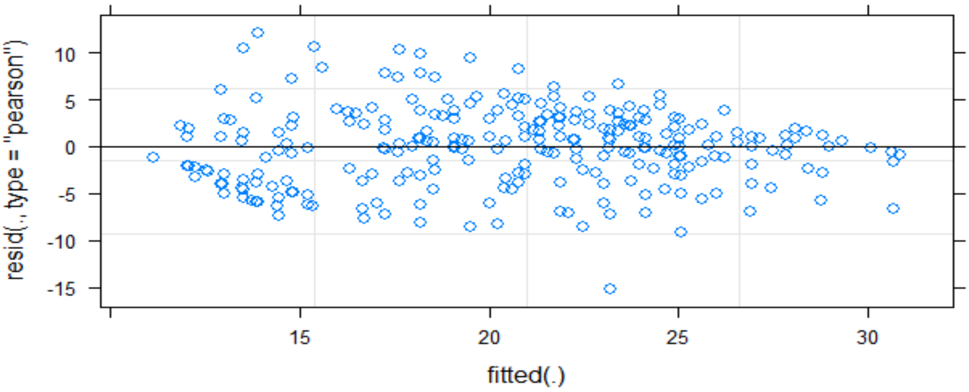
Secondly, the assumption of **homogeneity** of variance was checked. This assumption means, that if we go through different levels of one variable, the variance of another variable stays unchanged. The variance of the outcome variable should be similar across different groups. The best way to check this assumption is by using the Levene test in R from the 'car' package. Levene`s test tests the null hypothesis that the variances in different groups are equal. The output shows that all p-values > 0.05, which means all the data was non-significant across the two levels of the condition variable (Intervention and control) see table 6.2 for full details.

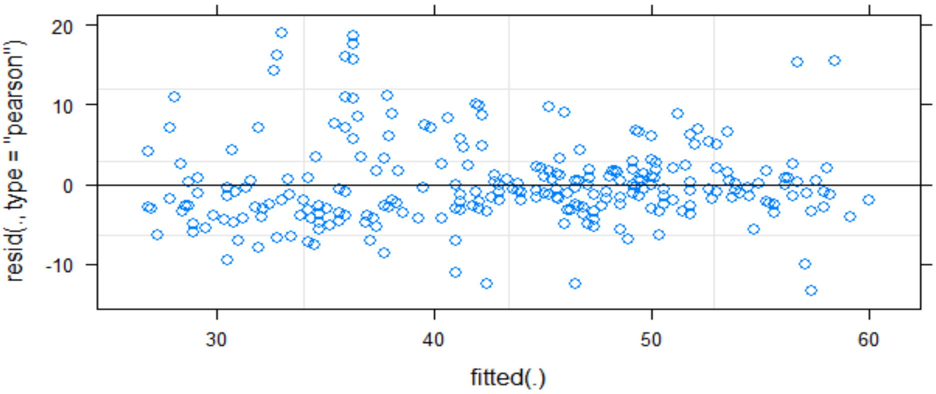
**Table 1 Homogeneity test for the study variables**

| Groups between | F | df1 | df2 | p |
|---|---|---|---|---|
| Pre-maths-score | 0.081 | 1 | 279 | 0.776 |
| Post-maths-score | 1.117 | 1 | 279 | 0.291 |
| Pre-self-efficacy score | 1.135 | 1 | 279 | 0.288 |
| Post-self-efficacy score | 0.006 | 1 | 279 | 0.936 |

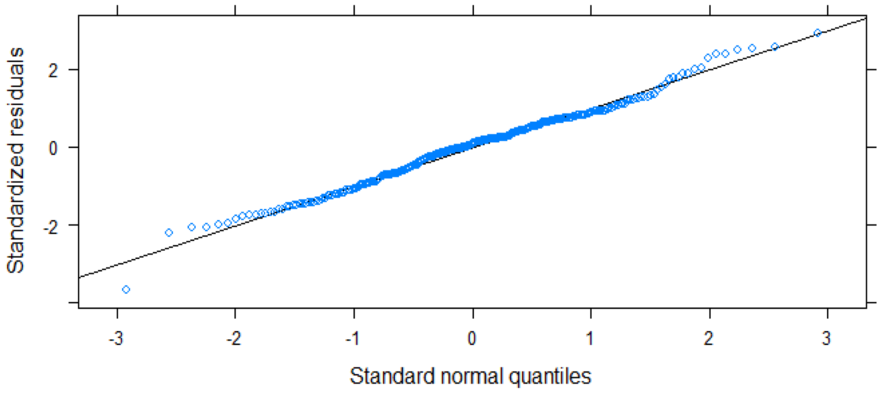
We can also check the homogenity of variance graphically. The next plots must reveal randomly distributated data, so homoskestisity can be assumed.

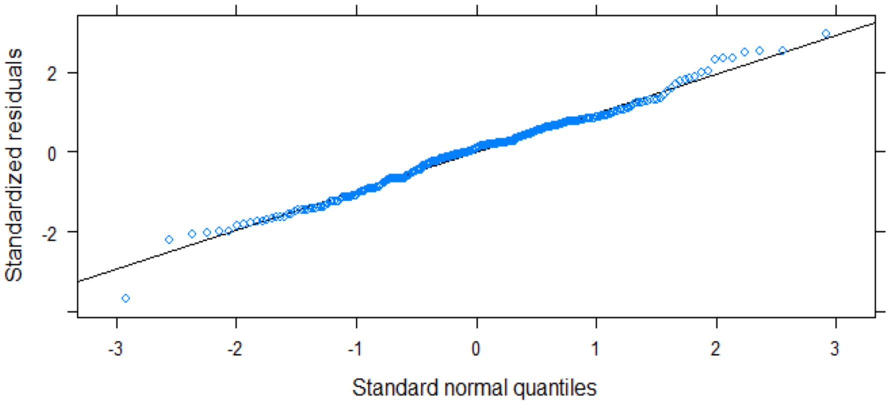
All models reveals randomly distributated values actoss srtraight line. So the assumption of homogenity of variance is met.





Finally, the **normality of residuals**, was checked to verify whether observed residuals are normally distributed (Field, 2009; Pallant. 2011). "In general, researchers are not overly concerned with the assumption of normality except when small samples are used" (Carver and Nash, 2012, p.145). Pallant (2011) added that "With large enough sample sizes (e.g., 30+), the violation of this assumption should not cause any major problems" (p 206). Although the samples in this study were large enough for normality is not a serious concern. The assumption was checked graphically by using Q-Q plots see the four figures below, which show that there was no problem with data normality.




Standardized residuals
2
0
-2
-3
-2
-1
0
1
2
3
Standard normal quantiles

## Appendix G2: R Codes

```
# data.t is the name of the dataset
data.t <- data.frame(data_t) # making data.t a data.frame
# Buildind 4 models
# the nested random effect is allowing different intercepts for each Teacher within School #intercept varying among School and Teacher within School
library(lme4)
model.math = lmer(post.math ~ condition+ pre.math+ (1|School/Teacher), data = data.t)
model.interaction.math = lmer(post.math ~ pre.math* condition + (1|School/Teacher), data = data.t)
model.self = lmer(post.self ~ condition + pre.self + (1|School/Teacher), data = data.t)
model.interaction.self = lmer(post.self ~ condition*pre.self + (1|School/Teacher), data = data.t)
## Asumptions
# Normality
# Shapiro-Wilk Normality test of Pre and Post score variables
shapiro.test(data.t$pre.math)
shapiro.test(data.t$post.math)
shapiro.test(data.t$pre.self)
shapiro.test(data.t$post.self)
# Histograms
hist(data.t$pre.math,freq = F, xlab = 'Pre-math-score', main='Histogram')
lines(density(data.t$pre.math))
hist(data.t$post.math,freq = F, xlab = 'Post-math-score', main='Histogram')
lines(density(data.t$post.math))
hist(data.t$pre.self,freq = F,xlab = 'Pre-self-score', main='Histogram')
lines(density(data.t$pre.self))
hist(data.t$post.self,freq = F,xlab = 'Post-self-score', main='Histogram')
lines(density(data.t$post.self))
# Homogenity of variance
# Residuals vs Fitted plots
plot(model.math)
plot(model.interaction.math)
plot(model.self)
plot(model.interaction.self)
# Levene`s  test
```

```
library(car)

leveneTest(data.t$pre.math, data.t$condition)

leveneTest(data.t$post.math, data.t$condition)

leveneTest(data.t$pre.self, data.t$condition)

leveneTest(data.t$post.self, data.t$condition)

# Linearity

# Residuals vs Dependent variable plots

plot(resid(model.math), data.t$pre.math)

plot(resid(model.interaction.math), data.t$post.math)

plot(resid(model.self), data.t$pre.self)

plot(resid(model.interaction.self), data.t$post.self)

# Normality of residuals

# Q-Q plots

library(lattice)

qqmath(model.math)

qqmath(model.interaction.math)

qqmath(model.self)

qqmath(model.interaction.self)

# Graphs of the model

library(ggeffects)

library(ggplot2)

pred.1 <- ggpredict(model.math, terms =  c('pre.math','School','condition','Teacher'), type = "random")

plot(pred.1, add.data = TRUE) # will build 5 plots

pred.3 <- ggpredict(model.self,terms =  c('pre.self','School','condition', 'Teacher'), type = "random")

plot(pred.3, add.data = TRUE) # will build 5 plots

# Significance of coefficients with Likelihood-Ratio Test

library(stats)

drop1(model.math, test = "Chisq")

drop1(model.interaction.math, test = "Chisq")

drop1(model.self, test = "Chisq")

drop1(model.interaction.self, test = "Chisq")
```

## Appendix H1: Approval from the Ministry of Education

المملكة العربية السعودية
وزارة التعليم
(٢٨٠)
الإدارة العامة للتعليم بمحافظة جدة
إدارة التخطيط والمعلومات -البحوث و الدراسات

وزارة التعليم
Ministry of Education

الرقم: ٤٠١٨١٢٦١٨٤
التاريخ: ٣٠/٢/١٤٤٠هـ
المرفقات: ....................................

رؤيتنا : متعلم .. معتز بدينه .. منتم لوطنه .. منتج للمعرفة .. منافس عالمياً .

" تطبيق البحث "

| | | | |
|---|---|---|---|
| الأسم | بدرية محمد حسن القرني | السجل المدني | ١٠٣٢٠٠٦٤٣٧ |
| الجوال | ٠٥٠٣٧٩٦٦٢٩ | البريد الإلكتروني | Ba754@york.ac.uk |
| الملحقية الثقافية | بلندن | التخصص | تربية |
| الدرجة العلمية | دكتوراه | عينة الدراسة | طالبات المرحلة الثانوية |
| عنوان الدراسة | التعلم المدمج والفصول المعكوسة : الآثار المحتملة على تعزيز تجربة تعلم الطالبات في المدارس الثانوية في اللمملكة العربية السعودية | | |
| الموضوع بشأن | بتطبيق أدوات بحثه في تعليم جدة . | | |

**إلـــى : الملحق الثقافي بسفارة المملكة العربية السعودية لدى المملكة المتحدة.**

**مـــن : مدير عام التعليم بمحافظة جدة .**

السلام عليكم ورحمة الله وبركاته

بناء على إفادتكم ( الموضح بياناتها أعلاه )، واستجابة لرغبتها في تزويدكم بالموافقة بتطبيق بحثها و جمع البيانات المتعلقة بعينة الدراسة .

