AMERICAN UNIVERSITY OF BEIRUT

EFFECT OF FLIPPED CLASSROOM ON EIGHTH GRADERS' ACHIEVEMENT IN MIDPOINT THEOREM IN TRIANGLES AT A PRIVATE SCHOOL IN BEIRUT

by
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A thesis
submitted in partial fulfillment of the requirements
for the degree of Master of Arts
to the Department of Education
of the Faculty of Arts and Sciences
at the American University of Beirut

Beirut, Lebanon
January 2020

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Date of thesis defense: January 11, 2021

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ACKNOWLEDGMENTS

I would like to thank all those who encouraged, guided, supported, and helped me complete this work.

ABSTRACT

OF THE THESIS OF

Nour Mohammad Zaher Hamad for Master of Arts
Major: Mathematics Education

Title: Effect of Flipped Classroom on Eighth Graders' Achievement in Midpoint Theorem in Triangles at a Private School in Beirut

Nowadays, considering the technological developments in different aspects of life and its fast widespread among students in Lebanon, the new generation uses information and communication technology more often. Thus, there is a need to enhance teaching settings using new learning technologies, which became an important area to examine and explore. The adopted flipped classroom model is a teaching setting composed of the FLIP pillars, which includes the integration of learning the new concept at home, using technology as a tool, and applying the concept in class (FLN, 2014). Linking the revised version of Bloom's Taxonomy with the four phases developed by Merrill (2002): we suggest that remembering and demonstration phases are processed outside the classroom while applying, and integration phases happen during class time. The study aims to explore the differences between mathematical performances in the midpoint theorem of eighth-grade students within a flipped classroom compared to a non-flipped classroom in Lebanon. It also aims to discover students' and the teacher's challenges faced and benefits gained from the implemented flipped classroom model. To assess the impact of this model on the performance of students and to check whether flipped classroom results in significant differences in the students' learning outcomes, a quasi-experimental design was deployed. To gain insight into the benefits gained and the challenges faced by the teacher and the students who experienced the flipped classroom, semi-structured interviews were conducted with both the students and the math teacher. The quantitative results indicated that the flipped classroom students performed better than the non-flipped classroom students showing a significant difference in the understanding level of low achievers only. The interviews conducted with the teacher and the students revealed that participants gained a fruitful experience at home and in class. The flipped classroom helped students gain a flexible and a calm environment to learn a new concept. It also helped them become independent learners who are mathematically confident, as it increased class time and improved classroom communication and personalized instructions. Besides the mentioned benefits, there existed some challenges the students and the teacher have faced in the flipped classroom. Students felt tensed to learn a new objective without having the teacher around. They considered the poor Lebanese infrastructure a challenge as well. The teacher found it an overwhelming experience.

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INTRODUCTION

Mathematics is a part of our society and everyday life. It is applied in different fields such as economics, marketing, politics, democratic applications, etc. (Skovsmose, 1990). Accordingly, Nasser and Birenbaum (2005) stated that students' performance in mathematics is of huge importance in most educational systems at all levels. As a result, it is important to seek high performance in mathematics and take into consideration that students who encounter difficulty in learning mathematics do not necessarily mean they have learning disabilities, but it might be due to an inappropriately designed teaching instruction (Carnine, 1997).

Through the past decades, technology has moved from being a luxury to being an essential need. Subsequently, since the early 1980s, individuals have been exposed to technology from a very young age (Roehl et al., 2013). Such a change has affected their way of thinking, communication, and accessing and analysing information, which made the use of technology an essential element in the educational field. Technology became increasingly common in today's classrooms by using it as a supplement teaching resource (Geiger et al., 2015). It enables instructors to use interactive boards, clickers for assessment, and dynamic software for illustrations (Wasserman, Quint, Norris & Carr, 2015). Thus, the educational field became more oriented towards a technology-interactive classroom setting (eg, Gadanidis & Geiger, 2010; Larkin & Jorgensen, 2015) using mobile technology, smart boards, and the internet.

Furthermore, students' interaction within the learning process of mathematics is highly important as the resources used for teaching. To interactively acquire mathematical knowledge, students need to participate in a meaningful mathematical practice (Li, Moschkovich & SpringerLink., 2013) such as problem-solving, critical thinking, and classroom discussion. Also, for students to develop their understanding professionally, educators need to make themselves available for individual, group, and class feedback when needed. They also need to be able to conduct assessment through observation, continuous follow-up, and data recording (Muir & Geiger, 2016) to inform future instructions and guidance (Graziano, 2017).

Flipped Classroom model is an example of a teaching setting that merges technology into the teaching process. The flipped classroom was established by Bergmann and Sams in 2012 (Muir & Geiger, 2016). It is a model in which what is supposed to be implemented in a classroom is delivered outside class time and what is supposed to be given as homework is implemented during class time (Lee et al., 2016; Heo & Choi, 2014).

There is consensus in research in mathematics education that most flipped classroom models are highly affected by students' ability to manage and control their effort on outside-class tasks and link them to classroom tasks through peer and instructor's individual, small group, and whole class feedback (ex. Muir & Geiger, 2016). Students should be able to complete pre-class tasks to be well-prepared for in-class work (Sun & Chiou, 2017). At home, online math instructions set for students to access may introduce a new concept, demonstrate a procedure, pose a challenging problem, or illustrate a real-life-scenario (Lim & Wilson, 2018). Students access the math instructions through web-based videos, notes, or readings (Baghat et al., 2016).

These instructions might include a brief review of prerequisites for students to build their knowledge on (Lo & Hew, 2017). Thus, working at home allows students to hold complete responsibility for their learning (Fulton, 2012).

1.1. Purpose and Research Questions

The purpose of this research study is to explore the differences between mathematical performances in the midpoint theorem of eighth-grade students within a flipped classroom compared to the non-flipped classroom. The non-flipped classroom model is used to describe a classroom setting, by which students are taught the new concept in class and then sent home to apply it. Also, the study discovers the students' and the math teacher's challenges faced and benefits gained in the flipped classroom model.

This research study addresses the following research questions:

1. Is there a significant difference between students' performance level in midpoint theorem within the flipped classroom and non-flipped classroom models?
2. What are the benefits gained and challenges faced by the students in the flipped classroom model?
3. What are the benefits gained and challenges faced in the flipped classroom model for the teacher?

1.2. Rationale of the Research Study

The flipped classroom model became recently one of the most popular trends in the educational field (Maciejewski, 2015). Most of the researchers compared the flipped classroom model to lecture-based instructions (ex. Mattis, 2014; Carlisle, 2018; and

Bhagat et al., 2016). They determined its effectiveness and reflected students' and instructors' attitudes towards a flipped classroom model by comparing their results to a lecture-based classroom setting. Few researchers such as Yong, Levy, and Lape (2015) compared the effect of flipped classroom to other learning settings rather than the lecture-based setting. Such a lack in research requires more investigation to compare students' performance in the flipped classroom model versus the non-flipped classroom model.

There is no consensus in mathematics education that the flipped classroom model necessarily leads to students' higher mathematical performance in comparison with the non-flipped classroom. For instance, Carlisle (2018) compared the achievement of high school students in mathematics within a flipped vs. lecture-based classroom setting. The results showed neither significant difference nor an impact on students' scores. Likewise, Yong et al. (2015) compared the flipped college differential equation course to an interactive differential equation course setting and noticed that within the first two years no difference occurred in learning. However, nursing students registered for a math course being delivered within a flipped classroom setting showed high accuracy in solving complex mathematical problems than those within the traditional setting (Mattis, 2014). Similarly, Scott, Green & Etheridge (2016), and Bhagat et al. (2016) noticed a significant improvement in students' performance in a nursing math course and calculus course. Such a contradiction in results raised an issue here and requires further studies to be done.

Furthermore, the research still lacks the effect of flipped classroom model on middle school students in mathematics. The main focus of the research studies, as noticed, was either on high school or university students. Sickle (2016) like Peterson

(2016) and many others have targeted college students in their research, whereas Dixon (2017), Saunders (2014), and Bhagat et al. (2016) and others have targeted high school students.

On the other hand, Osta (2007) argued that the demographic differences and the curriculum content taught in every country leads to differences in performance in every country. Thus, one cannot ignore the fact that students' performance levels differ according to what, how, and where they are taught. Few research studies studying flipped classroom model has been applied in Lebanon, (ex. Baytiyeh & Naja, 2016; Baytiyeh, 2017), and other studies were done in the West (ex. Lee et al., 2016; Muir & Geiger, 2016; Wasserman et al., 2015). Cultures and environments differ, what works in other settings might not work here and vice-versa. With such above findings related to the flipped classroom model, it is important to explore students' performance and to discover the benefits gained and the challenges faced by students and the teacher here in Lebanon.

Conclusively, the study compares the effect of flipped classroom model with that of the non-flipped classroom model on students' performance in mathematics. Also, it discovers the benefits gained and the challenges faced by the teacher and the students in a flipped classroom setting. Thus, the study extends previous research by being more specific in studying the effect of flipped classroom in a geometry lesson, specifically within grade eight students in Lebanon.

1.3. Significance of the Research Study

The following research provides further insight into the effect of flipped classrooms on students' performance in geometry (midpoint theorem lesson) at a private school in Beirut. It shows the impact of the flipped classroom model on students' performance in the geometry lesson "midpoint theorem", it reflects students' benefits gained and challenges faced in such a setting, and it provides an insight into teacher's benefits gained and challenges faced in the implemented flipped classroom during the math session.

CHAPTER 2

LITERATURE REVIEW

This research aims to examine the effect of the flipped classroom model on grade eight students' performance in midpoint theorem. It also aims to discover the benefits gained and the challenges faced by both the students and the teacher in the flipped classroom model.

In this chapter, the different definitions of the flipped classroom are presented. The benefits and the challenges, and the essentials to implement an effective flipped classroom model, are discussed. Finally, the adopted definitions and framework of the flipped and the non- flipped classrooms are presented.

2.1. Theoretical Framework regarding Flipped Classroom

Researchers defined flipped classrooms in different ways (Lage et al., 2000; Wasserman et al., 2015; Peterson, 2016; Guerrero, Beal, Lamb, and Baumgartel, 2015; Patterson et al., 2018). Table 1 categorizes the different definitions of the flipped classroom model into two main categories: (1) a teaching setting (Peterson, 2016; Muir & Geiger, 2016; Lage et al., 2000) and (2) an instructional strategy (Bishop and Vergler, 2013; Gannod, 2008; Enfield, 2013; Moroney, 2013; Gaughan, 2014). The first classification of flipped classroom model suggests that a student is assigned some material to learn before revealing it in the class (Eppard & Rochdi, 2017). Lage, Platt, and Treglia (2000), Peterson (2015), and Muir and Geiger (2016) defined a flipped classroom model as a setting by which what is done in class (concept delivery) is done outside the classroom and what is usually done outside the classroom (solving problems) is done in the class. While the latter definition describes the flipped classroom model as a pedagogical instructional method, where interactive content and active learning takes place outside the classroom and then direct instructions and face to face collaboration takes place in the classroom (Talbert, 2016; Anderson et al., 2001). When referring to such definitions, teachers were granted some flexibility and some freedom to use the flipped classroom model in different ways (Eppard & Rochdi, 2017).

Table 1 Definition of Flipped Classroom according to different studies

	Author	Definition	Findings
Teaching Setting	Lage, Platt, and Treglia (2000)	"inverting the classroom means that events that have traditionally taken place inside the classroom now take place outside the classroom and vice versa" (30-43)	- Students preferred future classes to be in the inverted classroom.
Teaching Setting	Peterson (2015)	A flipped classroom tries to ''flip'' the standard arrangement of a course in a way that the concepts delivery (traditionally done in-class lectures) is delivered outside class, whereas class time is reserved for working on problems.	- In flipped classroom, students outperformed others in the lecture class in the final exam by more than a letter grade. - Flipped classroom students felt more satisfied with the course generally.

	Author	Definition	Findings
Teaching Setting	Muir & Geiger (2016)	"A mode of teaching and learning 'in which direct instruction moves from the group learning space to the individual learning space, and the resulting group space is transformed into a dynamic, interactive environment where the educator guides students as they apply concepts and engage creatively in the subject matter" (Flipped Learning Network -FLN 2014 para. 1).	- Students and teacher showed positive attitude about the flipped classroom practices. - Students showed motivation to work with the teacher-created online mathematics resources.
Teaching Strategy	Baytiyeh & Naja (2017)	A set of pedagogical methods including (Love et al. 2014; Talbert, 2014; Gilboy, Heinerichs, and Pazzaglia 2015): highly structured, pre-class assignments, means of accountability, well-designed activities, open communication throughout the course, and internet technology	- Test results in the flipped classes were a little higher than traditional classes. - To students, flipped classes stimulated skills, which were needed for engineering careers including critical thinking, self-confidence, teamwork and problem solving. It provided also a deeper, wider point of view on learning.
	Carlisle (2018)	An instructional technique where course material normally delivered in class is recorded and accessed at home earlier to the content practiced	- No significant difference noticed between the traditional method and the flipped method on results.

	Author	Definition	Findings
		in the classroom (The Flipped Learning Network (FLN), 2014).	- In flipped classes, students showed less anxiety, greater self-efficacy and interest in mathematics on interviews and open-ended questions.
Teaching Strategy	Wasserman, Quint, Norris, & Carr (2015)	A classroom that involve some “active learning outside of class and some direct instruction during class”	- Performance of both the flipped and the traditional students was similar with procedural problems. Yet, flipped students' performance was slightly higher with conceptual exam problems. - Flipped students reported enhanced communication during class time. - Traditional students reported more effective use of class time although flipped students' performance was better in class.
	Patterson, McBride, & Gieger (2018)	A kind of active learning, flipped learning dwells on preparation before class time and a 'flip' in the teacher and students expectations. In other words, the students handle responsibility of their own	- Grades and pre/post surveys showed that students are more motivated to cooperate with their classmates and to ask questions to their teacher

Author	Definition	Findings
	learning experience while the teacher works as an assistant.	