نفيدكم أنه لا مانع لدينا بالموافقة بعد دراسة أداة البحث ؛ و ذلك تشجيعاً للبحث العلمي وبما يعود على الوطن بمثل هذه البحوث الميدانية ؛ شاكرين ومقدرين تعاونكم واهتمامكم.

والسلام عليكم ورحمة الله وبركاته

**مدير عام التعليم بمحافظة جدة**

**عبدالله بن أحمد الثقفي**

## Appendix H2: Approval from the Head of Schools Destrict

المملكة العربية السعودية
وزارة التربية والتعليم
(٢٨٠)
الإدارة العامة للتربية والتعليم بمحافظة جدة
إدارة التخطيط والمعلومات - البحوث و الدراسات

وزارة التربية والتعليم
Ministry of Education

الرقم : ٤٥ / ١/ ٣م
التاريخ : ٢١ / ٢ / ١٤٤٠هـ
المرفقات :

رؤيتنا : متعلم .. معتز بدينه .. منتم لوطنه .. منتج للمعرفة .. منافس عالمياً .

" تسهيل مهمة بحث "

| | | | |
|---|---|---|---|
| الأسم | بدرية محمد حسن القرني | السجل المدني | ١٠٣٢٠٠٦٤٣٧ |
| الجوال | ٠٥٠٣٧٩٦٦٦٢٩ | البريد الإلكتروني | Ba754@york.ac.uk |
| الملحقية الثقافية | بلندن | التخصص | تربية |
| الدرجة العلمية | دكتوراه | عينة الدراسة | طالبات المرحلة الثانوية |
| عنوان الدراسة | التعلم المدمج والفصول المعكوسة : الآثار المحتماة على تعزيز تجربة تعلم الطالبات في المدارس الثانوية في المملكة العربية السعودية | | |
| الموضوع بشأن | بتطبيق أدوات بحثه في تعليم جدة . | | |

**إلـــى : مديري و مديرات التعليم .**

**مـــن : مدير إدارة التخطيط والمعلومات.**

السلام عليكم ورحمة الله وبركاته ، وبعد :

بناء على خطاب المدير العام رقم : ٤٠١٨١٣٢١٨٤ في ٢٠ / ٢ / ١٤٤٠هـ، حول تسهيل مهمة الباحثة ( الموضح بياناته أعلاه ).

نأمل منكم تسهيل مهمة الباحثة بتطبيق أداة بحثها على عينة الدراسة؛ وفق اللوائح المنظمة. وننوه بأن الباحثة تتحمل مسؤولية جمع البيانات و الحفاظ على سريتها لاستخدامها لأغراض البحث العلمي فقط . شاكرين ومقدرين تعاونكم واهتمامكم.

والسلام عليكم ورحمة الله وبركاته.

**خليل بن فراج الوافي**

| | | |
|---|---|---|
| الاصدار / ٢ | التاريخ ١/٣/١٤٣٩هـ | مف - ع٣-١٥ |

## Appendix I1: Informed Consent Form - Head Teachers (English Version)

### Information sheet and consent form

**Dear head teacher**

My name is Badriah Algarni. I am a student at the University of York, working on a doctoral degree. I am currently carrying out a research project entitled Blended Learning and the Flipped Classroom: Potential Effects on Enhancing Students' Learning Experience in Saudi Arabia. I would like to invite your school to take part in this research project.

Before agreeing to take part, please read this information sheet carefully and let us know if anything is unclear or if you would like further information.

### Purpose of the study

The study is designed to investigate the potential effect of the flipped classroom on students' mathematical proficiency and self-efficacy in high school in Saudi Arabia. In addition, this study will examine students' perceptions of their experience with this new teaching approach, as well as the teachers' perceptions and their experience of the flipped class model and the challenges associated with this approach.

### What would this mean for your school?

The study will be conducted in two mathematics classrooms in your school. The study will start in the second semester 2019 and it will take approximately nine weeks. Data will be collected at the beginning and at the end of the study and will involve a pre-treatment survey, student pre- and post-tests, data usage, a survey of students' perceptions and self-efficacy, and interviews with teachers. Participants in this study will be in grade 11 mathematics classes. One classe will be the control groups, which will receive traditional teaching instruction, and the other class will be the experimental groups, which will implement flipped classroom instruction. The teacher is expected to flip one of her classrooms. This will be achieved by enabling students to prepare their lessons and complete homework by watching video lectures and answering online quizzes through the Moodle learning management system. Then, in the classroom session, students can work collaboratively with their peers and teacher to discuss the concepts presented in the videos in much more detail and engage in a variety of activities to practise further and/or to expand their learning through further investigation or application problems. At the end of the experiment, the researcher will collect information about participants' perceptions of their experience of the flipped classroom by conducting a survey of the students and interviews with the teachers. In this research, there are no foreseeable risks to the participants. Although there may be no direct benefit to them, a possible benefit from their being part of the proposed study is to enhance educator awareness of the effectiveness of utilising blended learning in mathematics, especially in vocational education. Participating in the proposed study will not entail any costs to the participants.

### Participation is voluntary

Participation is optional. If you do decide to take part, you will be given a copy of this information sheet for your records and will be asked to complete a participant information form. If you change your mind at any point during the study, you will be able to withdraw your participation without having to provide a reason.

**Processing of your data**

Under the General Data Protection Regulation (GDPR), the university has to identify a legal basis for processing personal data and, where appropriate, an additional condition for processing special category data.

In line with our charter, which states that we advance learning and knowledge by teaching and research, the university processes personal data for research purposes under Article 6 (1)(e) of the GDPR:

*Processing is necessary for archiving purposes in the public interest, or scientific and historical research purposes or statistical purposes.*

Research will only be undertaken where ethical approval has been obtained, where there is a clear public interest and where appropriate safeguards have been put in place to protect data.

In line with ethical considerations and in order to comply with the common law duty of confidentiality, we will seek your consent to participate where appropriate. This consent will not, however, be our legal basis for processing your data under the GDPR.

**Anonymity and confidentiality**

The data that participants provide (e.g., recordings of the interviews, test results, survey results, and data usage from Moodle) will be stored by code number. Any information that identifies any of the students or the teachers will be stored separately from the data. The participants are free to withdraw from the study at any time during data collection and up to two weeks after the data are collected. Information will be treated confidentially and shared on a need-to-know basis only. The university is committed to the principle of data protection by design and default and will collect the minimum amount of data necessary for the project. In addition, we will anonymise or pseudonymise data wherever possible.

**Storing and using your data**

We will put in place appropriate technical and organisational measures to protect your personal data. Data will be stored on a password-protected computer. Data will be kept for five years, after which time they will be destroyed. The data that I collect (i.e., test results, survey results and audio recordings) may be used in *anonymous* form in different ways. Please indicate on the consent form attached with a ☑ if you are happy for this anonymised data to be used in the ways listed.

**Transfer of data internationally**

It is possible that the data will be transferred internationally. The university's cloud storage solution is provided by Google, which means that data can be located at any of Google's globally spread data centres. The university has data protection-compliant arrangements in place with this provider. For further information, see:

https://www.york.ac.uk/it-services/google/policy/privacy/

**Your rights**

Under the GDPR, you have a general right of access to your data, a right to rectification, erasure, restriction, objection or portability. You also have a right to withdraw up to two weeks after the data are collected. If one of the participants withdraws, then their data are not processed. For further information, see: https://www.york.ac.uk/records-management/generaldataprotectionregulation/individualrights/

**Questions or concerns**

If you have any questions about this participant information sheet or concerns about how your data are being processed, please feel free to contact Badriah Algarni by email at ba754@york.ac.uk or by telephone on 00966503796629, or the Chair of Ethics Committee via email at education-research-administrator@york.ac.uk. If you are still dissatisfied, please contact the university's Data Protection Officer at dataprotection@york.ac.uk.

**Right to complain**

If you are unhappy with the way in which your personal data have been handled, you have a right to complain to the Information Commissioner's Office. For information on reporting a concern to the Information Commissioner's Office, see www.ico.org.uk/concerns

We hope that you will agree to take part in this study. If you are happy to participate, please complete the form attached and I will come to the school and collect it by 22 December 2018.

Thank you for taking the time to read this information.

Sincerely

Badriah Algarni

Email: ba754@york.ac.uk

**Consent Form**

**Please initial each box if you are happy to take part in this research.**

- I confirm that I have read and understood the information given to me about the above-named research project and I understand that this will involve me taking part as described above. ☐
- I understand that the purpose of the research is to investigate the potential effect of the flipped classroom on students' mathematical achievement and self-efficacy in high school in Saudi Arabia. ☐
- I understand that data will be stored securely in a locked filing cabinet or on a password-protected computer and only the researcher and her supervisor, Hugues Lortie-Forgues, will have access to any identifiable data. ☐
- I understand that the students will be protected by use of a code/pseudonym. ☐
- I understand that participation in this study is voluntary. ☐
- I understand that my data will not be identifiable, and the data may be used ….

  in publications that are mainly read by university academics ☐

  in presentations that are mainly attended by university academics ☐

  in publications that are mainly read by the public ☐

  in presentations that are mainly attended by the public ☐

  freely available online ☐

- I understand that data will be kept for five years, after which they will be destroyed. ☐
- I understand that data could be used for future analysis or other purposes, such as research and teaching purposes. ☐
- I understand that I can withdraw my data at any point during data collection and up to two weeks after the data are collected. ☐
- I understand that my anonymised data can be stored indefinitely and used in the future for research purposes. ☐

Name_________ Signature ____________ Date ________________________

# Appendix I2: Informed Consent Form - Head Teachers (Arabic Version)

**عزيزتي مديرة المدرسة**

أنا بدرية القرني، طالبة دكتوراة جامعة يورك. أقوم حاليًا بمشروعٍ بحثي بعنوان: "التعلم المدمج والصف المقلوب: التأثيرات المحتملة على تعزيز التحصيل الرياضي والكفاءة الذاتية للطالبات في المملكة العربية السعودية". وأودّ أن أدعوك لمشاركه مدرستك في هذا المشروع البحثي.

قبل الموافقة على المشاركة، يُرجى قراءة نشرة المعلومات هذه بتمعنٍ، وإبلاغنا إن كان هناك شيء غير واضحٍ أو إن كنت ترغبين في الحصول على مزيد من المعلومات.

**الغرض من الدراسة**

هذه الدراسة مصممةٌ لبحث التأثيرات المحتملة لتطبيق إستراتيجية الصف المقلوب على التحصيل الرياضي والكفاءة الذاتية لطالبات المرحله الثانوية. فضلًا عن ذلك، ستتناول انطباعات الطالبات حول تجربتهم مع هذه الاستراتيجية الجديدة، وكذلك انطباعات المعلمات وتجاربهم في نموذج الصف المقلوب والتحديات المرتبطة به.