The table above, table 1 shows that the flipped classroom may produce positive outcomes in terms of students' engagement (Guerrero et al., 2015; Muir & Geiger, 2016; Patterson, McBride, & Gieger, 2018), better students' grades (Baytiyeh & Naja, 2017; Peterson, 2015), positive attitude (Muir & Geiger, 2016), stimulation of new skills (Baytiyeh & Naja, 2017), interest in mathematics (Carlisle, 2018), and enhanced communication (Wasserman et al., 2015). Also, students preferred the flipped classroom instead of traditional ones where instructors teach first and students practice later (Lage et al., 2000). On the other hand, few researchers showed no significant difference between flipped and other learning strategies (Carlisle, 2018; Wasserman et al., 2015).

2.2. Benefits and challenges of the flipped classroom model

Many research studies (Morgan, 2014; Moore et al., 2014; Araujo et al., 2017) discussed what the use of flipped classroom model will add to the learning experience and how it improved it. This model had many benefits for both the in-class learning process and at home learning process. Through observations and interviews conducted with instructors and high school students, researchers were able to come up with the following positive aspects of flipped classroom model: increased class time, differentiation, flexible environment, and digital nativity, mathematical confidence, improved communication, personalized instructions, and better performance.

While the benefits are many, adopting and using the flipped classroom model may be faced by many challenges, including social, technical, and educational factors. The following are several challenges discussed in the literature: instructors' attitude, no better grades, Lebanese infrastructure, learning alone, and non-cooperating students.

2.2.1. Benefits gained at home

Differentiation. Differentiation was defined as "an instructor's reacting responsibly to a learner's needs" by Tomlinson and Allan (2000) (p. 4). Instructors willing to effectively differentiate in their classes need to identify differences in their students. Thus, instructors need to tackle their students' needs and different learning styles instead of using "homogenous methods" for teaching and assessment (Marlowe, 2012). According to Tomlinson (2001), differentiation could be in three aspects: process, content, and products. "Process" is how learners connect ideas, "Content" is the material sent and how students learn it, and "products" are the ways students establish learning. In these cases, the moderator was the student's interest and readiness. Each student was cognitively ready for material earlier than others were, and various interests required students to follow different forms of learning (Marlowe, 2012). Thus, the flipped classroom allows each student, according to his /her level, choose the teaching content and progress. Also, differentiation is achievable with students who need to expand their study (Chen et al., 2018) by sending them content that tackled their needs.

Students learned best when their learning style goes along with the instructor's instructional method (Borg and Shapiro, 1996). Rather than trying to tackle each learning style individually, using the flipped classroom model, the instructor can potentially widen the range of learning styles of a modern classroom (Marlowe, 2012). According to Heo and Choi (2014), students found it easier to understand the lesson explained by simply having access to various instructors' expertise (Fulton, 2012) and replayed the video several time (Muir & Geiger, 2016) which lad to better scores and less incomplete assignments (Schmidt & Ralph, 2016).

Flexible environment. With flipped classrooms, students accessed content whenever and wherever they wanted (Fulton, 2012). This allowed students to learn at their own pace (Ayçiçek & Yanpar Yelken, 2018) and granted them the chance to self-explore (Ma et al, 2018).

Digital nativity. "Digital Native" was a term first used by Marc Prensky (2001). Today, it was used to describe the new generation. They lived in a technology-saturated environment (Morgan, 2014). Thus, they were more technically experienced and skilful of the latest devices and technologies. If a school failed to cater some forms of the digital experience, engagement is less attained (Thompson, 2016).

Technology in flipped classrooms allowed instructors to produce and present learning materials in a variety of formats that suits different learning styles in its most convenient structure for students (Muir & Geiger, 2016). It offered a motivating, flexible, and student-derived learning environment (Lai &Kristonis, 2006). Thus, smart instructors in a flipped classroom must leverage the opportunity that students are digital natives to reach their students and deliver them the material their way. The flipped classroom environment allowed instructors to use digital devices for students' engagement (Smaldino, Lowther, Russell & Mims, 2008) like spreadsheets (Clark, 2005), audio and video communications (Seago, 2003), computer-assisted instructions (Nason, Chalmers & Yeh, 2012), and many more.

2.2.2. Benefits gained in class

Increased class time. Unlike traditional learning where instructors teach first and students learn by themselves later, flipped classrooms ensured students learn the new concept in advance whereby the classroom became mainly a place for instruction and presentations to attain deep learning (Ma et al, 2018). This model was developed educationally to produce the most efficient time for class activities. This way, students had the chance to "develop their abilities, create interactive discussion conditions, discovere different learning methods with different learning activities" (Ayçiçek & Yanpar Yelken, 2018). In conclusion, the students' active engagement in the class was increased when the flipped classroom model was used (Millard, 2012).

Improved Communication. Research has proved a strong relationship between "effective communication, students' achievement, and students' satisfaction with teaching" (Good and Brophy, 2003), showing the significance of communication. Since the flipped classroom's objective was to promote self-learning, this has led to "heated" communication and discussion (Hwang, Lai & Wang, 2015). In his comparison done between a class which used flipped classroom and a lecture-based classroom, Clark's (2015) quantitative results and qualitative findings showed a positive increase in students' communication and engagement when they used flipped classroom. Students viewed their increased student-to-student and student-to-instructor communication as a positive contribution to their experience. To be more accurate, students noticed enhancements in the usage of class time and the quality of instruction.

Flipped classroom changed the classroom environment into a more collaborative environment. It made the environment friendly by improving instructor-student relationship (Muir & Geiger, 2016) which made students more confidently able to ask questions (Heo & Choi, 2014) and engage in classroom activities (Schmidt & Ralph, 2016). Consequently, it strengthened team-based skills (Schmidt & Ralph, 2016) and allowed students to construct knowledge in both individual and social ways which provided a more personalized, interactive, and collaborative learning experience (Guerrero et al., 2015). Also, according to Heo and Choi (2014), students enjoyed moving at their own pace (Muir & Geiger, 2016; Guerrero et al., 2015). Subsequently, allowing instructors to tackle more challenging problems during class time, rather than at home (Muir & Geiger, 2016) causing students to work at a higher cognitive level to explore mathematical topics (Guerrero et al., 2015).

Personalized instructions. To an instructor, the flipped classroom helped instructors offer more learning opportunities for students (Mattis, 2015) by being able to engage both average and high achievers to apply the concept taught, and participate in more classroom discussions (Davies et al., 2013; Fautch, 2015; Mason et al., 2013; Baghat et al.,2016). It increased instructors' access to students' thinking, reasoning (Guerrero et al., 2015), and progress (Bergman & Sams, 2012; Muir & Geiger, 2016) because of the high interaction going on between the instructor and the student inside the class. In other words, it provided a medium that allowed for differentiated teaching for a range of students' abilities (Herried & Schiller, 2013; Muir & Geiger, 2016) effectively and creatively (Fulton, 2012).

Some teachers reported feeling different in class after they missed the interactivity of delivering lessons to students because they were not able to scale their students' understanding on spot yet the model increased class discussion (Oakes, Davies, Joubert & Lyakhova, 2018). One math teacher stated that as a result to using the flipped classroom, students started thinking more in depth. For example, when taking a lesson about inverse hyperbolic functions, the teacher explained that he would have done the same examples but would have taken more time in class. On the other hand, majority of the Irani teachers reflected that such a model allowed them to personalize instruction, connect more to the students who struggle academically, and manage class time more efficiently (Vaezi, Afghari, & Lotfi, 2019).

Better Performance. Several research studies were interested in exploring the effect of the flipped classroom on students' performance. For instance, Baghat et al. (2016) and Lee et al. (2016) explored the difference in learners' performance of students with different achievement levels for high school students. Both studies proved the effectiveness of the flipped classroom model by comparing the results of pre-tests to post-tests. They noticed that the flipped classroom model helped low achievers improve their performance more than it did with high achievers.

Similarly, students in the flipped classroom did not gain more knowledge than the lecture-based section as Scott et al. (2016) concluded in his study by comparing a flipped and lecture base calculus section. However, Mattis (2015) found that students in flipped classroom demonstrated higher accuracy in using math terminologies than students receiving lecture-based instruction. Besides, Mattis (2015) added: "regarding cognitive outcomes, flipped classroom model presented best results when problems were highly complex." Likewise, Mattis findings support that there was an alignment between procedural and conceptual knowledge in flipped classroom model (Naccarato & Karakok, 2015). Mainly this was because flipped classroom model increased students' interest in the subject (Scott et al., 2016) and promoted them to interact with the learning procedure more actively. In other words, in the flipped classroom, students became more self-directed learners, they gained more cognitive thinking strategies rather than simply mimicking instructors' method (Ford, 2015) allowing them to be more accurate in solving math problems (Mattis, 2015).

2.2.3. Challenges faced at home

Lebanese infrastructure. When using the flipped classroom model, the instructor aims at sending material and resources to the student before the classroom time via the internet. The latest technologies are based on several factors including the Internet and Electricity. People living in Lebanon have been suffering from electrical outages since 1975. In Beirut, daily cuts can last up to three hours, while outside Beirut; it can reach up to 14 hours per day ("Meet the man trying to fight the electricity crisis in Lebanon", 2018). On the other hand, ranking 161 in the world, Lebanon's internet speed is disastrous in comparison to other countries' speed ("Lebanon's Mobile and Broadband Internet Speeds - Speedtest Global Index", 2019).

Tensed and uncertainty. Students at early grade levels might not have the foundational skills to learn new concepts on their own (Guerrero et al., 2015), which only advantage the high achievers to benefit from such a procedure (Heo & Choi, 2014). Thus, students who lacked the mathematical background found it intense and hard to cope with the flipped classroom model (Ford, 2015). As a result, instructors found difficulty in finding a balance between lecture, to clarify the concept, and group work to practice and deepen the concept (Ford, 2015).

2.2.4. Challenges faced in class

Instructors' resistance. Zimmerman (2006) mentioned that the success of any new initiative in a school is highly dependent on instructors. When talking flipped classroom, if teachers' attitudes and scepticism toward this new model were not understood, the school had resource wastage, inefficiency, and resistance (Huang, Yue& Chang, 2018). The term resistant could describe instructors who do not want to integrate the new technology into their classrooms in general. Recently, many new technologies that serve education better are being available at schools. Yet, some instructors went against integrating technology in their teaching process (Howard, 2013) and preferred the old ways. Some of them are afraid to try or afraid of using technology. The reasons behind resistance to change vary. Greenberg & Baron (2000) mentioned few, including (a) the failure to identify the need for change; (b) changing the habit, instead of improving their current skills and strategies and developing new ones, some instructors believed that it was easier to stick to their current successful ones. Mumtaz (2000) described them as happy with their familiar and established teaching styles. Add to that, Goleman, Boyatzis, and McKee (2002) agreed that the school's environment played a major role in encouraging new technological practices. When instructors feel the environment is "unsafe", they might act defensively, stick to their old habits and refuse to accept embracing new technological initiatives.

While teachers' resistance was an important factor of the success of flipped classroom model, other factors in teachers' attitude and perceptions played a major role too. Teachers reported major challenges, which they faced while experimenting the flipped classroom model, were students reluctant to hold responsibility to finish pre-assigned materials, increased preparation time of the material and students' need for immediate feedback when completing pre-assigned materials yet they agreed the model enhanced student involvement in classroom (Vaezi, Afghari, & Lotfi, 2019). In addition, teachers noticed the extra burden of integrating their teaching content with an extracurricular one (Zhou, 2014). The burden included searching for or creating suitable instructional videos leading to an extra pressure in class preparation (Kuo & Ho, 2014) where teachers had to think specifically about what they should say and do in each video (Oakes, Davies, Joubert & Lyakhova, 2018).

No better grades. Although flipped classroom widened the students' resources for understating class material and studying them, yet several researchers did not notice an increase in their grades as Guerrero et al. (2015) witnessed when he compared students' test scores between flipped and lecture-based classroom instructions. Moreover, the founder of the Center for Highly Interactive Classrooms, Curricula, & Computing in Education and a professor at the University of Michigan, Elliot Soloway, said: "Technology has benefited retail, entertainment, research, and other industries because those areas redesigned themselves to take advantage of the technology but bolting technology onto an existing curriculum will not lead to increased student achievement" (Tynan-Wood, 2016). When using the flipped classroom, the goal is not about improving test scores only, it is about ensuring the students understand what they are studying.

Non-cooperating students. Although students enjoyed technology and follow what is trending, yet Bristol (2014) showed concerns regarding students who come to class not doing what they are supposed to do; watching a video, reading an article, etc. Add to it, instructors found difficulty in knowing whether the students did their job or not (Kordyban and Kinash, 2013).

2.3. Essentials to implement effective flipped classroom model

To implement the flipped classroom model, instructors must take into consideration several conditions before, while and after using it. First, Lee et al. (2016) suggested that instruction must be designed in a way that trigger students' own strengths and develop their confidence. In addition, it is important to make sure that it is feasible to access the internet and use technology by both the instructor and students.