**ماذا يعني ذلك بالنسبة لمدرستك؟**

اكتب إليك لأطلب إذنك للمشاركة في إجراء دراستي البحثية على فصلين من فصول الرياضيات في مدرستك. ستُجرى الدراسة في الفصل الدراسي الثاني 2019، وستستغرق حوالي تسعة أسابيع. ستُجمع البيانات في بداية البحث وفي نهايته وستشمل إستبانةً أوليةً، واختبارًا قبليًا وآخر بعديًا للطالبات، وبيانات الاستخدام من موقع Moodle، واستبانةً لانطباعات الطالبات وكفاءتهم الذاتية. ستجري هذه الدراسة على فصول الرياضيات للصف التاني ثانوي علمي، فصل في المجموعة الضابطة والتي ستتلقى تعليمات التدريس التقليدية، أما الفصل الاخر في المجموعة التجريبية والتي ستنفذ تعليمات الصف المقلوب. يُتوقع من المعلمة في الصف المقلوب أن "تقلب" الفصل من خلال السماح للطالبات بتحضير دروسهم، والدراسة، وحل الواجبات المدرسية في البيت عبر محاضرات الفيديو عن طريق نظام إدارة التعلم "الموودل"، والعودة إلى الحصة القادمة لمناقشة لهذه المفاهيم باستفاضة، والتدرب بشكلٍ أكبر، وتوسيع نطاق التعلم بإجراء مزيدٍ من التدريبات والتمارين. في نهاية التجربة، ستجمع الباحثة معلوماتٍ عن انطباعات المشاركات حول تجربتهم في الصف المقلوب من خلال تقديم استبانةٍ للطالبات وإجراء مقابلة مع معلمتهم.

الباحثة ستجري المقابلة في الوقت المناسب للمعلمة. وستشمل مجموعة من الأسئلة مثل: طريقة إعداد الدروس وكيف أثر الصف المقلوب على طريقة التدريس ومدى إستجابة الطالبات. من المتوقع أن تستغرق المقابلة حوالي 20-30 دقيقة. سيتم تسجيل المقابلة، ولن يتم الإفصاح عن هويتة المعلمه، وستتاح لها الفرصة أيضًا للتعليق على التفريغ الصوتي لمقابلتها.

لا يُتوقع وقوع مخاطر على المشاركين في هذا البحث. ومع أنه قد لا يعود عليهم بالنفع بشكلٍ مباشرٍ، إلا أن الفائدة المحتملة من مشاركتهم في الدراسة المقترحة هي تعزيز وعي المعلمات بمدى فاعلية استخدام التعلم المدمج في العملية التعليمية. كما لن يترتب على المشاركين في الدراسة المقترحة أيّ تكاليف.

### المشاركة اختيارية

المشاركة في هذه الدراسة اختيارية. وإذا قررت ذلك، سيتم إعطاؤك نسخةً من نشرة المعلومات هذه لتحتفظي بها في ملفاتك، وسيُطلب منك إكمال نموذج معلومات المشاركة. في حال غيّرتي رأيك في أيّ وقت خلال فترة البحث، يمكنك الانسحاب بدون الحاجة إلى إبداء سبب.

### معالجة بياناتك

بموجب اللائحة العامة لحماية البيانات (GDPR)، يتعين على الجامعة وضع أساسٍ قانونيٍ لمعالجة البيانات الشخصية، وشرطٍ إضافيٍ لمعالجة فئات البيانات المحددة، عند الاقتضاء. وتماشيًا مع ميثاقنا الذي ينص على تعزيز التعلم والمعرفة من خلال التدريس والبحث، تعمل الجامعة على معالجة البيانات الشخصية لأغراض البحوث وفقًا للفقرة (هـ) من البند (1) المادة (6) من اللائحة العامة لحماية البيانات (GDPR).

*المعالجة ضرورية لأغراض الأرشفة لتحقيق المصلحة العامة أو لأغراض البحث العلمي أو التاريخي أو لأغراض إحصائية.*

لن يُجرى البحث إلا عند الحصول على الموافقة الأخلاقية بحيث توجد مصلحة عامة واضحة وتُوضع الضمانات المناسبة لحماية البيانات.

تماشيًا مع التوقعات الأخلاقية، وامتثالًا لواجب السرية في القانون العام، سنطلب موافقتك على المشاركة عند اقتضاء ذلك. إلا أنّ هذه الموافقة لن تكون أساسنا القانوني لمعالجة بياناتك بموجب اللائحة العامة لحماية البيانات (GDPR).

### إخفاء الهوية والسرية

ستُخزّن البيانات التي تقدمها المعلمه وطالباتها (تسجيلات المقابلات، ونتائج الاختبارات، ونتائج الاستبانات، وبيانات الاستخدام من موقع Moodle) برقمٍ سريٍ. كما ستُخزّن كافة معلومات الطالبات ومعلمتهم محددة الهوية بشكلٍ منفصلٍ عن البيانات. ويمكن لمدرستك الانسحاب من المشاركة في الدراسة في أيّ وقت خلال فترة جمع البيانات ولمدةٍ أقصاها أسبوعين بعد الانتهاء من جمعها.

### تخزين بياناتك واستخدامها

سنطبّق تدابير تقنية وتنظيمية مناسبة لحماية بياناتك الشخصية. حيث ستُخزن البيانات على جهاز حاسوبٍ محميٍ بكلمة مرور. سيُحتفظ بالبيانات لمدة خمس سنوات ثم سيجري إتلافها بعد ذلك. يمكن أن تُستخدم البيانات التي سأجمعها (نتائج الاختبارات، ونتائج الاستبانات، وبيانات الاستخدام والتسجيلات الصوتية) بطرق مختلفة وبدون الإفصاح عن الهوية. يُرجى وضع إشارة ☑ في نموذج الموافقة المرفق إذا كنت موافقًا على استخدام هذه البيانات مجهولة الهوية بالطرق المدرجة.

### نقل البيانات إلى بلدان أخرى

من الممكن أن تُشارك البيانات عالميًا. تُقدم جوجل حلًا متمثلًا في اعتماد الجامعة على الخدمات السحابية، ما يعني إمكانية إيجاد البيانات في أيٍّ من مراكز بيانات جوجل المنتشرة عالميًا. وتمتلك الجامعة إجراءات حماية البيانات المعمول بها في جوجل.

للمزيد من المعلومات، يُرجى زيارة هذا الرابط: https://www.york.ac.uk/it-services/google/policy/privacy/

### حقوقك

بموجب اللائحة العامة لحماية البيانات (GDPR)، لديك الحق في الوصول إلى بيانات المشاركين أو تصحيحها أو حذفها أو تقييدها أو الاعتراض عليها أو إمكانية نقلها. كما لديك الحق في الانسحاب في مدةٍ أقصاها أسبوعين من جمع البيانات. وفي حال الانسحاب، لن تتم معالجة بيانات الطالبات والمعلمه المشاركين من مدرستك. للعثور على المعلومات، يرجى زيارة الموقع الإلكتروني: https://www.york.ac.uk/records-management/generaldataprotectionregulation/individualrights/

### الأسئلة والاستفسارات

إذا كان لديك أيّ أسئلة حول نموذج معلومات المشاركة، أو مخاوف بشأن كيفية معالجة بيانات الطالبات والمعلمه المشاركين من مدرستك، لا تترددي في التواصل مع بدرية القرني عبر البريد الإلكتروني: (ba754@york.ac.uk)

أو عبر الهاتف على الرقم 00966503796629، أو تواصل مع رئيس لجنة الأخلاقيات عبر البريد الإلكتروني: education-research-administrator@york.ac.uk. وإن لم يُلبي طلبك، يُرجى التواصل مع مسؤول حماية البيانات بالجامعة عبر البريد الإلكتروني:dataprotection@york.ac.uk

### الحق في تقديم الشكاوى

إن لم تكوني راضية عن تعاملنا مع بيانات المشاركين في هذة الدراسه، يحق لك تقديم شكوى إلى مكتب مفوض المعلومات. يمكن العثور على مزيدٍ من المعلومات حول الإبلاغ عن مشكلة إلى مكتب مفوض المعلومات عن طريق الموقع الإلكتروني: www.ico.org.uk/concerns

نأمل أن توافقي على مشاركه مدرستك في هذه الدراسة. إن وافقتي على ذلك، يُرجى إكمال النموذج المرفق. وسأحضر إلى المدرسة لأستلمه يوم 2018/12/22.

أشكرك على الوقت الذي قضيته في قراءة هذه المعلومات.

مع فائق تحياتي،

بدرية القرني

البريد الإلكتروني: ba754@york.ac.uk

## نموذج موافقة

**يُرجى وضع إشارة في كل مربع إذا كنت موافقًا على المشاركة في هذا البحث.**

☐ أؤكد أنني قد قرأت وفهمت المعلومات المقدمة لي حول المشروع البحثي المذكور أعلاه، وأتفهم أنه سيتضمن مشاركة الطالبات ومعلمتهم كما هو موضح أعلاه.

☐ أتفهم أن الغرض من البحث هو دراسة التأثيرات المحتملة لاستراتيجية الصف المقلوب على تحصيل الطالبات في مادة الرياضيات وكفاءتهم الذاتية في مرحلة الثانوية في المملكة العربية السعودية.

☐ أتفهم أن البيانات ستُخزّن بشكلٍ آمنٍ في خزانة ملفاتٍ مؤمّنةٍ أو على جهاز حاسوبٍ محميٍ بكلمة مرور، ولن يتمكن أحد من الوصول إلى أيّ بياناتٍ محددة الهوية سوى أنا ومشرفي هوغو لورتي فورغي

☐ أتفهم أن بياتات االمشاركين ستكون محميّة باستخدام رمزٍ/ اسمٍ مستعار.

☐ أتفهم أن المشاركة في هذه الدراسة اختيارية

أتفهم أنه لن يتم تحديد هوية بيانات المشاركين، ويمكن استخدام البيانات في ....

☐ المنشورات التي يقرأها الأكاديميون الجامعيون بصفةٍ رئيسيةٍ

☐ العروض التقديمية التي يحضرها الأكاديميون الجامعيون بصفةٍ رئيسيةٍ

☐ المنشورات التي يقرأها عامة الناس بصفةٍ رئيسيةٍ

☐ العروض التقديمية التي يحضرها عامة الناس بصفةٍ رئيسيةٍ

☐ المتاحة مجانًا عبر الإنترنت

☐ أتفهم أنه سيُحتفظ بالبيانات لمدة خمس سنوات ثم سيجري إتلافها بعد ذلك.

☐ أتفهم أن البيانات قد تستخدم للتحليل المستقبلي أو لأغراض أخرى مثل: البحوث والتدريس.

☐ أتفهم أن بإمكاني سحب البيانات في أيّ وقت خلال فترة جمع البيانات ولمدةٍ أقصاها أسبوعين بعد الانتهاء من جمعها.

☐ أتفهم أنه يمكن تخزين البيانات –مخفية الهوية– إلى أجلٍ غير مسمى واستخدامها لأغراض البحث في المستقبل.

أوافق على المشاركة في هذه الدراسة.

الاسم: ______________________________

التوقيع: ______________________________

التاريخ: ______________________________

## Appendix I3: Informed Consent Form - Teachers (English Version)

## Information sheet and consent form

**Dear teacher**

My name is Badriah Algarni. I am a student at the University of York, working on a doctoral degree. I am currently carrying out a research project entitled Blended learning and the flipped classroom: the potential effect to enhance students' mathematical proficiency and self-efficacy: a mixed method reseach from Saudi Arabia. I would like to invite you to take part in this research project.

Before agreeing to take part, please read this information sheet carefully and let us know if anything is unclear or if you would like further information.

### Purpose of the study

The study is designed to investigate the potential effect of the flipped classroom on students' mathematical achievement and self-efficacy in high school in Saudi Arabia. In addition, this study will examine students' perceptions of their experience with this new teaching approach, as well as the teachers' perceptions and their experience of the flipped class model and the challenges associated with this approach.

### What would this mean for you and your students?

I would like to ask for your permission to conduct my research at your school in two mathematics classrooms. The study will last for around nine weeks in the second semester of 2019. At the beginning and end of the study, data will be gathered, and this will involve a pre-treatment survey, student pre-test and post-test, data usage, and a survey of students' perceptions and self-efficacy. Participants in this study will be in grade 11 mathematics classes. Two classes will be the control groups, which will receive traditional teaching instruction, and the other two classes will be the experimental groups, which will implement flipped classroom instruction. The teacher is expected to flip one of her classrooms. This will be achieved by enabling students to prepare their lessons and complete homework by watching video lectures and answering online quizzes through the Moodle learning management system. Then, in the classroom session, students can work collaboratively with their peers and teacher to discuss the concepts presented in the videos in much more detail and engage in a variety of activities to practise further and/or to expand their learning. At the end of the experiment, the researcher will collect information about participants' perceptions of their experience of the flipped classroom by conducting a survey of the students and an interview with you.

The interview will be conducted by the researcher at a time convenient for you and will consist of a series of questions, such as your lesson planning process, routines and procedures, and perception of students' effort and achievements. The interview is expected to take about 20 to 30 minutes to complete. The interview will be recorded, and your identity will remain anonymous. You will also have the opportunity to comment on the written record of your interview.

In this research, there are no foreseeable risks to the participants. Although there may be no direct benefit to them, a possible benefit from their being part of the proposed study is to enhance educator awareness of the effectiveness of utilising blended learning in mathematics, especially in vocational education. Participating in the proposed study will not entail any costs to the participants.

**Participation is voluntary**

Participation is optional. If you do decide to take part, you will be given a copy of this information sheet for your records and will be asked to complete a participant information form. If you change your mind at any point during the study, you will be able to withdraw your participation without having to provide a reason.

**Processing of your data**

Under the General Data Protection Regulation (GDPR), the university has to identify a legal basis for processing personal data and, where appropriate, an additional condition for processing special category data. In line with our charter, which states that we advance learning and knowledge by teaching and research, the university processes personal data for research purposes under Article 6 (1)(e) of the GDPR:

*Processing is necessary for the performance of a task carried out in the public interest, historical research purposes or statistical purposes.*

Research will only be undertaken where ethical approval has been obtained, where there is a clear public interest and where appropriate safeguards have been put in place to protect data.

In line with ethical considerations and in order to comply with the common law duty of confidentiality, we will seek your consent to participate where appropriate. This consent will not, however, be our legal basis for processing your data under the GDPR.

**Anonymity and confidentiality**

The data that you and your students provide (i.e., in recordings of the interviews, test results, survey results, data usage and notes from observations) will be stored by code number. Any information that identifies you or any of the students will be stored separately from the data. You and your students are free to withdraw from the study at any time during data collection and up to two weeks after the data are collected.

Information will be treated confidentially and shared on a need-to-know basis only. The university is committed to the principle of data protection by design and default and will collect the minimum amount of data necessary for the project. In addition, we will anonymise or pseudonymise data wherever possible.

**Storing and using your data**

We will put in place appropriate technical and organisational measures to protect your personal data. Data will be stored on a password-protected computer. Data will be kept for five years, after which time they will be destroyed. The data that I collect (i.e., test results, survey results and audio recordings) may be used in *anonymous* form in different ways. Please indicate on the consent form attached with a ☑ if you are happy for this anonymised data to be used in the ways listed.

### Transfer of data internationally

It is possible that the data will be transferred internationally. The university's cloud storage solution is provided by Google, which means that data can be located at any of Google's globally spread data centres. The university has data protection-compliant arrangements in place with this provider. For further information, see:

https://www.york.ac.uk/it-services/google/policy/privacy/

### Your rights

Under the GDPR, you have a general right of access to your data, a right to rectification, erasure, restriction, objection or portability. You also have a right to withdraw up to two weeks after the data are collected. If one of the participants withdraws, then their data are not processed. For further information, see: https://www.york.ac.uk/records-management/generaldataprotectionregulation/individualrights/

### Questions or concerns

If you have any questions about this participant information sheet or concerns about how your data are being processed, please feel free to contact Badriah Algarni by email at ba754@york.ac.uk or by telephone on 00966503796629, or the Chair of Ethics Committee via email at education-research-administrator@york.ac.uk. If you are still dissatisfied, please contact the university's Data Protection Officer at dataprotection@york.ac.uk.

### Right to complain

If you are unhappy with the way in which your personal data have been handled, you have a right to complain to the Information Commissioner's Office. For information on reporting a concern to the Information Commissioner's Office, see www.ico.org.uk/concerns

We hope that you will agree to take part in this study. If you are happy to participate, please complete the form attached and I will come to the school and collect it by 22 December 2018.

Thank you for taking the time to read this information.

Sincerely

Badriah Algarni

Email: ba754@york.ac.uk

**Consent Form**

**Please initial each box if you are happy to take part in this research.**

- I confirm that I have read and understood the information given to me about the above-named research project and I understand that this will involve me taking part as described above. ☐
- I understand that the purpose of the research is to investigate the potential effect of the flipped classroom on students' mathematical achievement and self-efficacy in high school in Saudi Arabia. ☐
- I understand that data will be stored securely in a locked filing cabinet or on a password-protected computer and only the researcher and her supervisor, Hugues Lortie-Forgues, will have access to any identifiable data. ☐
- I understand that the students will be protected by use of a code/pseudonym. ☐
- I understand that participation in this study is voluntary. ☐
- I understand that my data will not be identifiable, and the data may be used ….

  in publications that are mainly read by university academics ☐

  in presentations that are mainly attended by university academics ☐

  in publications that are mainly read by the public ☐

  in presentations that are mainly attended by the public ☐

  freely available online ☐

- I understand that data will be kept for five years, after which they will be destroyed. ☐
- I understand that data could be used for future analysis or other purposes, such as research and teaching purposes. ☐
- I understand that I can withdraw my data at any point during data collection and up to two weeks after the data are collected. ☐
- I understand that my anonymised data can be stored indefinitely and used in the future for research purposes. ☐

Name_________ Signature ____________ Date ________________________

## Appendix I4: Informed Consent Form - Teachers (Arabic Version)

### عزيزتي المعلمة

أنا بدرية القرني، طالبة دكتوراة جامعة يورك. أقوم حاليًا بمشروعٍ بحثي بعنوان: "التعلم المدمج والصف المقلوب: التأثيرات المحتملة على التحصيل الرياضي والكفاءة الذاتية في المملكة العربية السعودية". وأودّ أن أدعوك للمشاركة في هذا المشروع البحثي.

قبل الموافقة على المشاركة، يُرجى قراءة نشرة المعلومات هذه بتمعنٍ، وإبلاغنا إن كان هناك شيء غير واضحٍ أو إن كنت ترغبين في الحصول على مزيد من المعلومات.

### الغرض من الدراسة

هذه الدراسة مصممةٌ لبحث التأثيرات المحتملة على تحصيل الطالبات في مادة الرياضيات وكفاءتهم الذاتية في مرحلة الثانوية في المملكة العربية السعودية. فضلًا عن ذلك، ستتناول انطباعات الطالبات حول تجربتهم مع هذه الاستراتيجية الجديدة، وكذلك انطباعات المعلمات وتجاربهم تجاة تطبيق نموذج الفصل المقلوب والتحديات المرتبطة به.

### ماذا يعني ذلك بالنسبة لك ولطالباتك؟

أكتب إليك لأطلب إذنك للمشاركة في إجراء دراستي البحثية على فصلين من فصول الرياضيات في مدرستك. ستُجرى الدراسة في الفصل الدراسي الثاني 2019، وستستغرق حوالي تسعه أسابيع. ستُجمع البيانات في بداية البحث وفي نهايته وستشمل استبانةً أوليةً، واختبارًا قبليًا وآخر بعديًا للطالبات، وبيانات الاستخدام من موقع Moodle، واستبانةً لانطباعات الطالبات وكفاءتهم الذاتية. ستجري هذه الدراسة على فصول الرياضيات للصف الثاني ثانوي علمي – فصل سيمثل المجموعة الضابطة والتي ستتلقى تعليمات التدريس التقليدية، أما الفصل الاخر سيمثل المجموعة التجريبية والتي ستنفذ تعليمات الصف المقلوب. يُتوقع من المعلمة في الصف المقلوب أن "تقلب" الصف من خلال السماح للطالبات بتحضير دروسهم، والدراسة، وحل الواجبات المدرسية في البيت عبر محاضرات الفيديو عن طريق نظام إدارة التعلم "المودل"، والعودة إلى الحصة القادمة لمناقشة لهذه المفاهيم باستفاضة، والتدرب بشكلٍ أكبر، وتوسيع نطاق التعلم بإجراء مزيدٍ من التطبيقات والتمارين. في نهاية التجربة، ستجمع الباحثة معلوماتٍ عن انطباعات المشاركات حول تجربتهم في الصف المقلوب من خلال تقديم استبانةٍ للطالبات وإجراء مقابلة معك.

الباحثة هي من ستجري المقابلة في الوقت المناسب لك. وستشمل مجموعة من الأسئلة مثل: طريقتك في إعداد الخطة الدراسية بعد تطبيق الصف المقلوب وكيف غيرت طريقة تدريسك، وتصوراتك بشأن هذة الاستراتيجية ومدى فاعليتها. من المتوقع أن تستغرق المقابلة حوالي 20–30 دقيقة. سيتم تسجيل المقابلة، ولن يتم الإفصاح عن هويتك، وستتاح لك الفرصة أيضًا للتعليق على التفريغ الصوتي لمقابلتك.

لا يُتوقع وقوع مخاطر على المشاركين في هذا البحث. ومع أنه قد لا يعود عليهم بالنفع بشكلٍ مباشرٍ، إلا أن الفائدة المحتملة من مشاركتهم في الدراسة المقترحة هي تعزيز وعي المعلمات بمدى فاعلية استخدام التعلم المدمج في التعليم. كما لن يترتب على المشاركين في الدراسة المقترحة أيّ تكاليف.

### المشاركة اختيارية

المشاركة في هذه الدراسة اختيارية. وإذا قررتي ذلك، سيتم إعطاؤك نسخةً من نشرة المعلومات هذه لتحتفظي بها في ملفاتك، وسيُطلب منك إكمال نموذج معلومات المشاركة. في حال غيّرتي رأيك في أيّ وقت خلال فترة البحث، يمكنك الانسحاب بدون الحاجة إلى إبداء سبب.

### معالجة بياناتك

بموجب اللائحة العامة لحماية البيانات (GDPR)، يتعين على الجامعة وضع أساسٍ قانونيٍ لمعالجة البيانات الشخصية، وشرطٍ إضافيٍ لمعالجة فئات البيانات المحددة، عند الاقتضاء. وتماشيًا مع ميثاقنا الذي ينص على تعزيز التعلم والمعرفة من خلال التدريس والبحث، تعمل الجامعة على معالجة البيانات الشخصية لأغراض البحوث وفقًا للفقرة (هـ) من البند (1) المادة (6) من اللائحة العامة لحماية البيانات (GDPR).