On the other hand, Muir and Geiger (2016) claimed that for an effective implementation of flipped classroom, instructors needed to take into consideration the FLIP framework which encompasses four pillars adopted by FLN (2014). The first pillar was ensuring a *flexible environment* for students to interact and fully engage in the process of learning. This environment was described as flexible because it allowed students to choose when and where they learn and instructors to be adaptable to students' learning (Muir & Geiger, 2016). The second pillar included a shift in the *learning culture* allowing class time to incorporate topics of greater depth and rich learning opportunities where students were highly involved in learning. The *intentional content* was the third pillar representing what instructors determine to teach and what material students should handle on their own. Hereby, teachers created relevant content in order to maximize class time for depth learning. Finally, the fourth pillar was the *professional educator* who was able to integrate different teaching strategies that suited all students without affecting the other. The instructor observed his students, provided them with instant feedback and assessed their work. Definitely, the FLIP framework recommended that students are at an age where they were capable of holding responsibility of their own learning (Muir & Geiger, 2016). Thus, Schmidt and Ralph

(2016) summarized the whole issue by discovering that the more interactive the work was at home, the more the FLIP framework was successful.

2.4. Home Environment

The flipped classroom model focused on two major environments: (1) Home environment where students were introduced to the educational context mainly through the online platforms and (2) the school environment where students practiced and applied the concepts learnt at home (Guerrero et al., 2015; Muir & Geiger, 2016). As the literature previously shed the light on what happens in the classroom, it was essential to target the role of language, community, and technology at home.

Role of Language. Students struggled when the medium of instruction differs from their native language to another one (Yushau & Bokhari, 2005), which was a main reason behind the poor performance of many students in mathematics (Barton & Barton, 2003). Even if the parents were resourceful, they might encounter a language barrier when helping their child with his math homework (Civil et al., 2008). For example, in French, a “nombre decimal” had a finite number of non-zero digits on the right hand side of the decimal separator, while in English, a “decimal number” can have infinitely, many non-zero digits.

While the previous might not be the case in Lebanon. Students in Lebanon started learning their foreign languages such as English or French, since day one at school. Math was taught using it. When young children were exposed to foreign languages since an early age, they returned to home encouraged and motivated to enhance their ability to talk a second language (Stewart, 2005) thus maintaining language proficiency with time. In addition, research proved that students learning foreign languages in early elementary years enhanced their cognitive abilities, significantly influenced achievement in other subjects like math and marked better achievement test scores in reading and math (Stewart, 2005). Yet, even if students mastered the foreign language, students faced problems understanding and communicating math vocabulary and terminologies which were considered to be “fairly superficial” (Thompson & Rubenstein, 2000).

*Role of Community***.** The students’ community, their family and neighbors, had an important role in their education. Some parents were able to help their kids at home when they struggled with homework, yet the majority did not (Schmidt & Ralph, 2016). In his research, Brown (2016) voiced out parents’ struggle helping their kids with their homework especially math, language and sciences. They did not recall the right concepts or simply were not comfortable with the material in front of them. This phenomenon was better seen in the upper elementary, middle and high school classes. Thus, parents referred to the community for assistance. This included asking other family members or neighbors for help or taking their kids to educational centers. Other parents engaged purposefully with their kids in activities that endorsed and targeted mathematical reasoning and knowledge (Civil et al., 2008).

Meanwhile, using the flipped classroom model, parents were granted an opportunity to better support their kids (Schmidt & Ralph, 2016). Since the implemented flipped classroom model delivered the basic knowledge at home, parents had the chance to access the same material their kids get (Brown, 2016). They were more active and involved with their kid’s learning (Hamdan et. al., 2013). In addition, parents were less pressured to grant their kids an immediate assistance knowing that the flipped classroom model offered them the opportunity to ask deep understanding questions to their teacher during classroom activities.

Role of Technology. In the past, students had received knowledge in the classroom or using textbooks (Evans, 2018). Evans (2018) added that students were not bound to this source; they had wide resources including websites and YouTube. Based on the classification of technology stated by Lou et al (2001), the flipped classroom model used technology as a communication media (Baytiyeh & Naja, 2017), tutorial (Carlisle, 2018), exploratory environment (Muir & Geirger, 2016) and a tool (Guerrero et al., 2015). In the flipped classroom, technology in all its categories was a main component to facilitate interaction between the instructor and students. In other words, the flipped classroom model used technology to provide students with a more flexible and engaging learning environment (Carbaugh & Doubet, 2016). The implemented flipped classroom aimed to deliver knowledge to students through online educational platforms.

Educational online platforms, also known as learning management systems, are online popular systems that had been supporting the learning and teaching processes at a distance such as Moodle, Blackboard, and Google Classroom (Dahlstrom, Brooks, & Bichsel, 2014; McGill & Hobbs, 2008) . They were defined as “a self-contained webpage with embedded instructional tools that permit faculty to organize academic content and engage students in their learning” (Gautreau, 2011, p.2). They offered a virtual way of fast and increased communication between the teacher and the student thus providing effectiveness in the educational processes (Fathema, Shannon & Ross, 2015). Online discussions, homework, lecture materials, movie, grades etc. were some tools that such educational platforms provided (Fathema, Shannon & Ross, 2015).

Some schools used such platforms for managing and supporting lessons. While others used them to send games that has exercises to motivate students to apply and practice what they have learned in class (Lui et al., 2013). Educational platforms were various in system features, supported activities, adoption approaches and user's point of view. For example, Chen et al. (2014) mentioned in his study the use of Facebook for students as a platform for communication and discussion initiation. Also, Wu, Chen, and Yang (2017) introduced a type of an educational web-based platform that offered high-quality educational material called the Open Course Ware. It served as a type of an online tutorial for students learning at home.

Mostly, the flipped classroom model assigned pre-class tasks through internet technology (Baytiyeh & Naja, 2017). At home, students' access the material assigned through an online platform (Guerrero et al., 2015; Wasserman et al., 2015).

2.5. The adopted definition and the implementation of the Flipped Classroom model

For the purpose of this study, we mainly focus on the flipped classroom model, defined by Peterson (2016) as follows: "A flipped classroom attempts to ''flip'' the typical structure of a course such that the presentation of concepts (traditionally achieved through in-class lectures) is presented outside class, whereas class time is reserved for working on problems or assignments (i.e., in-class ''homework'')" (p. 10). In other words, the adopted flipped classroom model is a teaching setting, which includes the integration of: learning the new concept at home, using technology as a tool, and applying the concept in class. The adopted flipped classroom model followed the FLIP pillars and is based on Bloom's Taxonomy embedded within the following four phases developed by Merrill (2002): (1) activation phase, prior-knowledge activation, (2) demonstration phase, knowledge demonstration, (3) application phase, knowledge application, and (4) integration phase, knowledge integration, see table 2.

Table 2 The Four Phases designed by Merrill (Merrill, 2002)

Phases	Description
Activation Phase	Learning occurs when students are directed to recall, relate, describe, or apply a previous concept as a foundation for the targeted objective.
Demonstration Phase	Learning occurs when students are directed to describe, demonstrate, relate, or explain the targeted objective.
Application Phase	Learning occurs when students are directed to illustrate or apply the targeted objective.
Integration Phase	Learning occurs when students are able to analyze, reflect on, discuss, and defend the targeted objective.

In the adopted flipped classroom, *activation phase, demonstration phase, and application phase* were applied during the out-of-class time whereas during class time, the activation phase, the application phase, and the integration phase were applied, see figure 2.

2.5.1. Out-of-class phases

Activation Phase. Learning at this phase was promoted when students' current knowledge is activated as a "foundation for the new knowledge" (Merrill, 2002). The teacher sent material for students to work on at home via an online application. For this study, the lesson was delivered to students through a video. The activation phase was attained through this video, which contained recall of relevant concepts or knowledge previously learned by asking questions (embedded questions) and revealing the correct answer. This phase was essential for the new objective to be delivered.

Demonstration Phase. The video sent by the teacher to students first recalled concepts previously learned by students. Then, the demonstration phase took place by revealing the new targeted objective to students within the same video. Through it, the teacher asked students to perform suitable procedures, in this case, hands-on activities, to demonstrate the new knowledge. It is important to mention that the teacher was not present and the instructions were embedded within the video where students were able to pause the video at any time or play it back continuously as to learn at their own pace.

Application Phase. As mentioned previously, the video sent by the teacher to students first held the activation phase then the demonstration phase. The video's third objective was to showcase the application phase where it continued to embed an exercise for application to assess students understanding. In other words, students' learning was promoted when new-targeted objective was applied by the students. Thus, the video asked students to apply the taught concept by solving some online simple exercises. The teacher was still absent through the process yet was able to check students' answers and responses, before coming to class to analyze whether they learned the new objective as planned or no.

2.5.2. *In-class phases*

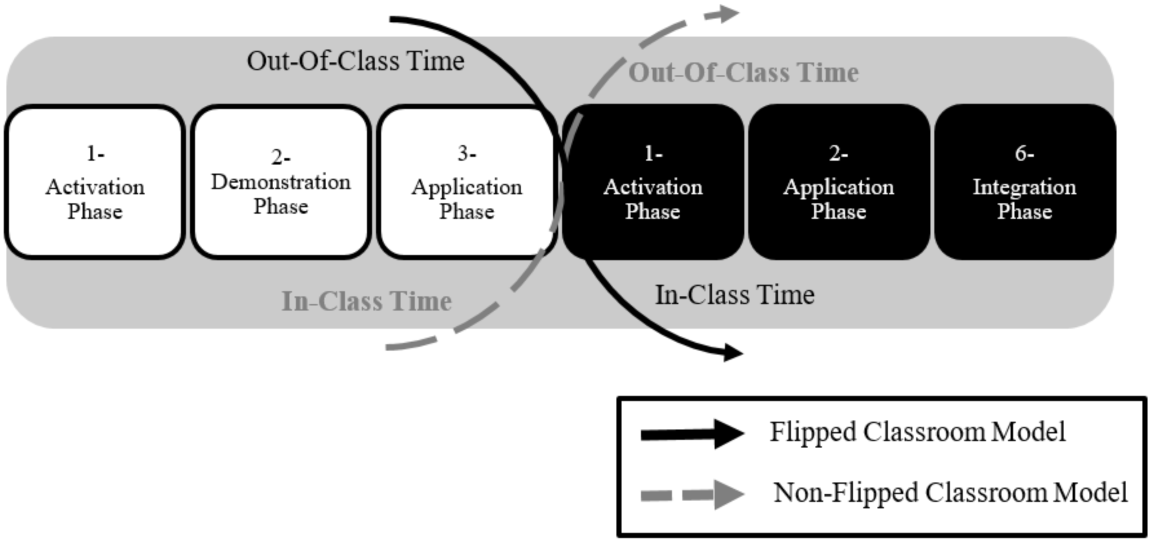
Activation Phase: After completing tasks prior class time and during class time, the teacher reviewed the topic covered in the video to clarify any misunderstandings. In other words, students summed up what they have learned at home as the teacher went over the new objectives covered in the video and gave feedback to students' responses. This was when the activation phases is repeated but covering the new objectives.

Application Phase: After revising the new objectives, the time for application was also repeated. Students worked individually, in pairs or in groups to apply the concept taught by solving simple and direct tasks under the teacher's supervision. The teacher provided students with direct and constructive feedback as they applied the concept taught. This was essential for the teacher to make sure whether students acquired the new objectives.

Integration Phase: Finally, after making sure that all students acquired the new objectives, students continued to apply what they have learned, yet in more high level thinking problems that included analyzing, evaluating, or creating. Sitting in pairs or in groups under the supervision of the teacher, students were given exercises where they shared ideas and went into discussions that could deepen their understanding and helped in integrating their knowledge into more advanced cases.

2.6. The adopted definition and the implementation of the non-flipped classroom

Figure 1 The Adopted Flipped and Non-Flipped Classroom design



The adopted non-flipped classroom model is a teaching setting. It includes the integration of concept delivery in class and exercise completion at home. Like the flipped classroom model, the adopted non-flipped classroom model was designed based on the four phases developed by Merrill (2002): (1) activation phase, (2) demonstration phase, (3) application phase, and (4) integration phase.

In the non-flipped classroom, *activation phase, demonstration phase, and application phase* were applied during class time whereas during out-of-class time, the *activation phase, the application phase, and the integration* phase were applied, see figure 2.1.

2.6.1. In-Class Phases

Activation phase. Class time was divided into three main parts. First, the teacher started the session by asking questions similar to those asked during the activation phase in the flipped classroom model. The purpose of these questions was to help students recall relevant concepts or previously learned knowledge essential for the new concept to be taught. Such a discussion covered the activation phase.

Demonstration phase. The first part of the session focused on the activation phase. Then, the demonstration phase took place by revealing the new targeted objective to students. Students worked in groups and cooperated under the instructor's supervision. They applied hands-on activities, similar to the ones in the demonstration phase in the flipped classroom model to discover the new concept as the teacher supervised and promoted students with feedback when needed.

Application phase. As mentioned before, the first two phases of the session focused on activation and demonstration. The session's last phase focused on the application phase. Students worked individually on applying the concept taught by solving an exercise to assess their understanding. Meanwhile, the teacher passed by each student to check their work and to assess their understanding. In case students were not able to apply the concept, the teacher either (1) assigned a friend to cooperate with these students and help them or (2) helped the students by explaining again the targeted concept. Finally, the teacher assigned a homework for students to complete at home. The homework was composed of two main objectives: (1) to study notes and (2) to solve two exercises. These exercises are the same as the ones completed by students in the flipped classroom during class time.

2.6.2. Out-of-Class Phases

Activation phase. After completing tasks in class, as mentioned before, students were assigned a homework. First, students studied notes already found in their books. In other words, students, on their own, summed up what they have learned in class. This is when activation phase is repeated but covering the new objective.

Application phase. After studying notes, students worked individually to complete the second objective of the assigned homework. Students applied the concept taught by solving the first exercise. It is important to mention that the first assigned exercise is composed of a simple and a direct task.

Integration phase. Finally, students continued to apply the concept taught. They applied it by solving the second exercise, which required more analysis. Not to forget, the teacher is not present during the application phase and the integration phase.

As noticed, there are differences in the sequence of phases between the implemented flipped classroom and the non-flipped classroom, see figure 2.1, and to technology use; however the teaching and learning practices (instruction) in each phase of the two classrooms flipped and non-flipped are similar / identical. Add to it, the exercises assigned as homework in the non-flipped classroom model are the same exercises assigned as classwork in the flipped classroom model and vice-versa. An example corresponding to the suggested models is illustrated in chapter 3.

2.7. Bloom's taxonomy and the adopted flipped classroom model

In this study, the adopted flipped classroom model is based on delivering factual, conceptual, and procedural knowledge at home (independent study via technology), and conceptual and procedural knowledge in class through peer to peer and students to instructor interaction.

At home, the implemented flipped classroom focused on Blooms' lowest levels of the cognitive dimension (Remembering, understanding, and applying). Students were asked to watch a video at home. The video included three main parts: recall of basic knowledge (activation phase), hands-on-activity to construct the targeted concept (demonstration phase), and a direct application (application phase). While in class, Blooms' higher levels of the cognitive dimension are targeted (analysing, evaluating, and creating). In class, students cooperated and worked together in applying the knowledge received under the teacher's guidance. Students assessed each other, shared knowledge and evaluated their work.

Linking the revised version of Bloom's Taxonomy with flipped learning, we find a correlation. Learning (remembering and understanding) is processed outside the classroom independently, while working on higher levels of the cognitive dimension (applying and analyzing) happened during class time under the supervision of the teacher. In other words, one of the advantages of flipped learning is that students are actively assisted in class during exercises that demand higher order cognitive levels.

Add to it, Bloom's Taxonomy assessed how well students have understood the material (remember and understand), how well students can apply the concept taught (apply), and how well can students distinguish between concepts (analyse). At the end of the study, students were assessed in the math achievement test (MAT) according to Bloom's Taxonomy levels to see how effective the flipped classroom model is on students' achievement and performance.

CHAPTER 3

METHODOLOGY

This study is conducted to investigate the effect of the flipped classroom model on eighth grade students' achievement in mathematics, the midpoint theorem lesson. It also discovers students' and the teacher's benefits gained and challenges faced in the implemented flipped classroom. This chapter gives a summary of the research methods that were used in this study. It delivers information on the design of the research, the school context, the participants, the instructional material, the design of the flipped and the non-flipped classrooms, data collection tools, validity and reliability of tools, and data collection and analysis procedure.

3.1. Research Design

This study applied a mixed-method research design; it utilized both quantitative and qualitative designs to provide a better understanding of the research problem. The quantitative research design helped us investigate the effect of the flipped classroom model on students' performance in midpoint theorem. The qualitative design helped us discover the benefits gained and challenges faced, of a phenomena, the flipped classroom model by the students and the teacher (Gall, Gall, & Borg, 2010).

The quasi-experimental design was applied. This type of experiment is usually used to assess the benefits of a specific intervention where the participants chosen for the experiment were not decided randomly. This was the case for this study, students were divided into two sections according to the schools' regulations. One section was chosen to be the control group (non-flipped classroom) and the other to be the experimental group (flipped classroom). The independent variable in this study was the classroom setting (flipped and non-flipped classroom), while the dependent variables were students' performance, benefits gained, and challenges faced. The moderators were the teacher, the lesson implemented, and the participating students' achievement level.

The independent variable varied in the setting by which students receive the knowledge and apply their knowledge. The flipped classroom was receiving knowledge at home and applying knowledge in class. Whereas the non-flipped classroom occupied receiving knowledge in class and applying knowledge at home. The dependent variables were students' performance, the challenges faced and benefits gained by both students and the teacher in the flipped classroom. Students' performance was measured by the math achievement post-test. While the challenges faced and the benefits gained were collected through semi-structured interviews conducted with the teacher and each participating student in the flipped classroom. The moderators were the teacher, the lesson implemented, and the participating students' performance level. The teacher giving the lesson was the same in both sections. The implemented lesson was also the same in both sections, but the lesson plan was flipped according to the setting. In other words, the instructional strategies used to deliver each learning outcome was the same in both classes but flipped. Moreover, the performance level of students was measured by the math achievement pre-test. The pre-test categorized students into low and high achievers.

3.2. School context

The study took place in a private school in Beirut, Lebanon. The school is an independent educational institute that serves students from Kindergarten to Grade 12. The school has been operating in Beirut since 1980, and another branch was opened in Mount Lebanon in 2000. It serves around nine hundred students, most students are middle class and Lebanese. The school adopts a mixed-gender classes in kindergarten and the elementary level, but are all-girls classes in the middle and secondary levels. It follows the official Lebanese curriculum. Moreover, the school strives to remain up to date with the latest technologies that will enhance the teaching and learning process. This school was chosen for convenience of the researcher since it was the school that she was teaching in.

3.3. Participants

The participants for this study were grade eight female students who were enrolled in the school described above for the academic year 2019-2020. A total of twenty six grade eight female students, 12-14 years old, and a middle school math teacher participated in the study. Students were already divided into two sections according to the school's policy which takes into consideration the students' performance level. The first section contained twelve students and was assigned as the experimental group where they experienced the flipped classroom model. The other section, contained fourteen students and was assigned as the control group, where students experienced non-flipped classroom model during their mathematics classes. The study was applied to both sections on the same geometry unit (midpoint theorem in a triangle).

3.4. Instructional Material

The unit taught in this study was the midpoint theorem in a triangle from the Lebanese curriculum of grade eight. The unit of midpoint theorem in a triangle comprises of four lessons given over a period of four sessions. The lessons covered are: (1) Introduction to Midpoint Theorem in a Triangle, (2) Midpoint Theorem in a Triangle Application, (3) Introduction to Converse of Midpoint Theorem in a Triangle, (4) Midpoint Theorem in a Triangle and its converse.

This unit required students to have prerequisite knowledge and skill on proving a trapezoid and special parallelograms. At the end of the unit, students will be able to: (1) state the midpoint theorem in a triangle, (2) prove the midpoint theorem in a triangle, (3) apply the midpoint theorem in a triangle, (4) state the converse of midpoint theorem in a triangle, (5) prove the converse of midpoint theorem in a triangle, (6) apply the converse of midpoint theorem in a triangle, and (7) differentiate between the midpoint theorem in a triangle and its converse. In both experimental and control groups, the lesson covers the first two learning objectives, the second lesson covers the third learning objective, the third lesson covers the fourth, fifth, and the sixth learning objective, and the fourth lesson covers the seventh learning objective.

The unit of the midpoint theorem for this study was designed and prepared by the researcher, and it was reviewed by a grade eight math teacher and the math coordinator. Students in the experimental group section were introduced to the unit of midpoint theorem using the flipped classroom model, while students in the control group were introduced to the unit through a non-flipped classroom model. The two sections below described the lesson design used in each group.

3.5. Flipped Classroom Design

The designed unit for the experimental group was guided by the flipped classroom framework adopted in this study. Both the flipped and the non-flipped designs were based on Merrill's (2002) "First Principles of Instruction" design theory. The researcher prepared the lesson plans for this experiment (Appendix 2), the lessons constituted of two parts, the first part is related to the activities carried out during instruction at home, and the second part is related to the activities carried out during class time. At home the activation phase, demonstration phase, and application phase were implemented. Whereas during class time, the activation phase, the application phase, and the integration phase were implemented.

For home instruction, the researcher prepared short videos where the teacher explained the lesson. Since videos shorter than six minutes were found to be more engaging to students (Guo et al., 2014), the videos designed in the study did not exceed six minutes. The videos included three main phases; the first phase consisted of recall of relevant concepts or knowledge previously learned (activation phase). For example, in lesson three, students at the beginning of the video, recall what does the midpoint theorem in a triangle states. The second phase of the video included hands on activity for building knowledge in order to demonstrate the new knowledge (demonstration phase). Like when students in lesson three follow certain instructions to discover the converse of midpoint theorem in a triangle. The third part included exercises for application to assess students' understanding (application phase). Students applied the concept and checked whether they got it right or not. As participating students watch the video, it pauses and posts embedded questions that are either a multiple choice question or an open-ended question to track students' attention and keep them on track. The video does not continue playing unless the student answers the question and is opening the page to follow up. This allowed the teacher to follow up on students' progress and their work at home, whether they are concentrating, got the concept, still having difficulty, etc. It even helped students discover whether they got the idea or not.

To implement these activities there was a technical integration between Edpuzzle and Google Classroom, where the instructor created videos through Edpuzzle and sent them to students via Google Classroom. Participating students accessed math instructions at home via an online application called "EDpuzzle". EDpuzzle is an online tool that allows instructors to upload new videos or edit already existing videos which included open-ended or multiple-choice assessment questions. It is a cost free application that works on both iOS and android software allowing instructors to embed videos within other applications such as Google Classroom and many more (Baker, 2016). The instructors can track participating students' progress and the videos' number of views. In the study, participating students also used Google Classroom, which was already used in the school. Google Classroom, a free web service designed for both teachers and students for educational purposes. It allows teachers to create an online classroom, post assignments, and announcements, evaluate students' work after being submitted online and communicate with students outside class time. Google Classroom can be accessed through internet browsers or a mobile application. It requires students to have a Google account where they can sign in and access the videos posted by the instructor.

During class time, the instructor first reviewed the topic covered in the video to clarify any misunderstandings (activation phase). For example, the session started with the teacher asking students about the converse of midpoint theorem in a triangle and when and why is it applied. Thus, making the concept clearer to students. Then, students worked in pairs or in groups to apply the concept taught in solving simple and direct tasks under the instructor's supervision (application phase). Students were assigned to work in pairs to share ideas and solve an exercise that includes a direct application on the converse of midpoint theorem in a triangle, while the teacher passes by and follow up students' discussion and work. Finally, after making sure that all students were able to apply the theorem, students were given more complex and advanced exercises (integration phase). Students worked in groups or in pairs to share ideas and go into discussions that could deepen their understanding and help in integrating their knowledge into more advanced problems. The problem required students to apply higher order thinking levels by which they should apply the concept as they try to solve the exercise.

3.6. Non-Flipped Classroom Design

Like the flipped classroom design, the non-flipped design was also based on Merrill's (2002) "First Principles of Instruction" design theory. The non-flipped classroom model was implemented in the control group. The researcher prepared the lesson plans (Appendix 3). The lessons were also constituted of two parts, one related to activities carried out during class time and the other related to activities carried out at home.

During class time, the activation phase, demonstration phase, and application phase were applied. First, through questioning, students recalled the relevant concepts essential for the new idea being delivered (activation phase). For example, during the third session, the teacher asked the students to state the midpoint theorem in a triangle and to give an example and state when it is applied. Then, students worked in groups and cooperated under the instructor's supervision. They applied hands-on activities for a discovery learning process (demonstration phase). During the session, students followed instructions assigned to discover the converse of the midpoint theorem. Last, students solved an exercise to assess their understanding (application phase). For example, a direct application was assigned for students to solve as the teacher pass by each and make sure they were able to apply the theorem properly. Add to it, students were given a set of exercises to solve at home applying the knowledge acquired.

On the other hand, at home, the activation phase, the application phase, and the integration phase were adopted. Students were assigned to study notes already found in their books (activation phase), then work on their assigned homework (application phase and integration phase). Note that the exercises assigned and the activities prepared are all common between the two classes. Even the questions that are asked by the teacher during class time are the same as those embedded within the video lesson in the flipped classroom. The only difference was that in the non-flipped classroom the factual knowledge was delivered by the instructor and not through a video. Note that every task included in the video was implemented by the teacher during class time in the control group. The only difference was that students cooperated as they followed instructions instead of working individually.

3.7. Data Collection Tools

Data for this study was collected through two tools: Two Mathematics Achievement Tests (MAT),a pre-test and a post-test, and two semi-structured interviews.

3.7.1. Math Achievement Test (MAT)

The MAT was used to measure participating students’ performance on the unit explained. Its purpose was to evaluate participants’ understanding, application, and analysis of the targeted objectives in the lesson taught. A forty-five minutes pre-test and a forty-five minutes post-test were conducted with a week in between as a time framework. The pre-test (Appendix 4) assessed participating students’ prior knowledge on parallel lines and quadrilaterals (parallelogram family and trapezoid), geometry lessons taken at the beginning of the year. It allowed the researcher to identify participating students’ levels of achievement in geometry (low achievers or high achievers). Participants in the lower half were considered low achievers and those in the second half as the high achievers. The pre-test was applied for both groups before covering the objectives of the geometry lesson, midpoint theorem in a triangle. Before the pre-test, students had a forty-five minutes session by which the instructor recalled concepts already taught at the beginning of the year in geometry.

On the other hand, the post-test assessed both groups participating students’ performance in the unit taught after the intervention (Appendix 5). It assessed participating students’ understanding, application, and analysis of the targeted objectives. All tests were written by the researcher according to the learning objectives taught to students within each lesson, and according to bloom’s taxonomy levels of knowledge and thinking. Then, they were revised by both the math teacher and coordinator of the school at the middle school level. This offered equal opportunities for low and high achievers to be justly assessed.