*المعالجة ضرورية لأغراض الأرشفة لتحقيق المصلحة العامة، أو لأغراض البحث العلمي ،أو التاريخي أو لأغراض إحصائية.*

لن يُجرى البحث إلا عند الحصول على الموافقة الأخلاقية بحيث توجد مصلحة عامة واضحة وتُوضع الضمانات المناسبة لحماية البيانات.

تماشيًا مع التوقعات الأخلاقية، وامتثالًا لواجب السرية في القانون العام، سنطلب موافقتك على المشاركة عند اقتضاء ذلك. إلا أنّ هذه الموافقة لن تكون أساسنا القانوني لمعالجة بياناتك بموجب اللائحة العامة لحماية البيانات (GDPR).

### إخفاء الهوية والسرية

ستُخزّن البيانات التي تقدمينها أنت وطالباتك (تسجيلات المقابلات، ونتائج الاختبارات، ونتائج الاستبانات، واستخدام البيانات من موقع Moodle) برقمٍ سريٍ. كما ستُخزّن كافة معلوماتك ومعلومات الطالبات محددة الهوية بشكلٍ منفصلٍ عن البيانات. ويمكنك أنت وطالباتك الانسحاب من المشاركة في الدراسة في أيّ وقت خلال فترة جمع البيانات ولمدةٍ أقصاها أسبوعين بعد الانتهاء من جمعها.

### تخزين بياناتك واستخدامها

سنطبّق تدابير تقنية وتنظيمية مناسبة لحماية بياناتك الشخصية. حيث ستُخزن البيانات على جهاز حاسوبٍ محميٍ بكلمة مرور. سيُحتفظ بالبيانات لمدة خمس سنوات ثم سيجري إتلافها بعد ذلك. يمكن أن تُستخدم البيانات التي سأجمعها (نتائج الاختبارات، ونتائج الاستبانات، واستخدام البيانات والتسجيلات الصوتية) بطرق مختلفة وبدون الإفصاح عن الهوية. يُرجى وضع إشارة ☑ في نموذج الموافقة المرفق إذا كنت موافقًا على استخدام هذه البيانات مجهولة الهوية بالطرق المدرجة.

### نقل البيانات إلى بلدان أخرى

من الممكن أن تُشارك البيانات عالميًا. تُقدم جوجل حلًا متمثلًا في اعتماد الجامعة على الخدمات السحابية، ما يعني إمكانية إيجاد البيانات في أيٍّ من مراكز بيانات جوجل المنتشرة عالميًا. وتمتلك الجامعة إجراءات حماية البيانات المعمول بها في جوجل. للمزيد من المعلومات، يُرجى زيارة هذا الرابط: https://www.york.ac.uk/it-services/google/policy/privacy/

### حقوقك

بموجب اللائحة العامة لحماية البيانات (GDPR)، لديك الحق في الوصول إلى بياناتك الشخصية أو تصحيحها أو حذفها أو تقييدها أو الاعتراض عليها أو إمكانية نقلها. كما لديك الحق في الانسحاب في مدةٍ أقصاها أسبوعين من جمع البيانات. وفي حال الانسحاب، لن

تتم معالجة بياناتك. للعثور على المعلومات، يرجى زيارة الموقع الإلكتروني: https://www.york.ac.uk/records-management/generaldataprotectionregulation/individualrights/

**الأسئلة والاستفسارات**

إذا كان لديك أيّ أسئلة حول نموذج معلومات المشاركة، أو مخاوف بشأن كيفية معالجة بياناتك، لا ترددي في التواصل مع بدرية القرني عبر البريد الإلكتروني: (ba754@york.ac.uk)

أو عبر الهاتف على الرقم 00966503796629، أو تواصل مع رئيس لجنة الأخلاقيات عبر البريد الإلكتروني: education-research-administrator@york.ac.uk. وإن لم يُلبي طلبك، يُرجى التواصل مع مسؤول حماية البيانات بالجامعة عبر البريد الإلكتروني: dataprotection@york.ac.uk

**الحق في تقديم الشكاوى**

إن لم تكوني راضية عن تعاملنا مع بياناتك الشخصية، يحق لك تقديم شكوى إلى مكتب مفوض المعلومات. يمكن العثور على مزيدٍ من المعلومات حول الإبلاغ عن مشكلة إلى مكتب مفوض المعلومات عن طريق الموقع الإلكتروني: www.ico.org.uk/concerns

نأمل أن توافقي على المشاركة في هذه الدراسة. إن وافقتي على ذلك، يُرجى إكمال النموذج المرفق. وسأحضر إلى المدرسة لأستلمه يوم 2018/12/22.

أشكرك على الوقت الذي قضيته في قراءة هذه المعلومات.

مع فائق تحياتي،

بدرية القرني

البريد الإلكتروني: ba754@york.ac.uk

**نموذج موافقة**

**يُرجى وضع إشارة في كل مربع إذا كنت موافقًا على المشاركة في هذا البحث.**

☐ أؤكد أنني قد قرأت وفهمت المعلومات المقدمة لي حول المشروع البحثي المذكور أعلاه، وأتفهم أنه سيتضمن مشاركتي كما هو موضح أعلاه.

☐ أتفهم أن الغرض من البحث هو دراسة التأثيرات المحتملة لاستراتيجية الصف المقلوب على تحصيل الطالبات في مادة الرياضيات وكفاءتهم الذاتية في مرحلة الثانوية في المملكة العربية السعودية.

☐ أتفهم أن البيانات ستُخزّن بشكلٍ آمنٍ في خزانة ملفاتٍ مؤمّنةٍ أو على جهاز حاسوبٍ محميٍ بكلمة مرور، ولن يتمكن أحد من الوصول إلى أيّ بياناتٍ محددة الهوية سوى أنا ومشرفي هوغو لورتي فورغي

☐ أتفهم أن بياناتي وبيانات الطالبات ستكون محميّة باستخدام رمزٍ/ اسمٍ مستعار.

☐ أتفهم أن المشاركة في هذه الدراسة اختيارية

أتفهم أنه لن يتم تحديد هوية بياناتي، ويمكن استخدام البيانات في ....

☐ المنشورات التي يقرأها الأكاديميون الجامعيون بصفةٍ رئيسيةٍ

☐ العروض التقديمية التي يحضرها الأكاديميون الجامعيون بصفةٍ رئيسيةٍ

☐ المنشورات التي يقرأها عامة الناس بصفةٍ رئيسيةٍ

☐ العروض التقديمية التي يحضرها عامة الناس بصفةٍ رئيسيةٍ

☐ المتاحة مجانًا عبر الإنترنت

☐ أتفهم أنه سيُحتفظ بالبيانات لمدة خمس سنوات ثم سيجري إتلافها بعد ذلك.

☐ أتفهم أن البيانات قد تستخدم للتحليل المستقبلي أو لأغراض أخرى مثل: البحوث والتدريس.

☐ أتفهم أن بإمكاني سحب بياناتي في أيّ وقت خلال فترة جمع البيانات ولمدةٍ أقصاها أسبوعين بعد الانتهاء من جمعها.

☐ أتفهم أنه يمكن تخزين بياناتي –مخفية الهوية– إلى أجلٍ غير مسمى واستخدامها لأغراض البحث في المستقبل.

أوافق على المشاركة في هذه الدراسة.

الاسم: ______________________________________

التوقيع: ________________________________

التاريخ: ______________________________________

## Appendix I 5: Informed Consent Form for Students in the Flipped Classroom Group (English Version)

### Information sheet and consent form

**Dear student**

My name is Badriah Algarni. I am a student at the University of York, working on a doctoral degree. I am currently carrying out a research project entitled; Blended learning and the flipped classroom: the potential effect to enhance students' mathematical proficiency and self-efficacy: a mixed method reseach from Saudi Arabia. I would like to invite you to take part in this research project.

Before agreeing to take part, please read this information sheet carefully and let us know if anything is unclear or if you would like further information.

### Purpose of the study

The study is designed to investigate the potential effect of the flipped classroom on students' mathematical proficiency and self-efficacy in high school in Saudi Arabia. In addition, this study will examine students' perceptions of their experience with this new teaching approach, as well as the teachers' perceptions and their experience of the flipped class model and the challenges associated with this approach.

### What would this mean for you?

I am writing to request your participation in my research, which will be conducted in two mathematics classrooms in your school. You were selected because you enrolled in a grade 11 mathematics class. The study will start in the second semester 2019 and it will take approximately nine weeks. Data will be collected at the beginning and at the end of the study and will involve a pre-treatment survey, a pre-test and post-test, data usage from Moodle and a survey of students' perceptions and self-efficacy. You will study mathematics through the application of flipped classroom instruction during the project. Your teacher is expected to flip the classrooms. This will be achieved by enabling you to prepare your lessons and complete homework by watching video lectures and answering online quizzes through the Moodle learning management system. Then, in the classroom session, you can work collaboratively with your peers and teacher to discuss the concepts presented in the videos in much more detail and engage in a variety of activities to practise further and/or to expand your learning through further investigation or application problems. At the end of the experiment, I will collect some information. You will be asked to answer some questions, where you rate your perceptions, self-efficacy and experience of the flipped classroom instruction. It will take around 10 minutes for you to fill out the survey. You will also be given a proficiencytest in addition to your regular course quizzes in order to evaluate the influence of the flipped classroom on your results. In addition, I will collect data usage through Moodle. In this research, there are no foreseeable risks to you. Although there may be no direct benefit to you, a possible benefit from being part of the proposed study is to enhance teachers' awareness of the effectiveness of utilising blended learning in mathematics, especially in vocational education. Participating in the proposed study will not involve any cost to you.

## Participation is voluntary

Participation is optional. If you do decide to take part, you will be given a copy of this information sheet for your records and will be asked to complete a participant information form. If you change your mind at any point during the study, you will be able to withdraw your participation without having to provide a reason.

## Processing of your data

Under the General Data Protection Regulation (GDPR), the university has to identify a legal basis for processing personal data and, where appropriate, an additional condition for processing special category data.

In line with our charter, which states that we advance learning and knowledge by teaching and research, the university processes personal data for research purposes under Article 6 (1)(e) of the GDPR:

*Processing is necessary for archiving purposes in the public interest, or scientific and historical research purposes or statistical purposes.*

Research will only be undertaken where ethical approval has been obtained, where there is a clear public interest and where appropriate safeguards have been put in place to protect data.

In line with ethical considerations and in order to comply with the common law duty of confidentiality, we will seek your consent to participate where appropriate. This consent will not, however, be our legal basis for processing your data under the GDPR.

## Anonymity and confidentiality

The data that you will provide (e.g., test results, survey results, and data usage on Moodle) will be stored by code number. Any information that identifies you will be stored separately from the data. Only the teacher will be able to associate the information collected to the name of the students. You are free to withdraw from the study at any time during data collection and up to two weeks after the data are collected. Information will be treated confidentially and shared on a need-to-know basis only. The university is committed to the principle of data protection by design and default and will collect the minimum amount of data necessary for the project. In addition, we will anonymise or pseudonymise data wherever possible.

## Storing and using your data

We will put in place appropriate technical and organisational measures to protect your personal data. Data will be stored on a password-protected computer. Data will be kept for five years, after which time they will be destroyed. The data that I collect (i.e., test results, survey results and data usage on Moodle) may be used in *anonymous* form in different ways. Please indicate on the consent form attached with a ☑ if you are happy for this anonymised data to be used in the ways listed.

## Transfer of data internationally

It is possible that the data will be transferred internationally. The university's cloud storage solution is provided by Google, which means that data can be located at any of Google's globally spread data centres. The university has data protection-compliant arrangements in place with this provider. For further information, see:

https://www.york.ac.uk/it-services/google/policy/privacy/

## Your rights

Under the GDPR, you have a general right of access to your data, a right to rectification, erasure, restriction, objection or portability. You also have a right to withdraw up to two weeks after the data are collected. If one of the participants withdraws, then their data are not processed. For further information, see: https://www.york.ac.uk/records-management/generaldataprotectionregulation/individualrights/

## Questions or concerns

If you have any questions about this participant information sheet or concerns about how your data are being processed, please feel free to contact Badriah Algarni by email at ba754@york.ac.uk or by telephone on 00966503796629, or the Chair of Ethics Committee via email at education-research-administrator@york.ac.uk. If you are still dissatisfied, please contact the university's Data Protection Officer at dataprotection@york.ac.uk.

## Right to complain

If you are unhappy with the way in which your personal data have been handled, you have a right to complain to the Information Commissioner's Office. For information on reporting a concern to the Information Commissioner's Office, see www.ico.org.uk/concerns

We hope that you will agree to take part in this study. If you are happy to participate, please complete the form attached and I will come to the school and collect it by 22 December 2018.

Thank you for taking the time to read this information.

Sincerely

Badriah Algarni

Email: ba754@york.ac.uk

**Consent Form**

**Please initial each box if you are happy to take part in this research.**

- I confirm that I have read and understood the information given to me about the above-named research project and I understand that this will involve me taking part as described above. ☐
- I understand that the purpose of the research is to investigate the potential effect of the flipped classroom on students' mathematical achievement and self-efficacy in high school in Saudi Arabia. ☐
- I understand that data will be stored securely in a locked filing cabinet or on a password-protected computer and only the researcher and her supervisor, Hugues Lortie-Forgues, will have access to any identifiable data. ☐
- I understand that will be protected by use of a code/pseudonym. ☐
- I understand that participation in this study is voluntary. ☐
- I understand that my data will not be identifiable, and the data may be used ….

  in publications that are mainly read by university academics ☐

  in presentations that are mainly attended by university academics ☐

  in publications that are mainly read by the public ☐

  in presentations that are mainly attended by the public ☐

  freely available online ☐

- I understand that data will be kept for five years, after which they will be destroyed. ☐
- I understand that data could be used for future analysis or other purposes, such as research and teaching purposes. ☐
- I understand that I can withdraw my data at any point during data collection and up to two weeks after the data are collected. ☐
- I understand that my anonymised data can be stored indefinitely and used in the future for research purposes. ☐

Name_________ Signature ____________ Date ________________________

**Appendix I6**: **Informed Consent Form for Students in the Flipped Classroom Group (Arabic Version)**

**عزيزتي الطالبة**

أنا بدرية القرني، طالبة دكتوراة جامعة يورك. أقوم حاليًا بمشروعٍ بحثي بعنوان: "التعلم المدمج والصف المقلوب: التأثيرات المحتملة على تعزيز المهارات الرياضيه والكفاءة الذاتية في المملكة العربية السعودية". وأودّ أن أدعوك للمشاركة في هذا المشروع البحثي.

قبل الموافقة على المشاركة، يُرجى قراءة نشرة المعلومات هذه بتمعنٍ، وإبلاغنا إن كان هناك شيء غير واضحٍ أو إن كنتي ترغبين في الحصول على مزيد من المعلومات.

**الغرض من الدراسة**

هذه الدراسة مصممةٌ لبحث التأثيرات المحتملة على تحصيل الطالبات في مادة الرياضيات وكفاءتهم الذاتية في مرحلة الثانوية في المملكة العربية السعودية. فضلًا عن ذلك، ستتناول انطباعات الطالبات حول تجربتهم مع هذه الاستراتيجية الجديدة، وكذلك انطباعات المعلمات وتجاربهم في تطبيق نموذج الصف المقلوب والتحديات المرتبطة به.

**ماذا يعني ذلك بالنسبة لك ؟**

أكتب إليك لأطلب مشاركتك في بحثي ، والذي سيتم إجراؤه في فصلين دراسيين للرياضيات في مدرستك. تم اختيارك لأنك طالبة في الصف الثاني ثانوي علمي. ستبدأ الدراسة في الفصل الدراسي الثاني 2019 وستستغرق حوالي تسعة أسابيع. سيتم جمع البيانات في بداية ونهاية الدراسة وستتضمن مسحًا قبل التجربه واختبارًا أوليًا واختبارًا لاحقًا وتقريراستخدام البيانات من Moodle واستطلاعًا لتصورات الطالبات والكفاءة الذاتية. سوف تدرسين الرياضيات من خلال تطبيق تعليمات الفصل المقلوب أثناء المشروع. يتوقع من معلمتك قلب الفصل الدراسي. سيتم تحقيق ذلك من خلال تمكينك من إعداد دروسك وإكمال واجباتك المدرسية من خلال مشاهدة محاضرات الفيديو والإجابة على الاختبارات عبر الإنترنت من خلال نظام إدارة التعلم Moodle. بعد ذلك ، أثناء الحصه الدراسيه في المدرسة، يمكنك العمل بشكل تعاوني مع زملائك ومعلمتك لمناقشة المفاهيم المعروضة في مقاطع الفيديو بمزيد من التفصيل والانخراط في مجموعة متنوعة من الأنشطة لمزيد من الممارسة و / أو لتوسيع التعلم الخاص بك من خلال مزيد من التطبيقات والتمارين. في نهاية التجربة ، سأجمع بعض المعلومات. سيُطلب منك الإجابة على بعض الأسئلة ، حيث تقوم بتقييم تصوراتك وكفاءتك الذاتية وتجربتك في التدريس في الفصل الدراسي المقلوب. سيستغرق ملء الاستبيان حوالي 10 دقائق. باتضافة إلى إختبار بعدي من أجل تقييم تأثير الفصل الدراسي المقلوب على نتائجك. بالإضافة إلى ذلك ، سأجمع بيانات الاستخدام من موقع Moodle. في هذا البحث ، لا توجد مخاطر متوقعة عليك. على الرغم من أنه قد لا تكون هناك فائدة مباشرة لك ، فإن الفائدة المحتملة لكونك جزءًا من الدراسة المقترحة هي تعزيز وعي المعلمات بفاعلية استخدام التعلم المدمج في الرياضيات . لن تنطوي المشاركة في الدراسة المقترحة على أي تكلفة عليك.

**المشاركة اختيارية**

المشاركة في هذه الدراسة اختيارية. وإذا قررت ذلك، سيتم إعطاؤك نسخةً من نشرة المعلومات هذه لتحتفظ بها في ملفاتك، وسيُطلب منك إكمال نموذج معلومات المشاركة. في حال غيّرت رأيك في أيّ وقت خلال فترة البحث، يمكنك الانسحاب بدون الحاجة إلى إبداء سبب.

### معالجة بياناتك

بموجب اللائحة العامة لحماية البيانات (GDPR)، يتعين على الجامعة وضع أساسٍ قانونيٍ لمعالجة البيانات الشخصية، وشرطٍ إضافيٍ لمعالجة فئات البيانات المحددة، عند الاقتضاء. وتماشيًا مع ميثاقنا الذي ينص على تعزيز التعلم والمعرفة من خلال التدريس والبحث، تعمل الجامعة على معالجة البيانات الشخصية لأغراض البحوث وفقًا للفقرة (هـ) من البند (1) المادة (6) من اللائحة العامة لحماية البيانات (GDPR).

*المعالجة ضرورية لأغراض الأرشفة لتحقيق المصلحة العامة أو لأغراض البحث العلمي أو التاريخي أو لأغراض إحصائية.*

لن يُجرى البحث إلا عند الحصول على الموافقة الأخلاقية بحيث توجد مصلحة عامة واضحة وتُوضع الضمانات المناسبة لحماية البيانات.

تماشيًا مع التوقعات الأخلاقية، وامتثالًا لواجب السرية في القانون العام، سنطلب موافقتك على المشاركة عند اقتضاء ذلك. إلا أنّ هذه الموافقة لن تكون أساسنا القانوني لمعالجة بياناتك بموجب اللائحة العامة لحماية البيانات (GDPR).

### إخفاء الهوية والسرية

ستُخزّن البيانات التي سوف تقدمينها(نتائج الاختبارات، ونتائج الاستبانات، وبيانات الاستخدام من موقع مودل) برقمٍ سري. كما ستُخزّن كافة معلوماتك محددة الهوية بشكلٍ منفصلٍ عن البيانات. ويمكنك الانسحاب من المشاركة في الدراسة في أيّ وقت خلال فترة جمع البيانات ولمدةٍ أقصاها أسبوعين بعد الانتهاء من جمعها.

### تخزين بياناتك واستخدامها

سنطبّق تدابير تقنية وتنظيمية مناسبة لحماية بياناتك الشخصية. حيث ستُخزن البيانات على جهاز حاسوبٍ محميٍ بكلمة مرور. سيُحتفظ بالبيانات لمدة خمس سنوات ثم سيجري إتلافها بعد ذلك. يمكن أن تُستخدم البيانات التي سأجمعها (نتائج الاختبارات، ونتائج الاستبانات، واستخدام البيانات والتسجيلات الصوتية) بطرق مختلفة وبدون الإفصاح عن الهوية. يُرجى وضع إشارة ☑ في نموذج الموافقة المرفق إذا كنت موافقًا على استخدام هذه البيانات مجهولة الهوية بالطرق المدرجة.

### نقل البيانات إلى بلدان أخرى

من الممكن أن تُشارك البيانات عالميًا. تُقدم جوجل حلًا متمثلًا في اعتماد الجامعة على الخدمات السحابية، ما يعني إمكانية إيجاد البيانات في أيٍّ من مراكز بيانات جوجل المنتشرة عالميًا. وتمتلك الجامعة إجراءات حماية البيانات المعمول بها في جوجل. للمزيد من المعلومات، يُرجى زيارة هذا الرابط: https://www.york.ac.uk/it-services/google/policy/privacy/

### حقوقك

بموجب اللائحة العامة لحماية البيانات (GDPR)، لديك الحق في الوصول إلى بياناتك الشخصية أو تصحيحها أو حذفها أو تقييدها أو الاعتراض عليها أو إمكانية نقلها. كما لديك الحق في الانسحاب في مدةٍ أقصاها أسبوعين من جمع البيانات. وفي حال الانسحاب، لن

تتم معالجة بياناتك. للعثور على المعلومات، يرجى زيارة الموقع الإلكتروني: https://www.york.ac.uk/records-management/generaldataprotectionregulation/individualrights/

## الأسئلة والاستفسارات

إذا كان لديك أيّ أسئلة حول نموذج معلومات المشاركة، أو مخاوف بشأن كيفية معالجة بياناتك، لا تتردد في التواصل مع بدرية القرني عبر البريد الإلكتروني: (ba754@york.ac.uk)

أو عبر الهاتف على الرقم 00966503796629، أو تواصل مع رئيس لجنة الأخلاقيات عبر البريد الإلكتروني: education-research-administrator@york.ac.uk. وإن لم يُلبي طلبك، يُرجى التواصل مع مسؤول حماية البيانات بالجامعة عبر البريد الإلكتروني: dataprotection@york.ac.uk

## الحق في تقديم الشكاوى

إن لم تكن راضيًا عن تعاملنا مع بياناتك الشخصية، يحق لك تقديم شكوى إلى مكتب مفوض المعلومات. يمكن العثور على مزيدٍ من المعلومات حول الإبلاغ عن مشكلة إلى مكتب مفوض المعلومات عن طريق الموقع الإلكتروني: www.ico.org.uk/concerns

نأمل أن توافقي على المشاركة في هذه الدراسة. إن وافقت على ذلك، يُرجى إكمال النموذج المرفق. وسأحضر إلى المدرسة لأستلمه يوم 2018/12/22.