In short, there were two achievement tests: a pre-test and a post-test tackling geometry. Participating students were given forty-five minutes to complete each test. The tests were assigned directly after they were exposed to the planned sessions.

3.7.2. Semi structured interview

A semi structured interview was conducted individually with each participating student in the flipped classroom. It was held with the students without the presence of any of their colleagues, math teacher, or researcher. The interviews were conducted during school time in the IT office. It was audiotaped and lasted for twenty to twenty five minutes with each student. The purpose of these interview questions (Appendix 6) was to discover students' challenges faced and benefits gained during the flipped classroom model with a main focus on the home and the class environments. This helped us to answer the second research question.

Additionally, a second semi-structured interview was set with the teacher who participated in the study (Appendix 7). Only the researcher held the interview with the teacher without the interference of the math coordinator or school principal. It was audiotaped and lasted for approximately thirty minutes. The purpose of the interview questions was to obtain insight into the teacher’s point of view towards the benefits gained and challenges faced during the implemented flipped classroom model. This helped us to answer the third research question.

3.8. Validity and Reliability

*Math Achievement Test***.** The researcher clarified the purpose of the research study and its instruments used to the math teacher and the coordinator. Then, they went over the MAT items and provided their comments on the planned MAT written by the researcher. They had a positive degree of agreement of 90% for the items of the pre-test and a positive degree of agreement of 94% for the items of the post-test. This established the content validity of the test. Besides, to check internal reliability of the MAT, the Cronbach alpha was used. For the pre-test, the Cronbach alpha was acceptable (α= .755), and for the post-test the Cronbach alpha was also acceptable (α=0.7).

Semi-structured Interview. Since the researcher was a teacher in the school and to ensure objectivity of answers, the interview was done by an outside researcher. The latter visited the school to consent and interview participants. Then, the outside researcher interviewed participants who voluntarily agreed to reflect their experience in the flipped classroom. It is worth mentioning that the interviews were held with the participating students without the presence of any of their colleagues, the math teacher, nor the researcher to make sure that they are comfortable and frank while answering the interviewer.

To establish credibility, the member checking method was employed. “Member checking may be conducted at the end of an interview by summarizing the data and allowing the respondent to immediately correct errors of fact or challenge interpretations” (Erlandson, Harris, Skipper, & Allen, 1993). In other words, the outside researcher repeated the notes she has written to the participating students while the latter was asked to correct any misunderstanding or wrong interpretation. Similar method was done with the teacher. Finally, the outside researcher along with the researcher went over all interview answers to make sure they were in agreement and consistent. Add to it, to confirm the accuracy of the findings and ensure reliability, an inquiry audit is conducted. It involves having an outside researcher examine the process of data collection and analysis by which the researcher kept track of all steps taken throughout the study (Cohen & Crabtree, 2006).

Classroom Observation. To make sure that the implementation of the models was following the plan put by the researcher, the researcher observed the classroom setting in both groups, experimental and control groups. The researcher used classroom observation to detect how the teacher gave the session. In specific, the classroom observation gave evidence to the researcher that the teacher followed the plan assigned during class time. This helped in reducing errors that might be done during class time to ensure credibility. In addition to the consistent observation, the researcher met with the teacher after each session to give and take feedback on the plan in hand.

3.9. Data Collection Procedure

Students participating in the study took the MAT before and after the lesson is explained. Before implementing the geometry lesson “midpoint theorem in a triangle”, participating students completed the forty-five minutes pre-test in geometry (Appendix 4) which was written according to the school’s policy. After the MAT (pre-test) is collected, both the researcher and the math teacher scored the pre-test in a period of two days to help in identifying the participating students’ achievement levels in geometry and to achieve internal validity. Then, within a period of a week, participants underwent a total of four sessions, forty five minutes each, by which the lesson plans were constructed according to Merrill's phases, schools' regulations, and calendar. Both groups, took the same lesson plan but through flipped instructions. The control group followed the non-flipped classroom model while the experimental group followed the flipped classroom model. Although both groups were covering the same learning objectives, and following the same instructional strategies, the instructional strategies flip (Table 3). Unlike the flipped classroom, in the non-flipped classroom, students were required to reach the desired learning objectives during class time. In both models, the instructional strategies used were: (1) *recall concepts, (2) building knowledge, (3) group interaction, (4) questioning, and (5) application. Recall concepts* is when the teacher triggers previous knowledge essential for students to apply the targeted concept. When students follow instructions to learn the new targeted concept, it is said that students are *building knowledge.* When students interact, discuss and reflect on their work while the teacher supervises and provides students with feedback, *group interaction* happens. *Questioning* occurs when the teacher asks students about the concept taught. At last, *application* takes place when students apply the concept taught.

Table 3 Applied Instructional Methods in Experimental Group (Flipped Classroom) versus Control Group (Non-Flipped Classroom) at home and in class

	Lesson	**Setting**	**Instructional strategies**	**Recall concepts**	**Building knowledge**	**Group Interaction**	**Questioning**	**Application**
Geometr	**1**	**Home**	**NF**	✓				✓
			F		✓			✓

	Class	**NF**		✓	✓		✓
		F	✓		✓	✓	✓
2	**Home**	**NF**	✓				✓
		F	✓			✓	✓
	Class	**NF**	✓		✓	✓	✓
		F	✓		✓	✓	✓
3	**Home**	**NF**	✓				✓
		F	✓	✓			✓
	Class	**NF**	✓	✓	✓		✓
		F	✓		✓	✓	✓
4	**Home**	**NF**	✓				✓
		F	✓			✓	✓
	Class	**NF**	✓		✓	✓	✓
		F	✓		✓		✓

At the end of the lesson, in both groups, students completed a forty-five minutes achievement test on the lesson (Appendix 5) that allowed the researcher to study students’ performance and to compare which group performed better.

After seven to ten days of the study implementation, twelve participants participated in an approximately twenty-minute interview during school time. The interview was held with the participating students without the presence of any of their colleagues, math teacher, or researcher. Later, after transcribing the interviews, participants were asked to give further clarifications of their answers. Due to the pandemic faced, participants were contacted through Google Classroom. Participating students were allowed to answer in open text format by which their answers are based on their feelings and knowledge.

Likewise, after two weeks of the study implementation, a thirty minutes semi-structured interview was conducted with the math teacher. Like participating students’ interview, the teacher’s interview focused on discovering the benefits gained and the challenges faced in the flipped classroom during class time. Only the researcher held the interview with the teacher without the interference of the math coordinator or school principal. All interviews were audio-recorded and transcribed for analysis.

3.10. Data Analysis Procedure

After the tests were scored and after conducting all interviews and transcribing them, the researcher started with the analysis of the collected data to answer the research questions. Data from the MAT were analysed quantitatively and data from the interviews were analysed qualitatively. In the sections below we describe the analysis procedure that took place.

3.10.1. Quantitative data analysis procedure

Prior to data analysis, the MAT of both groups were scored by the researcher and the math teacher then reviewed by the math coordinator. They followed the rubric (Appendix 8) that was developed by the researcher and supervised by the math coordinator earlier. Then, a comparison of the scoring of the researcher and the math teacher was conducted to establish validity. There was 90% degree of agreement between the scoring of the researcher and that of the math teacher. However, in case of disagreement, the researcher and the math teacher met to discuss and solve any existing conflict to reach an agreement. After that, the median that divides the score curve in the middle was calculated and the participating students were identified as high or low achievers based on their scores. Since the median judges the class performance (Pogge, 2005), participants who scored above or equal to the median were identified as high achievers and those who scored below the median were identified as low achievers. None scored equal to the median.

To answer the first research question "Is there a significant difference between students' performance level within the flipped and the non-flipped classroom?" the Mann-Whitney U-test was employed at 0.05 level of significance. The Mann-Whitney U-test was chosen because the data was not normally distributed and the sample size was not large enough.

3.10.2. Qualitative data analysis procedure

To answer the second and the third research questions and to discover the benefits gained and the challenges faced by the participating students and teacher during the flipped classroom model, the audiotaped interviews were transcribed by the researcher. The researcher analysed students' and teacher's interviews using the constant comparative method (Corbin & Strauss, 2008) to unfold the benefits gained and the challenges faced at home and in class during the flipped classroom model. To build categories, open and analytical coding were employed. As the researcher highlighted the data, notes were taken (open coding). Later theses open codes were collected and placed under themes which could be modified later (analytical coding).

The analysis of students' interview was done on high achievers versus low achievers in the same manner. They were coded for the benefits gained by students (at home and in class) and for the challenges faced by students (at home and in class). Similarly, the teacher's interview was coded for the benefits gained by the teacher and for the challenges faced by the teacher during class time. The coding process started from existing themes in the literature (Tables 4 and 5) and then the researcher added additional themes that emerged from the analysis of the data collected.

Table 4 Existing benefits gained and challenges faced by participating students in the flipped classroom model in the literature

Main themes	Existing Categories	Description
Benefits gained at home	Flexible Environment	Allows students to choose when and where they learn and instructors to be adaptable to students' learning (Muir & Geiger, 2016)
Challenges faced at home	Lebanese infrastructure	People living in Lebanon have been suffering from electrical outages since 1975. Ranking 161 in the world, Lebanon's internet speed is disastrous in comparison to other countries' speed ("Lebanon's Mobile and Broadband Internet Speeds - Speedtest Global Index", 2019).
	Tensed and uncertainty	Students found the flipped classroom model intense and hard to cope with (Ford, 2015).
Benefits gained in class	Increased class time	This model is developed educationally to produce the most efficient time for class activities (Ma et al, 2018).
	Improved communication	Students viewed their increased student-to-student and student-to-instructor communication as a positive contribution to their experience (Clark, 2015).

Table 5 Existing benefits gained and challenges faced by participating teacher in the flipped classroom model in the literature

Main themes	Existing Categories	Description
Benefits gained	• Improved communication	A positive increase in students' communication and engagement during class time (Clarks, 2015).
	• Personalized Instructions	Allowed instructor to personalize instruction, connect more to the students who struggle academically, and manage class time more efficiently (Vaezi, Afghari, & Lotfi, 2019).
Challenges faced	• Overwhelming	The extra burden of integrating teaching content with an extracurricular one (Zhou, 2014).

Coding for the benefits gained by the students. Students' interviews were analysed to extract themes/categories for the benefits gained in the flipped classroom model by the students. The literature review showed that the benefits gained for students could be divided to benefits at home and benefits in class. Data from students' interview question II were used to extract the benefits gained for students at home, while data from students' interview question III were used to extract the benefits gained in class. The researcher read the data and underlined the statements were the students expressed a positive experience, feeling, or response. For example, when a student says "I enjoyed the flipped classroom", this was considered as a benefit gained because it describes a feeling. Similarly, when a student says "I felt more confident in learning", this was considered as a benefit because it describes a positive experience.

After that, the researcher collected the responses that described that same benefit together and a title was given to the benefit category. For example, several students said that they were able to access the explanation when it suits them best, these statements were considered under the category *flexible environment*.

Coding for the challenges faced by the students. Students' interviews were also analysed to extract themes/categories for the challenges faced during the flipped classroom model for the students. The literature review showed that students faced challenges while at home and during class time. Data from students' interview question II were used to extract the challenges faced by students at home, while data from students' interview question III were used to extract the challenges faced by students during class time. The researcher read the data and underlined the statements were the students expressed a negative experience, feeling, or response. For example, when a student says "this was too much to handle", this was considered as a challenge because it describes a negative feeling. Similarly, when a student said "I had a problem with the internet at home", this was considered as a challenge because it describes a problem faced.

After that, the researcher collected the responses that described that same challenges together and a title was given to the challenge category. For example, several students expressed their worry studying at home without having a teacher around to guide them, these statements were considered under the category *teacher's absence*.

Coding for benefits gained by the teacher. The teacher's interview was also analysed to extract themes/categories for the benefits gained from the flipped classroom model for the teacher. In the study, the teacher had to implement the lesson plans without planning. Thus, the benefits collected were related to those gained during class time only. Data from the teacher's interview questions were used to extract the benefits gained by the teacher during Merrill's phases, activation phase, application phase, and demonstration phase. The researcher read the data and underlined the statements were the teacher expressed a positive experience, feeling, or response. For example, when the teacher says "I was relaxed and happy too", this was considered as a benefit gained because it describes a positive feeling. Similarly, when the teacher said "… another benefit, that the student has a direct contact with the teacher in class. When they finish they can directly check their work", this was considered as a benefit because the teacher mentioned that it was a benefit.

After that, the researcher collected the responses that described that same benefit together and a title was given to the benefit category despite which phase it described. For example, the teacher mentioned that she was able to focus on students' work individually and connect more to those who struggle several times, these statements were considered under the category *personalized instructions*.

Coding for challenges faced by the teacher. The teacher's interview was also analysed to extract themes/categories for the challenges faced from the flipped classroom model for the teacher. In the study, the teacher had to implement the lesson plans without planning. Thus, the challenges collected were related to those faced during class time. Data from the teacher's interview questions were used to extract the challenges faced by the teacher during Merrill's phases, activation phase, application phase, and demonstration phase. The researcher read the data and underlined the statements were the teacher expressed a negative experience, feeling, or response. For example, when the teacher says "It was tiring. I had to move from one group to another and still remember where each group has reached and their discussion and answer their questions and give them feedback all at the same time", this was considered as a challenge faced because it describes a negative experience.

After that, the researcher collected the responses that described that same challenge together and a title was given to the challenge category despite which phase it described. For example, the teacher mentioned that she felt worn-out during class time several times, these statements were considered under the category *overwhelming*.

Interrater agreement. To ensure reliability and to make sure that categories generated were trustworthy, an independent researcher coded the data following the strategy of the researcher. The independent researcher coded four of the twelve student interviews and the teacher interview. First, the researcher met with the second coder and described the process of coding. Then, the second coder did the coding and met again with the researcher to discuss and compare the obtained results. When a disagreement existed, the researcher and the second coder discussed the obtained results until they reached an agreement. The results of the comparison showed that there was around 89.5% agreement between the coding of the researcher and the second coder for the student interviews and 97% agreement for the coding of the teacher's interview.

CHAPTER 4

RESULTS

This research aims to study the effectiveness of flipped classroom instructions on students' performance in midpoint theorem in a triangle and to examine the benefits gained and challenges faced by students and the teacher. This chapter reports the results of this study following the order of the research questions. The first part of this chapter reports the quantitative findings. The second part reports findings of the qualitative results.

Twenty-six grade eight students participated in this study, the participants were divided into two sections where the flipped design classroom was implemented in one (experimental group) and a non-flipped design classroom was implemented in the other (control group). All twelve participants of the experimental group attended all sessions. They were involved in a semi-structured interview and completed the pre and post-tests. All participants, except one (participant 12) did not participate in the pre-test due to absence.

4.1. Findings regarding research question 1

Comparing scores between students in the flipped and the non-flipped classroom. To answer the first research question, which aimed at investigating potential significant differences in the post-test scores between the two groups, we conducted a non-parametric Mann Whitney U Test (Table 6). Although when comparing means, the mean score of the flipped classroom participants (M= 7.88) was more than the mean score of the non-flipped classroom participants (M=7.34), yet the Mann-Whitney U test (U = 72.5, p =.553) showed no statistically significant difference existed between the two groups. It is important to note that the sample size is relatively small thus the quantitative findings are only indicators.

Table 6 Comparing the significance level of post-test items of the flipped versus non flipped classroom

Scores	Means		Mean Difference:	Man Whitney U score	*p* value
	flipped	non-flipped			
Post-test scores	7.88	7.34	.54	72.5	.553

To explore more the results of the post-test in the flipped classroom versus the non-flipped classroom, the post-test scores were differentiated according to Bloom's Taxonomy and then the non-parametric Mann Whitney U test was conducted on each level. The second analysis aimed to test for statistical significance of the effect of the flipped classroom on participants' performance level based on Bloom's Taxonomy. Running the test again on each level offered a deeper insight into the effect of the flipped classroom on the participants' performance based on Bloom's Taxonomy even though the sample size is relatively small and the quantitative findings are only indicators that need further research with a larger pool of students. Table 7 shows that the means for the post-test of the flipped classroom are higher than those of the post-test of the non-flipped classroom within all levels. Yet, only the Understanding level had a test significance of mean difference (MD) =3.21. Thus the Mann Whitney U test (U=54, p=0.024) showed a significant difference in the understanding level between the two groups. On the other hand, the means were almost the same within the Remembering, Applying, and Analysing levels showing no significant differences.

Table 7 Comparing the significance level of post-test items of the flipped versus non flipped classroom according to the levels of Bloom's Taxonomy

Bloom's Level	Means		Mean Difference:	Mann Whitney U scores	*p* value
	flipped	non-flipped			
Remembering	6.67	6.25	.42	78	.745
Understanding	10	6.79	3.21	54	.024
Applying	7.86	7.6	.26	81	.872
Analysing	7.92	7.43	.49	74.5	.623

The tests were conducted for the third time to test for statistical significance according to the participants' performance levels (high/low) between the flipped and non-flipped classes. For low achievers (Table 8), results show that low performers' mean scores on the post-test were higher in the flipped classroom within the Understanding and Analysing levels. In specific, the Mann Whitney U test showed a significant difference for low achievers (U=7.5, p.047) in the Understanding level, but no significant difference within the Remembering, Applying, and Analysing levels.

Table 8 Comparing the significance level of post-test items of flipped versus non flipped classroom of low achievers

Bloom's Level	Means		Mean Difference:	Mann Whitney U score	*p* value
	flipped	non-flipped			
Remembering	4.5	4.64	-.14	17	.934
Understanding	10	4.29	5.71	7.5	.047
Applying	7.71	6.63	1.08	14	.563
Analysing	6.7	6.79	-0.09	16.5	.87

Such a result was reflected in students' post-test. Item 2.1 targeted the Understanding level in Bloom's Taxonomy. It assesses students' ability to differentiate between either applying the midpoint theorem or its converse to find the measure of a segment and to show that the two given segments are parallel and then use the parallels to prove a trapezoid. In the flipped classroom, all low achievers were able to show their work step by step in a well-comprehended manner. They all applied the midpoint theorem. They proved the parallels by identifying the correct triangle and midpoints as follows:

> In triangle ABC; D midpoint of [AB] (given) and E midpoints of [AC] (given).
> Then (DE) is parallel to (BC) and DE=1/2BC = 6cm (by midpoint theorem).

Whereas, only three out of the seven low achievers in the non-flipped classroom (42.85%) were able to write a complete and well comprehended proof. The other two of the seven participants (28.56%) of the low achievers had a wrong answer. One of them applied the converse of the midpoint theorem to prove parallels which is impossible, and the other understood that she should apply the midpoint theorem but she applied it in the wrong triangle. Such mistakes show that students did not fully understand the aim of the theorems or because they had difficulty identifying the givens. The rest (28.56%) applied the correct theorem to prove parallels but did not prove the trapezoid. That made their answers incomplete and caused them to lose grades.

In conclusion, the analysis of students' answers align with the results obtained by the Mann Whitney U-test. Low achievers in the flipped classroom appear to understand and write a proof that flows logically using the correct mathematical terms and notations unlike those in the non-flipped classroom who had difficulty identifying in which triangle to apply the theorem or which theorem to use to prove parallels.

As for high achievers (Table 9), results show that the mean scores on the post-test were higher in the flipped classroom within the Remembering (MD= .36), Understanding (MD= .71), and Analysing (MD= .71) levels, but showing no significant difference at any level.

Table 9 Comparing the significance level of post-test items of flipped versus non flipped classroom of high achievers according to the levels of Bloom's Taxonomy

Bloom's Level	Means		Mean Difference:	Mann Whitney U scores	*p* value
	flipped	non-flipped			
Remembering	8.21	7.86	.36	22.5	.762
Understanding	10	9.29	.71	21	.317
Applying	7.96	8.57	-.61	21	.602

Analysing	8.79	8.07	.71	20	.560

In conclusion, the flipped classroom had no significant impact on students' remembering, applying, nor analysing level, whether students were high or low achievers. However, it has a significant impact on low achievers' understanding level over the non-flipped classroom in the midpoint theorem.

4.2. Findings regarding research question 2

The benefits gained and challenges faced by students who experienced the flipped classroom model

The purpose of the second research question was to investigate grade eight students' point of view on the benefits gained and challenges faced during the flipped classroom model. When participants were asked to provide description of their experience in the flipped classroom, the mentioned benefits gained and the challenges faced varied. However, according to their answers and the literature of the study themes emerged under the following categories: benefits gained at home, benefits gained in class, challenges faced at home, and challenges faced in class.

Benefits gained by students at home. Results show that the participating student found several benefits when studying at home during the flipped classroom design (Table 10). Results show that the participating students found that the flipped classroom helped them study at their own pace (58%), focus on explanation more at home (67%), study within a calm and comfortable environment (41.6%) and how supportive their parents were during the experiment (17%). They also mentioned that they benefited from being independent learners (50%) and mentioned that the content delivered was easy and clear (100%).

Table 10 Benefits gained at home by participating students in the flipped classroom model

Benefit Gained	High achievers %	Low achievers %	Total %
Flexible Environment	57.14%	42.86%	58%
Focus more	38.5%	62.5%	67%
Calm and Comfortable Environment	40%	60%	41.6%
Supportive Parents	100%	-	17%
Independent learners	66.66%	33.33%	50%
Easy and clear content	60%	40%	100%

Flexible environment. Results show that seven out of twelve participants (58%) indicated that the flipped classroom allowed them to study at their own pace. The environment at home allowed participants to access, pause, and repeat the lesson whenever and wherever it suits them best. Both high and low achievers described how the flipped classroom model allowed them to work at their own pace. Four participants were high achievers (57.14%) and three were low achievers (42.86%); they all claimed that the flipped classroom gave them the opportunity to repeat the content when needed and to have enough time for note-taking.

For example, participant 3, who is a high achiever, commented: “I am free to access the explanation at any time when I am in the mood to learn a new idea.” Also, during the interview, she added that she can “pause, play, or even repeat according to what suits me best.” Another high achiever (Participant 4) stated that she “liked the fact that you can eat and move from one place to another while learning a new idea.”

Similarly, when participating students were asked to describe how they spend their time at home completing the assigned task, participants 8 who is a high achiever answered: "I didn't feel restricted by time nor place." This suggests that the high achievers preferred the flipped classroom because it allowed them to move from place to place, eat while learning, and access the content sent when they are in the mood of learning. The results cast a new light on high achievers' ability to learn at their own pace or multi-function while studying. In other words, the flipped classroom allowed high achievers to study at their own pace feeling comfortable doing more than one task at a time.

Meanwhile, the low achievers described how the flipped classroom allowed them to work at their own pace as well, but they described it from a different point of views. These participants described that the flipped classroom allowed them to pause, repeat, and take notes without any restriction at home and without being judged. Participant 5 explained, "I have enough time to take notes". While, participant 2 added that she "worked while not being afraid to be judged by others." Whereas, participant 9 reported that she loved the idea of "studying at any time and any place". In other words, low achievers highlighted the fact that the flipped classroom gave them enough time to learn and to answer without being judged by others. Besides, since some low achievers spend more time learning a new idea, results demonstrated that the flipped classroom provided them with sufficient time to achieve the required outcome bearing in mind that they will not be judged at home.

The present findings show that the flipped classroom makes the content delivered at home accessible as stated by 50% of the participating students in this study and is repeated when needed as stated by 42% of the participating students. As a result, the flipped classroom offers students, whether high or low achievers, the opportunity to study at their own pace by choosing the place and the time that best suits their learning habits.

Focus more. Results also show that most of the participants found that the flipped classroom helped them to direct their thoughts and efforts towards the lesson being implemented at home. Eight out of twelve participants (67%) emphasized that since the environment at home is better they were able to focus more than usual. Five of them (62.5%) were low achievers (Participants 1, 2, 5, 9, and 12) and three of them (38.5%) were high achievers (Participants 3, 6, and 10). They all mentioned that the home environment helped them concentrate and work hard on the tasks assigned.

High achievers (e.g. participants 6 and 10) reported that they were able to focus more than before at home because distractions were less and they had the opportunity to repeat. For instance, participant 10 explained, “This was because in school we get distracted and lose attention.” Moreover, participant 3 clarified “since repetition was an option, I re-watched and focused on the concept that I missed”.

As for low-achievers, they claimed that they focused more at home because they were able to fully focus on the lesson explanation as much as needed without worrying about following up with the teacher and copying notes concurrently. For example, participant 5 claimed that “having the lesson explained at home gave me the opportunity to focus on understanding the notes rather than copying them before the session ends.” In addition, participants 1, 2, 9 and 12 reported that they should try their best to understand the lesson at home thus allowing them to focus more on the explanation.

Calm and Comfortable Environment. Results also found that five out of twelve participants (41.6%) %) in the flipped classroom pointed out that their environment at home somehow lacks public disturbance unlike when being at school. Three out of them were low achievers (60%) and the rest were high achievers (40%). They described having a calm environment that is unaffected by disturbance, less noisy and has fewer distractions.

The flipped classroom gave both high and low achievers the opportunity to learn a new idea, concentrate better, or focus on a new concept by being in control of the environment they are learning in. In other words, students get the opportunity to manage and set up the place they want to learn by making it quiet, calm, and less distractive. High achievers found that the environment at home is less noisy (participant 11) and less distractive (participant 3). Low achievers claimed that, at home, they were able to avoid the distractions they used to face in the classroom (participants 1 and 7) and to manage the noises around them (participant 5). Participant 5 explained: “At home, I can manage and control the noises around me. When something distracts me, I can close the door or change the room”. Both high and low achievers agreed that, at home, they were able to control the disturbance around them, thus allowing them to concentrate more. Both participants 1 and 11, the first being a low achiever and the latter a high achiever, stated while being interviewed that they were able to understand faster (participant 1) and concentrate more (participant 11). This was due to the calm environment the flipped classroom offered at home.

In addition, three high achievers described their experience as nice and comfortable. They focused on how the flipped classroom made their learning experience more comfortable. Being at home made receiving new ideas at their comfort zone that facilitated their understanding (participants 4, 8, and 12) and made them feel motivated to complete the task (participant 4). Also, participant 8 expressed: “I felt comfortable working and studying math.” while participant 12 asserted, “I found myself more comfortable with practicing math and understanding the material better, in general the whole experience was comfortable.”

Supportive Parents. The analysis of the data revealed that all participants mentioned that their parents did not interfere while studying during the experiment. Only two high achievers (17%) described how their parents provided them with encouragement and emotional support. They claimed that their parents encouraged the flipped classroom learning setting as a setting that helped their daughters keep their grades high and save time while learning. For example, while participant 11 was describing her experience during the flipped classroom, she stated that: “Since the flipped classroom kept my grades high, my parents who did not like me sitting on the computer were encouraging and fine with the process.” Participant 12 added, “Although my parents had no role through my learning experience, they expressed how they found it useful and time saver”. Few participants mentioned their parents' point of view during the interview. Yet, it is noticeable that only high achievers reflected on their parents' satisfaction towards the flipped classroom model and capability to keep their daughters' high scores.