أشكرك على الوقت الذي قضيته في قراءة هذه المعلومات.

مع فائق تحياتي،

بدرية القرني

البريد الإلكتروني: ba754@york.ac.uk

**نموذج موافقة**

**يُرجى وضع إشارة في كل مربع إذا كنت موافقًا على المشاركة في هذا البحث.**

☐ أؤكد أنني قد قرأت وفهمت المعلومات المقدمة لي حول المشروع البحثي المذكور أعلاه، وأتفهم أنه سيتضمن مشاركتي كما هو موضح أعلاه.

☐ أتفهم أن الغرض من البحث هو دراسة التأثيرات المحتملة لاستراتيجية الصف المقلوب على تحصيل الطالبات في مادة الرياضيات وكفاءتهم الذاتية في مرحلة الثانوية في المملكة العربية السعودية.

☐ أتفهم أن البيانات ستُخزّن بشكلٍ آمنٍ في خزانة ملفاتٍ مؤمّنةٍ أو على جهاز حاسوبٍ محميٍ بكلمة مرور، ولن يتمكن أحد من الوصول إلى أيّ بياناتٍ محددة الهوية سوى أنا ومشرفي هوغو لورتي فورغي

☐ أتفهم أن بيانتاتي ستكون محميّة باستخدام رمزٍ/ اسمٍ مستعار.

☐ أتفهم أن المشاركة في هذه الدراسة اختيارية

أتفهم أنه لن يتم تحديد هوية بياناتي، ويمكن استخدام البيانات في ....

☐ المنشورات التي يقرأها الأكاديميون الجامعيون بصفةٍ رئيسيةٍ

☐ العروض التقديمية التي يحضرها الأكاديميون الجامعيون بصفةٍ رئيسيةٍ

☐ المنشورات التي يقرأها عامة الناس بصفةٍ رئيسيةٍ

☐ العروض التقديمية التي يحضرها عامة الناس بصفةٍ رئيسيةٍ

☐ المتاحة مجانًا عبر الإنترنت

☐ أتفهم أنه سيُحتفظ بالبيانات لمدة خمس سنوات ثم سيجري إتلافها بعد ذلك.

☐ أتفهم أن البيانات قد تستخدم للتحليل المستقبلي أو لأغراض أخرى مثل: البحوث والتدريس.

☐ أتفهم أن بإمكاني سحب بياناتي في أيّ وقت خلال فترة جمع البيانات ولمدةٍ أقصاها أسبوعين بعد الانتهاء من جمعها.

☐ أتفهم أنه يمكن تخزين بياناتي –مخفية الهوية– إلى أجلٍ غير مسمى واستخدامها لأغراض البحث في المستقبل.

أوافق على المشاركة في هذه الدراسة.

الاسم: ________________________________________

التوقيع: ________________________________________

التاريخ: ________________________________________

## Appendix I7: Informed Consent Form for Students in the Traditional Group (English Version)

### Information sheet and consent form

**Dear student**

My name is Badriah Algarni. I am a student at the University of York, working on a doctoral degree. I am currently carrying out a research project entitled Blended learning and the flipped classroom: the potential effect to enhance students' mathematical proficiency and self-efficacy: a mixed method 299ork299rch from Saudi Arabia. I would like to invite your school to take part in this research project.

Before agreeing to take part, please read this information sheet carefully and let us know if anything is unclear or if you would like further information.

### Purpose of the study

The study is designed to investigate the potential effect of the flipped classroom on students' mathematical achievement and self-efficacy in high school in Saudi Arabia. In addition, this study will examine students' perceptions of their experience with this new teaching approach, as well as the teachers' perceptions and their experience of the flipped class model and the challenges associated with this approach.

### What would this mean for you?

I am writing to request your participation in my research, which will be conducted in two mathematics classrooms in your school in the second semester 2019. You were selected because you enrolled in a grade 11 mathematics class. One class will be the control group, which will receive traditional teaching instruction, and the other class will be the experimental group, which will implement flipped classroom instruction. You will be in the control group. The study will start in the winter semester 2019 and will take approximately nine weeks. Data will be collected at the beginning and at the end of the study and will involve a pre-test and post-test and a survey of students' self-efficacy. During the project, you will study mathematics as usual. At the end of the experiment, I will collect some information. You will be asked to answer some questions, where you rate your self-efficacy in learning maths by the traditional approach. It will take around 10 minutes for you to fill out the survey. You will also be given an achievement test in addition to your regular course quizzes. In this research, we are testing the effectiveness of the flipped classroom approach, so, if it works well, all the course materials, including video lectures, will be available to you at the end of the experiment period, and you could benefit from this material to prepare for the final exam. In addition, you will help by being part of the proposed study in enhancing teachers' awareness of the effectiveness of utilising blended learning in mathematics, especially in vocational education. Participating in the proposed study will not involve any cost to you.

### Participation is voluntary

Participation is optional. If you do decide to take part, you will be given a copy of this information sheet for your records and will be asked to complete a participant information form. If you change your mind at any point during the study, you will be able to withdraw your participation without having to provide a reason.

### Processing of your data

Under the General Data Protection Regulation (GDPR), the university has to identify a legal basis for processing personal data and, where appropriate, an additional condition for processing special category data.

In line with our charter, which states that we advance learning and knowledge by teaching and research, the university processes personal data for research purposes under Article 6 (1)I of the GDPR:

*Processing is necessary for archiving purposes in the public interest, or scientific and historical research purposes or statistical purposes.*

Research will only be undertaken where ethical approval has been obtained, where there is a clear public interest and where appropriate safeguards have been put in place to protect data.

In line with ethical considerations and in order to comply with the common law duty of confidentiality, we will seek your consent to participate where appropriate. This consent will not, however, be our legal basis for processing your data under the GDPR.

**Anonymity and confidentiality**

The data that you will provide (e.g., test results, survey results) will be stored by code number. Any information that identifies you will be stored separately from the data. Only the teacher will be able to associate the information collected to the name of the students. You are free to withdraw from the study at any time during data collection and up to two weeks after the data are collected. Information will be treated confidentially and shared on a need-to-know basis only. The university is committed to the principle of data protection by design and default and will collect the minimum amount of data necessary for the project. In addition, we will anonymise or pseudonymise data wherever possible.

**Storing and using your data**

We will put in place appropriate technical and organisational measures to protect your personal data. Data will be stored on a password-protected computer. Data will be kept for five years, after which time they will be destroyed. The data that I collect (i.e., test results and survey results) may be used in *anonymous* form in different ways. Please indicate on the consent form attached with a ☑ if you are happy for this anonymised data to be used in the ways listed.

**Transfer of data internationally**

It is possible that the data will be transferred internationally. The university's cloud storage solution is provided by Google, which means that data can be located at any of Google's globally spread data centres. The university has data protection-compliant arrangements in place with this provider. For further information, see:

https://www.york.ac.uk/it-services/google/policy/privacy/

**Your rights**

Under the GDPR, you have a general right of access to your data, a right to rectification, erasure, restriction, objection or portability. You also have a right to withdraw up to two weeks after the data are collected. If one of the participants withdraws, then their data are not processed. For further information, see: https://www.york.ac.uk/records-management/generaldataprotectionregulation/individualrights/

**Questions or concerns**

If you have any questions about this participant information sheet or concerns about how your data are being processed, please feel free to contact Badriah Algarni by email at ba754@york.ac.uk or by telephone on 00966503796629, or the Chair of Ethics Committee via email at education-research-administrator@york.ac.uk. If you are still dissatisfied, please contact the university's Data Protection Officer at dataprotection@york.ac.uk.

**Right to complain**

If you are unhappy with the way in which your personal data have been handled, you have a right to complain to the Information Commissioner's Office. For information on reporting a concern to the Information Commissioner's Office, see www.ico.org.uk/concerns

We hope that you will agree to take part in this study. If you are happy to participate, please complete the form attached and I will come to the school and collect it by 22 December 2018.

Thank you for taking the time to read this information.

Sincerely

Badriah Algarni

Email: ba754@york.ac.uk

**Consent Form**

**Please initial each box if you are happy to take part in this research.**

- I confirm that I have read and understood the information given to me about the above-named research project and I understand that this will involve me taking part as described above. ☐
- I understand that the purpose of the research is to investigate the potential effect of the flipped classroom on students' mathematical achievement and self-efficacy in high school in Saudi Arabia. ☐
- I understand that data will be stored securely in a locked filing cabinet or on a password-protected computer and only the researcher and her supervisor, Hugues Lortie-Forgues, will have access to any identifiable data. ☐
- I understand that I will be protected by use of a code/pseudonym. ☐
- I understand that participation in this study is voluntary. ☐
- I understand that my data will not be identifiable, and the data may be used ….

  In publications that are mainly read by university academics ☐

  in presentations that are mainly attended by university academics ☐

  in publications that are mainly read by the public ☐

  in presentations that are mainly attended by the public ☐

  freely available online ☐

- I understand that data will be kept for five years, after which they will be destroyed. ☐
- I understand that data could be used for future analysis or other purposes, such as research and teaching purposes. ☐
- I understand that I can withdraw my data at any point during data collection and up to two weeks after the data are collected. ☐
- I understand that my anonymised data can be stored indefinitely and used in the future for research purposes. ☐

I agree to participate in this study. Name_________ Signature ____________

Date ________________________

## Appendix I8: Informed Consent Form for Students in the Traditional Group (Arabic Version)

### عزيزتي الطالبة

أنا بدرية القربي، طالبة دكتوراة جامعة يورك. أقوم حاليًا بمشروعٍ بحثيٍ بعنوان: "التعلم المدمج والصف المقلوب: التأثيرات المحتملة على تعزيز المهارات الرياضيه والكفاءة الذاتية في المملكة العربية السعودية". وأودّ أن أدعوك للمشاركة في هذا المشروع البحثي.

قبل الموافقة على المشاركة، يُرجى قراءة هذه المعلومات بتمعنٍ، وإبلاغنا برأيك (إن كان هناك شيء غير واضحٍ أو إن كنت ترغب في الحصول على مزيد من المعلومات).

### الغرض من الدراسة

هذه الدراسة مصممةٌ لبحث التأثيرات المحتملة على تحصيل الطالبات في مادة الرياضيات وكفاءتهم الذاتية في المرحلة الثانوية في المملكة العربية السعودية. فضلًا عن ذلك، ستتناول انطباعات الطالبات حول تجربتهم مع هذه الاستراتيجية الجديدة، وكذلك انطباعات المعلمات وتجارهم في نموذج الفصل المقلوب والتحديات المرتبطة به.

### ماذا يعني ذلك بالنسبة لك؟

أكتب إليكم لأطلب مشاركتكم في بحثي، والذي سيتم إجراؤه في الفصلين الدراسيين لمادة الرياضيات في مدرستك، في الفصل الدراسي الثاني 2019م لقد تم اختيارك لأنك طالبة في الصف الثاني الثانوي العلمي. سيمثل الفصل الأول المجموعة الضابطة، والتي ستتلقى تعليمات التدريس التقليدية، بينما سيمثل الفصل الآخر المجموعة التجريبية، والتي ستقوم بتنفيذ تعليمات الصف المقلوب. سوف تكونين في المجموعة الضابطة. ستبدأ الدراسة في الفصل الدراسي الثاني 2019م وستستغرق حوالي تسعة أسابيع.

سيتم جمع البيانات في بداية الدراسة وفي نهايتها وستتضمن اختبارًا أوليًا واختبارًا لاحقًا ومسحًا للكفاءة الذاتية للطالبات. خلال هذا البحث ستدرسين الرياضيات كالمعتاد. وفي نهاية التجربة، سأجمع بعض المعلومات. سيُطلب منك الإجابة على بعض الأسئلة، حيث ستقيمين كفاءتك الذاتية في تعلم الرياضيات من خلال تجربتك في النهج التقليدي. سيستغرق ملء الاستبيان حوالي 10 دقائق. ستحصلين أيضًا على اختبار بعدي. في هذا البحث، نختبر فاعلية منهج الفصل المقلوب، لذلك، إذا عمل بشكل جيد، فستتوفر لك جميع مواد هذا البحث، بما في ذلك محاضرات الفيديو، في نهاية فترة التجربة، ويمكنك الاستفادة من هذة المواد للتحضير للامتحان النهائي. بالإضافة إلى ذلك، سوف تساعدين من خلال كونك جزءًا من الدراسة المقترحة في تعزيز وعي المعلمات بفاعلية استخدام التعلم المدمج في التعليم. لن تنطوي المشاركة في الدراسة المقترحة على أي تكلفة عليك.

### المشاركة اختيارية

المشاركة في هذه الدراسة اختيارية. وإذا قررتِ ذلك، سيتم إعطاؤك نسخةً من نشرة المعلومات هذه لتحتفظي بها في ملفاتك، وسيُطلب منك إكمال نموذج معلومات المشاركة. في حال غيّرتِ رأيك في أيّ وقت خلال فترة البحث، يمكنك الانسحاب بدون الحاجة إلى إبداء سبب.

### معالجة بياناتك

يتعين على الجامعة وضع أساسٍ قانونيٍ لمعالجة البيانات الشخصية، وشرطٍ إضافيٍ GDPRبموجب اللائحة العامة لحماية البيانات لمعالجة فئات البيانات المحددة، عند الاقتضاء. وتماشيًا مع ميثاقنا الذي ينص على تعزيز التعلم والمعرفة من خلال التدريس والبحث، تعمل الجامعة على معالجة البيانات الشخصية لأغراض البحوث وفقًا للفقرة (هـ) من البند (1) المادة (6) من اللائحة العامة لحماية البيانات GDPR

المعالجة ضرورية لأغراض الأرشفة لتحقيق المصلحة العامة أو لأغراض البحث العلمي أو التاريخي أو لأغراض إحصائية.

.لن يُجرى البحث إلا عند الحصول على الموافقة الأخلاقية بحيث توجد مصلحة عامة واضحة وتُوضع الضمانات المناسبة لحماية البيانات

تماشيًا مع التوقعات الأخلاقية، وامتثالًا لواجب السرية في القانون العام، سنطلب موافقتك على المشاركة عند اقتضاء ذلك. إلا أنّ هذه GDPRالموافقة لن تكون أساسنا القانوني لمعالجة بياناتك بموجب اللائحة العامة لحماية البيانات

**إخفاء الهوية والسرية**

ستُخزّن البيانات التي سوف تقدمينها (نتائج الاختبارات، ونتائج الاستبانات) برقمٍ سريٍ، كما ستُخزّن كافة معلوماتك محددة الهوية بشكلٍ منفصلٍ عن البيانات، ويمكنك الانسحاب من المشاركة في الدراسة في أيّ وقت خلال فترة جمع البيانات ولمدةٍ أقصاها أسبوعين .بعد الانتهاء من جمعها

### تخزين بياناتك واستخدامه

سنطبّق تدابير تقنية وتنظيمية مناسبة لحماية بياناتك الشخصية. حيث ستُخزن البيانات على جهاز حاسوبٍ محمي بكلمة مرور. سيُحتفظ بالبيانات لمدة خمس سنوات ثم سيجري إتلافها بعد ذلك.

يمكن أن تُستخدم البيانات التي سأجمعها (نتائج الاختبارات، ونتائج الاستبانات، واستخدام البيانات والتسجيلات الصوتية) بطرق مختلفة في نموذج الموافقة المرفق إذا كنت موافقًا على استخدام هذه البيانات مجهولة الهوية ☑وبدون الإفصاح عن الهوية. يُرجى وضع إشارة بالطرق المدرجة.

### نقل البيانات إلى بلدان أخرى

من الممكن أن تُشارك البيانات عالميًا. تُقدم جوجل حلًا متمثلًا في اعتماد الجامعة على الخدمات السحابية، ما يعني إمكانية إيجاد البيانات المنتشرة عالميًا. وتمتلك الجامعة إجراءات حماية البيانات المعمول بها في جوجل. للمزيد من المعلومات، جوجل في أيٍّ من مراكز بيانات يُرجى زيارة هذا الرابط: https://www.york.ac.uk/it-services/google/policy/privacy/

### حقوقك

لديكِ الحق في الوصول إلى بياناتك الشخصية أو تصحيحها أو حذفها أو تقييدها أو GDPRبموجب اللائحة العامة لحماية البيانات الاعتراض عليها أو إمكانية نقلها. كما لديكِ الحق في الانسحاب في مدةٍ أقصاها أسبوعين من جمع البيانات. وفي حال الانسحاب، لن تتم معالجة بياناتك. للعثور على المعلومات، يرجى زيارة الموقع الإلكتروني: https://www.york.ac.uk/records-management/generaldataprotectionregulation/individualrights/

### الأسئلة والاستفسارات

إذا كان لديكِ أيّ أسئلة حول نموذج معلومات المشاركة، أو مخاوف بشأن كيفية معالجة بياناتك، لا تترددي في التواصل مع بدرية القرني عبر البريد الإلكتروني: (ba754@york.ac.uk)

أو عبر الهاتف على الرقم 00966503796629، أو تواصل مع رئيس لجنة الأخلاقيات عبر البريد الإلكتروني: education-research-administrator@york.ac.uk . وإن لم يُلبي طلبك، يُرجى التواصل مع مسؤول حماية البيانات بالجامعة عبر البريد الإلكتروني: dataprotection@york.ac.uk

### الحق في تقديم الشكاوى

إن لم تكوني راضية عن تعاملنا مع بياناتك الشخصية، يحق لك تقديم شكوى إلى مكتب مفوض المعلومات. يمكن العثور على مزيدٍ من المعلومات حول الإبلاغ عن مشكلة إلى مكتب مفوض المعلومات عن طريق الموقع الإلكتروني: www.ico.org.uk/concerns

نأمل أن توافقي على المشاركة في هذه الدراسة. إن وافقتِ على ذلك، يُرجى إكمال النموذج المرفق. وسأحضر إلى المدرسة لأستلمه يوم 2018/12/22م.

**أشكرك على الوقت الذي قضيته في قراءة هذه المعلومات.**

**نموذج موافقة**

**يُرجى وضع إشارة في كل مربع إذا كنت موافقًا على المشاركة في هذا البحث.**

☐ أؤكد أنني قد قرأت وفهمت المعلومات المقدمة لي حول المشروع البحثي المذكور أعلاه، وأتفهم أنه سيتضمن مشاركتي كما هو موضح أعلاه.

☐

أتفهم أن الغرض من البحث هو دراسة التأثيرات المحتملة لاستراتيجية الصف المقلوب على تحصيل الطالبات في مادة الرياضيات وكفاءتهم الذاتية في مرحلة الثانوية في المملكة العربية السعودية.

☐ أتفهم أن البيانات ستُخزّن بشكلٍ آمنٍ في خزانة ملفاتٍ مؤمّنةٍ أو على جهاز حاسوبٍ محميٍ بكلمة مرور، ولن يتمكن أحد من الوصول إلى أيّ بياناتٍ محددة الهوية سوى أنا ومشرفي هوغو لورتي فورغي

☐ أتفهم أن بيانتاتي ستكون محميّة باستخدام رمزٍ/ اسمٍ مستعار.

☐ أتفهم أن المشاركة في هذه الدراسة اختيارية

أتفهم أنه لن يتم تحديد هوية بياناتي، ويمكن استخدام البيانات في ....

☐ المنشورات التي يقرأها الأكاديميون الجامعيون بصفةٍ رئيسيةٍ

☐ العروض التقديمية التي يحضرها الأكاديميون الجامعيون بصفةٍ رئيسيةٍ

☐ المنشورات التي يقرأها عامة الناس بصفةٍ رئيسيةٍ

☐ العروض التقديمية التي يحضرها عامة الناس بصفةٍ رئيسيةٍ

☐ المتاحة مجانًا عبر الإنترنت

☐ أتفهم أنه سيُحتفظ بالبيانات لمدة خمس سنوات ثم سيجري إتلافها بعد ذلك.

☐ أتفهم أن البيانات قد تستخدم للتحليل المستقبلي أو لأغراض أخرى مثل: البحوث والتدريس.

☐ أتفهم أن بإمكاني سحب بياناتي في أيّ وقت خلال فترة جمع البيانات ولمدةٍ أقصاها أسبوعين بعد الانتهاء من جمعها.

☐ أتفهم أنه يمكن تخزين بياناتي –مخفية الهوية– إلى أجلٍ غير مسمى واستخدامها لأغراض البحث في المستقبل.

أوافق على المشاركة في هذه الدراسة.

الاسم: ____________________________________________

التوقيع: _______________________________________

التاريخ: _______________________________________________

# Abbreviation

| | |
|---|---|
| BL | Blended Learning |
| CTML | Cognitive Theory of Multimedia Learning |
| EEF | Education Endowment Foundation |
| FC | Flipped Classroom |
| FLGI | Flipped Learning Global Initiative |
| GPA | Grade Point Average |
| ICT | Information and Communication Technology |
| IRP | Interview Protocol Refining |
| IT | Information Technology |
| K12 | primary and secondary education |
| PISA | Programme for International Student Assessment. |
| PL | Peer Learning |
| SAAT | Scholastic Achievement Admission Test |
| SCT | Social Cognitive Theory |
| SSEM | Source of Self-efficacy in Mathematics |
| STEM | Since, Technology, Engendering, and mathematics |
| TIMSS | Trends International Mathematics and Science Study |

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