Independent learner. The analysis also revealed that 50% of the participants noted that the flipped classroom model helped them become “more responsible” towards their learning. They described that they felt as independent who take responsibility of carrying their own learning, monitoring their progress, and assessing their outcome. The flipped classroom model allowed high achievers (66.6%) to be independent learners by dedicating enough time to learn on their own, feeling more responsible about their learning experience, and exerting more effort to avoid referring to the teacher. On the other hand, low achievers (33.33%) felt more responsible because they were afraid to stay behind.

High achievers found that the flipped classroom model gave them the opportunity to dedicate enough time to learn a new concept, to rely on themselves instead of fully depending on the teacher, and to exert more effort to track their understanding. Participant 8 noted,

> I learned to rely more on myself and my understanding and the teacher's explanation and to solve according to my understanding without the help of anyone. Basically, to rely more on myself to learn the lesson….It felt good, I grew confidence when I held the responsibility to rely on myself rather than on the teacher all the time. (P8)

On the other hand, low achievers formed one third (33%) of those who claimed that the flipped classroom model made them self-dependent. Participants 1 and 2 focused on being responsible of their own learning due to not being able to catch up during class time. Participant 1 elaborated "I felt I was more responsible of my learning, I had to focus more and not skip because I knew it will affect my learning in class. I won't be able to follow up". Similarly, participant 2 expressed that she felt more responsible to understand the concept at home knowing that the explanation will not be repeated, she said "I felt more responsible since I had to focus more and try my best to understand and learn on my own especially that the explanation will not be repeated".

Easy and clear content. Throughout the semi-structured interview, all participants mentioned at least one benefit gained in the content delivered at home. The content described the materials sent and the tasks assigned to participants to watch and to complete at home. Participants described the content delivered at home as “easy” (91.6%) and “clear” (41.6%).

Results show that the flipped classroom made the content easy to understand and to complete for both high and low achievers. This was because of the embedded questions, ability to repeat the explanation, and availability of content. Both high and low achievers benefited from the embedded questions that helped them understand better and focus more. High achievers added that the embedded questions helped them keep track of their understanding. Only high achievers found that repeating the video and replaying the content was of a great benefit to them. It allowed them to repeat without annoying others to clarify what they missed or misunderstood. Lastly, having the material in hand allowed both high and low achievers to take advantage to use and review and study for the exam. High achievers added that the availability of the content gave them the freedom to watch when in mood and helped in compensating their absence.

Mostly high achievers were the ones who described the content as "easy" and "clear." About 60% of the participants who described the content as "easy" and "clear" were high achievers. They claimed that the homework was easy to complete (participants 3 and 10) and described the lesson as easy to understand (participant 8). Few added that the lesson and the ideas learned were clear (Participants 6 and 11). In other words, as participant 3 stated, “I liked how easy, clear, direct, and simple I felt the information were in this method.”

Besides, high achievers discussed what made tasks easy to fulfil at home by describing three special features of the explanation sent: embedded questions, ability to repeat, and availability. Two participants (28.57%) gave credit to the questions embedded within the lesson. For example, participant 6 said: “questions were helpful to keep track of my understanding.” Participant 10 noted that “the questions at home helped me figure out if I understood the idea right or not.” The second feature highlighted by students was the ability to repeat the explanation several times. Five out of seven participants (71.42%) described the advantages of repeating the explanation. It allowed them to clarify what they missed or misunderstood without annoying their friends with the repetitions (participant 3, 4 and 12). Also, participants 10 and 11 agreed that it allowed them to repeat what they missed if any distraction by a family member happened. Also, having the videos (material) available for participants all the time was noted as a great advantage by participants 3, 6, 10, 11, and 12 (71.42%). Participant 3 commented: “The video was free to access whenever I am in the mood.” Participants mentioned that the explanation was accessible at any time, compensated for their absence (participant 6), and can be accessed for revision to help in studying for the exam (participants 3, 6, 10, 11, and 12).

On the other hand, low achievers formed only 36.36% of those who declared that the content delivered at home was "easy" and 40% of those who claimed that the content delivered at home was "clear." Like high achievers, participant 2 found that the homework was easy to complete. Also, participants 1, 2, and 9 found that the lesson was easy to understand and the content was clear. Similarly, low achievers mentioned that what made the content easy were the questions embedded (participant 9) and the availability of the content (participant 5). The questions helped participant 9 understand and focus more on the content explained. Participant 5 described the content as notes or as a digital notebook that she can access whenever she can for revision and studying.

Benefits gained by students in class. When participants were asked about their class environment, they described the time spent in class as "beneficial and effective" (53.3%) and indicated that there existed an improved class communication (83.3%). Also, 75% described how the time spent in class made them feel mathematically confident (Table 11).

Table 11 Benefits gained in class by participating students in the flipped classroom model

Benefit Gained	High achievers %	Low achievers %	Total %
Increased class time	57.14%	42.85%	58.3%
Improved Communication	60%	40%	83.3%
Mathematical confidence	55.55%	44.44%	75%

Increased class time. The analysis of the data revealed that the flipped classroom saved class time by making it more productive and efficient for class activities. Although the sessions' duration did not change, seven out of twelve participants (58.33%) declared that the flipped classroom model allowed them to complete more tasks in a more focused and useful way. In other words, class time was "beneficial and effective" to students. 57.14% of the participants were high achievers, and 42.85% were low achievers. They expressed how "beneficial" or "effective" class time was, and the reasons for that included coming ready to class and completing more tasks in a more focused way.

Both high and low achievers (Participants 3, 10, and 9) agreed that the flipped classroom model allowed them to come to class with basic knowledge of the lesson being covered. For example, participant 3, a high achiever, explicitly said: "We were almost all present in class with basic knowledge. When I went to class, I was ready to solve related exercises and to share information with my friends." Similarly, participant 9, a low achiever, reported: "Most of the time, I understood the lesson, at home, which helped me come to class ready to solve exercises."

The second reason was precisely described by participant 12, who mentioned that the opportunity to do more tasks and practice more became higher in class. Participants who saw it as an advantage to work more and to be more productive during the class time were distributed as such: 60% were high achievers, and 40% were low achievers. High achievers described the class setting as a setting that allows students to focus on solving more exercises under the teachers' supervision. For example, participant 12 commented: "The flipped classroom gave us more time to focus on solving and applying rather than wasting time in class on explanation." Also, participant 11 added that "the flipped classroom was effective during class time, we were able to understand the lesson, solve exercises, and ask the teacher in class." On the other hand, low achievers found that the time in the class passed fast because it was filled with work. Participant 2 explained "In class, I felt that the time was beneficial and filled with work. We did more things in class than usual, yet time in the class passed fast. We spent less time repeating the explanation and wasting time".

In brief, both high and low achievers benefited from the flipped classroom during class time. They both proclaimed that it helped them come ready to class with basic knowledge, solve more exercises with their classmates under the teacher's supervision, and avoid wasting time on repeating ideas.

Improved communication. The class interaction includes two kinds of interactions, the student-student interaction and the teacher-student interaction. The first describes the interaction between peers in the classroom. It addresses the theme of how did the flipped classroom affects students' communication with each other during class time. The latter describes the interaction between the teacher and the students during class time. It describes the effect of the flipped classroom on how the teacher and the students communicate and interact during class time. The flipped classroom increased such communication and added a positive contribution to students’ experience (Clark, 2015). Ten out of twelve participants (83.3%) commented positively on their classroom interaction during the study by which 60% were high achievers and 40% were low achievers.

Student-student interaction. The implemented flipped classroom made participants’ interaction between each other different. Nine out of ten participants (90%) mentioned the benefits they gained while communicating with their classmates. Five out of the nine participants (55.5%) were high achievers. During class time, high achievers interjected and completed one another's thoughts on the lesson and the work assigned. They focused on sharing ideas and content. They were able to communicate well and to help each other complete the exercises assigned. Participant 10 elaborated “The flipped classroom made me feel at ease and more confident when solving exercises and when sharing lesson notes with my classmates”. For example, when participants were asked to describe their point of view during class time, participant 3 commented as follows: “When participating in class, it felt easy to complete each other's ideas.” While participant 8 commented: “We worked together to correct each other's work.” Add to it, participant 11 found coming to class with basic knowledge helped her understand how her friends were thinking. As a result, this made her participate more and share her thoughts during class time.

On the other hand, low achievers formed 44.44% of those who found that student-student interaction was a benefit gained. When interacting together, participants recalled what they learned at home alone. This in return, helped them understand what they have missed. For instance, participant 2 stated: “As I worked with my friends, we recalled what we learned at home.” It was smooth and enjoyable, participants 1 and 9 reflected.

Teacher-Student Interaction. All ten participants described the teacher’s role during class time. Six out of the ten participants (60%) were high achievers. They claimed that the flipped classroom changed the teacher’s role in class. She became a guide and a reference to refer to while solving exercises. Unlike the usual classroom were the teacher used to control the setting and to give very limited time for questions. Participant 12 found that the flipped classroom made her communication with the teacher easier than before and helped her ask the teacher freely whenever in need. That helped her make sure that she got the idea explained. Also, participant 3 supported the fact that the teacher is no more someone who tries to state facts and lead the way towards the conclusion but “a guide, who guided us through questioning that made us dig deeper into what we learned at home and see the big image of it.” The other 40% were low achievers. Like high achievers, they both agreed and reflected that the teacher’s availability while solving and applying the learned concept helped them a lot in understanding better and having fewer major mistakes while solving. They noticed that the teacher was available to answer any of their questions by recalling what they learned. For example, participant 2, a low achiever described the teacher’s role in class as a reference. Participant 2 said: “The teacher recalled what we learned and answered our questions when we needed her. She was like a reference to refer to when in need”.

All other participants (Low achievers 1, 2, 5, 9, and high achievers 3, 6, 8, 10, 11, 12) stated that the teacher was helpful as she answered their questions.

In summary, both high and low achievers benefited from the presence of the teacher during class time. They both considered it as a great benefit to have a teacher as a reference to ask and to refer to when in need. They both felt the need to have a teacher while solving exercises. She helped them deepen their understanding and strengthen their ability to apply the concept learned. Explicitly, high achievers described their relationship to be like that of a guide and his mentor. According to student, the flipped classroom made the teacher be someone who orients students' thinking rather than just explaining a new concept or delivering information.

Mathematical confidence. Results showed that the flipped classroom allowed students to show growth in thinking, a positive attitude towards mistakes, and self-reliance. Nine out of twelve participants (75%) claimed that the flipped classroom model made them grow confident about learning the midpoint theorem in a triangle. The flipped classroom boosted participants' confidence level in mathematics. They felt more confident about the lesson objectives. The flipped classroom model helped them explain to each other, answer accurately, and gain a deeper understanding of the midpoint theorem.

Five of them were high achievers (55.55%). They claimed that the flipped classroom helped them become more confident about the material they learned. This is because they were able to explain to their friends during the application phase, get correct answers on most questions asked during class time, share their thinking strategy with their friends, and obtain a direct feedback from the teacher. Participant 8 noted, Working with my friends made me grow confident in what I learned at home. It was like I know the idea and my friends and teacher supported this idea when thinking aloud. It was like repeating what is in my head out loud. Like a confirmation of what I know. Yes, confirmation. This made me feel happy and confident and proud and like wow the flipped classroom made the lesson easy to understand and stick in my head. Maybe I can describe myself now as more knowledgeable and confident in midpoint theorem. You can ask me and see yourself". (P8)

Participants 3, 10, and 11 described their confidence as the ability to understand the lesson in a deeper manner. For example, participant 11 declared that "The flipped classroom made me more confident of my understanding, I was able to dig deep into the ideas. For example, I noticed that whatever the teacher asks me I was able to answer correctly." Participants 3 and 10 found themselves able to answer their friends' questions and explain to their friends while solving in class. Participant 10 clarified "When I discussed what I learned and explained the idea in class, I found myself doing it with confidence and confident about my explanation".

On the other hand, low achievers formed 44.44% of those who felt mathematically confident. They claimed that the flipped classroom model boosted their confidence level by making them feel that the lesson is easy to understand and that they are able to explain the idea. Participant 1 claimed,

> Usually, I need help from my friends to explain for me the math lesson but this time I was able to understand it on my own and even explain it to a friend. Imagine, when my friend asked me to explain for her the midpoint theorem, I was able to answer her and even give her an example," participant 7 declared.

> “To me, my mistakes in the quiz were concentrating mistakes and not because there is an idea that was not clear. Now if you ask me to solve the quiz again I will be able to get a full mark…. Although my grade was no good but I get nervous in exams, I don’t know why. (P1)

In addition to feeling mathematically confident, participating students described the content received during class time. Although the teacher did not explain any new idea, class time included the revision done by the teacher at the beginning of the session and the direct feedback received after or during solving an exercise. While high achievers did not shed any light on the material presented in class, low achievers expressed how class time was important to them. They expressed that material presented in class was essential to their understanding. They indicated that the revision and the direct feedback helped them understand more (Participants 1, 5, and 9), solve with more confidence and with more accuracy (Participant 2), and resolve any faced misconception (Participants 1 and 9).

4.2.2. Challenges faced by students who experienced the flipped classroom model

Students who experienced the flipped classroom model reported a number of challenges that they faced at home and in class. All the interviewed participating students reported at least one difficulty they experienced during the flipped classroom model.

*Challenges faced by students at home.*When describing their experience of learning at home during the flipped classroom model, the participating students expressed some challenges that affected their learning process. Results show that at home, participating students found the absence of the teacher (66%), the poor Lebanese infrastructure (50%), feeling tensed and uncertain most of the time (42%), and the lack of support from parents (8.3%) to be challenges to their flipped classroom experience. Table 12 shows the distribution of the challenges described by the participating students.

Table 12 Challenges faced at home by participating students in the flipped classroom model

Challenges faced	High achievers %	Low achievers %	Total %
Absence of the teacher	50%	50%	66%
Lack of supportive parents	-	100%	8.3%
Feeling tensed and uncertain	50%	50%	50%
Poor Lebanese infrastructure	NA	NA	42%

Absence of the teacher. Results show that eight out of twelve participants (66%) mentioned that learning a new concept without having the teacher around was a major challenge. Four of them (50%) were high achievers and the other four (50%) were low achievers. High achievers agreed that the teacher's presence during the explanation is of high importance. They needed her to clarify few ideas and give further examples to make sure that the concept taught is clear and fully understood. Participant 3 commented that "Sometimes at home I felt that I needed the teacher to be around to clarify few issues but then as I moved on things get better". Similarly, participant 10 noted that she missed the teachers' presence to help her in learning, she said:

> I had a problem at home, I needed the teacher when the lesson was explained to clarify few ideas at the spot and not postpone until I go to class. For example, in a video there was a question to choose the correct answer. I got mixed up with

> the given and did not really know what I should do. I needed someone to make things clear. (P10)

Participant 12 indicated that she needed more examples for better understanding. She said “While watching I felt that the teacher’s presence was essential to give us an extra example more than the ones available to make sure we understood well”.

On the other hand, low achievers claimed that during the explanation assigned at home they had the need to ask questions and get direct feedback. They used phrases as “it was annoying”, “I had to wait till the next day when I no more feel the need to ask”, and “I needed answers while watching and not later”. Participant 5 preferred face to face communication while learning a new concept. She described her concern as follows:

> It was annoying not to have the teacher around when learning a new lesson. I was not able to ask freely whenever I wanted…I prefer face to face, see the teacher live, moving, and talking to us and not with a computer. Explaining face to face is better, I understand more. (P5)

Also, participant 7 needed to ask the teacher at the spot and get an answer directly, she explained:

> At home, I had few questions to the teacher but the teacher was not available. For example, at first, I did not understand the converse of midpoint theorem and what did the explanation in the video mean when they said the something related to the sides of the triangle. I got mixed up. (P7)

Although participants 1, 3, 11, and 12 argued that the teacher’s absence during the explanation of the lesson was a challenge, they stated that the flipped classroom made them feel independent and more responsible towards their learning experience and considered it as a benefit. For instance, participant 1 stated,

> But at home I didn't like how while I'm studying, sometimes I felt that I needed to ask questions but I wasn't able to... I forgot them for the next day … I didn't think about writing them down to ask later since I needed an instant answer. That made me more responsible towards learning on my own. I think this is good. (P1)

Lack of supportive parents. Results also show that 8.3% of the participating students found that the lack of their parent's support was a challenge to their learning at home during the flipped classroom model. Some participants expressed that their parents did not support their work or behavior while learning at home. Participant 5 described that her parents were annoyed of the idea of the flipped classroom. She said, "My parents didn't like the idea that I am studying on my phone. They were afraid that I might waste my time on other applications or I will have eye problems" (P5).

Feeling tensed and uncertainty. Although the home environment was comfortable to some participating students, results show that six participants (50%) described that their experience was overwhelming during the flipped classroom at home. They describe being in constant worry and uncertainty, they used phrases such as: "I was worried", "afraid", "not sure", "on my nerves", "overloaded", and "tiring". Three of them were high achievers (50%). They were worried about not being able to completely understand the concept taught, to skip a part, or the assigned video does not open. Participant 11 said,

> A problem I was afraid to face was that the video don't open and miss the explanation but thank God that did not happen. You know the feeling, I was on my nerves all the time that something goes wrong. (P11)

Also, when the interviewer asked participant 8 to describe how she felt about learning a new idea at home through a video, she answered,

> … but there was something that made me feel worried, I was afraid that I understood the idea wrong so it might affect my grades, I wasn't sure until the next day until I noticed that I understood. (P8)

Similarly low achievers, who were 3 participants (50%), focused on describing their concern that the flipped classroom added extra load on their work at home and made them feel worried to misunderstand the concept. Participant 7 expressed her worry by saying

> I was worried that I understand the lesson wrong. I usually take time to understand and sometime mix things up. My math teacher always tells me to pay attention to that because all my mistakes are because I start with an idea but then end up with a different idea and in class the way we learned made this feeling go away. Yes I felt worried at home. (P7)

Participant 5 also felt overwhelmed, she stated

> … to me it was tiring, I had to use the computer, take notes, answer questions and learn a new idea all on my own, plus work on my other homework. This was too much to handle. (P5)

The poor Lebanese infrastructure. Results show that five out of twelve participating students (42%) found it challenging deal with technology at home. The implemented flipped classroom model highly depends on the availability of the internet at home. Unfortunately, technical problems such as electricity outage and connection problems occurred and caused a drawback in students' learning process. Throughout the interview, participants mentioned challenges they faced while opening the website, connecting to the internet, and electricity outages. For example, participant 1 claimed, "I had difficulty logging in and accessing the class created online". When participants were asked about the reasons for not submitting or watching the whole video, they mentioned having issues with the electricity and internet connection at home. Participant 3 said, "While I was watching the explanation, the electricity went off so I didn't complete watching the video." Participant 5 reported "I had a problem in the internet at home".

Challenges faced by students in class. Results show that the participants did not face many challenges during class time in the flipped classroom model. Only two participants (16.66%), who are both low achievers noted that they had difficulty asking in class. They assumed that they should not ask questions related to understanding the concept taught. They either felt worried to be judged by the teacher or felt shy. Participant 5 was worried that the teacher will judge her if she asked for further elaboration or clarification,

> I felt shy to tell the teacher that I did not understand. I should understand the lesson on my own at home and come ready but sometimes I had difficulty. I felt if I asked the teacher to repeat she will judge me maybe or be mad and say that I am not studying or doing any effort… I did my best but I did not like it… I told you before I prefer having the teacher explaining live, I understand better (P5).

However, participant 1 had a different point of view. She did not have a problem in understanding and asking questions related to that. Instead, she felt anxious because she usually feel hesitant under pressure, she said, "I understood on the teacher but sometimes she asked me questions that made me not sure what to answer, so I freeze. I need time to cope".

In conclusion, participants mentioned benefits gained more than the challenges faced. According to participating students, the implemented flipped classroom helped them in both environments, the classroom, and at home. It gave them the opportunity to focus more, learn at their own pace, guarantee a calm and comfortable environment to study, and become independent learners. Also, it increased class time more by making it more beneficial and effective through increased and improved class interaction with the teacher and between students themselves. This increased participants' mathematical confidence. Although benefits overweighed the challenges, participants mentioned a few challenges. They stated that the absence of the teacher while learning a new concept was a great challenge. Furthermore, they felt tensed and uncertain and had few issues with the Lebanese infrastructure. Other than that, they described their overall experience as a positive experience and 50% of the participants recommend implementing the flipped classroom in other subject matter.

4.3. Findings regarding research question 3

The benefits gained and challenges faced by the teacher who experienced the flipped classroom model. The purpose of the third research question was to investigate grade eight math teacher's point of view on the benefits gained and the challenges faced during the flipped classroom model (Table 13). When she was asked to provide description of her experience in the implemented flipped classroom, the following benefits gained were derived: improved communication, personalized instructions, and the following challenges faced were derived as well: time limit and an overwhelming experience.

Table 13 Benefits gained and challenges faced by participating teacher in the flipped classroom model

Main themes	Categories	Description
Benefits gained	• Improved communication	A positive increase in students' communication and engagement during class time (Clark's, 2015).
	• Personalized Instructions	Allowed instructor to connect more to the students who struggle academically, and manage class time more efficiently (Vaezi, Afghari, & Lotfi, 2019).
Challenges faced	• Limited time	Insufficient time to complete the assigned tasks in class.
	• Overwhelming	The extra effort to keep track of individual progress.

4.3.1. Benefits Gained by the teacher

Improved communication. Results show that the teacher mentioned several benefits that described a positive increase in students' communication and engagement during class time (Clarks, 2015). The flipped classroom enabled her to engage easily with the whole classroom. She noticed that during the flipped classroom, students were excited to participate and share their knowledge with their classmates and teacher. For example, the teacher mentioned that,

> Most of the time, students interacted and showed a positive attitude. They were excited to participate and share their knowledge with their classmates and

> me…Communicating with them was easy. I was able to get an answer from almost all the students in the class. Things went fluently.

Also, the flipped classroom helped students answer with higher accuracy than those in the non-flipped classroom during class discussions. It also allowed students to work together in a more focused manner. The teacher reported,

> Most of the time, students interacted well and were confident about what they were saying. They participated more than students in the other section. We had meaningful conversations and more-focused ones. In the non-flipped classroom, students' asked me to repeat, restate, and clarify. However, in the flipped class, they asked me to give more examples, they asked if we had a specific case, does the theorem work? You know questions that show that students are thinking and not asking just to ask."

In other words, the teacher clarified that "questions asked by students in the flipped classroom held more meaning than in the non-flipped classroom that made class time beneficial."

Personalized Instructions. Also, results showed that the flipped classroom helped the teacher give direct feedback to students who struggle academically and to manage class time more efficiently. During the interview, the teacher mentioned that the flipped classroom helped her gain insight and focus more on each student's level of reasoning and understanding. It enabled her to resolve any misconception by providing direct feedback and by asking more focused questions. The flipped classroom allowed her to know who worked hard to understand at home and who did not. For instance, the teacher commented that,

> I remember a student who was not able to fully engage during a classroom discussion. She had difficulty following up. So, I assumed that she did not watch the video at home. After the class, I talked to her, and I was right. It was good that the discussion and the group work in class helped her overcome this issue by the end of the session.

Moreover, when the interviewer asked the teacher to mention the benefits she gained during class time, she answered,

> I was able to focus more on each student's work and tell how well each got the idea and understood it. Such a way helped me monitor students' way of thinking and allowed me to discover the misconceptions and give direct feedback to fix the problem at its early stages.

4.3.2. Challenges faced by the teacher

Overwhelming. Although class time was efficient and allowed the teacher to focus on students as individuals and not as groups, results show that the flipped classroom made the teacher carry extra burden. Her tasks during class time increased to become more than just teaching a whole class. She kept track of each student despite where each student has reached, each level of understanding, or the exercise they are solving. Add to it, the participating teacher has mentioned that her work with students does not end in the class. She collected students' copybook to check whether they followed her instructions or not. She said,

> Honestly, class time was tiring. I had to move from one group to another, keep in mind what every student is thinking, where did they reach, and what was our last argument. Plus, I had to keep my eyes on each student to see if they are

> working and cooperating and give direct feedback to twelve students in less than ten minutes… despite collecting copybooks and checking their work, did they solve the whole exercise, did they skip, and did they do what I asked them to do. You know it is all time-consuming.

Limited time. Although teaching was more focused on individual progress, results show that the time given to think, discuss, and share ideas, was insufficient to complete the recommended tasks done in a non-flipped classroom. Although students were sharing thoughts, some groups were not able to discuss the different methods to solve an exercise. It was either because they were slower than their friends or they wasted time. Results show that when students are allowed to think alone about a solution to an exercise, they can come up with strategies different than their friends. Thus, a variety of answers and methods occur. Unfortunately, the flipped classroom offered only class time for students to think about, share, and apply the objectives taught. While the non-flipped classroom allowed students to think at home and then share and apply the method in the class. In other words, the tasks that need to be completed during class time in the flipped classroom were distributed over home and class time in the non-flipped classroom. Consequently, results show that the limited time given to students during class time and the dense material of the Lebanese curriculum does not allow students to have sufficient time to think of the various methods and discuss them all. The teacher clarified that during the interview. She stated that: "According to the Lebanese curriculum, we have a limited number of sessions to finish the assigned objectives, and thinking and discussing during class time requires more time to complete the assigned lesson." She also mentioned her concern on the flipped classroom by stating, In the non-flipped classroom, students came to class ready to discuss different methods and ways and even misconceptions during class time. However, in the flipped classroom model the discussion was narrowed to two or four students and varied. I discussed methods with groups that I did not with others.

CHAPTER 5

DISCUSSION

This research study, aimed to examine the effectiveness of flipped classroom model on students' performance in midpoint theorem in a triangle. The analysis also aimed to identify the teacher and students' benefits gained and challenges faced in the implemented flipped classroom model.

This chapter discusses the results of this research study. It discusses the impact of the flipped classroom on students' performance in midpoint theorem. It also discusses the benefits gained and the challenges faced by both the students and the teacher in the flipped classroom. Then, this chapter identifies its limitations and implications for practice and further research.

5.1. The effect of the flipped classroom on students' performance in midpoint theorem

In this study, the comparison was between the flipped and the non-flipped classroom where the settings differed. Results presented in Chapter 4 showed that the flipped classroom had a significant impact on low achievers' understanding level in midpoint theorem and no significant impact on students' remembering, applying, nor analysing levels. This is somewhat expected since remembering, applying, and analysing need to be demonstrated over time. This is very important since any application of the material will be highly based on this understanding. The studies of Carlisle (2018), Sickle (2016), Bhagat et al. (2016), Peterson (2015), Dixon (2017), and Guerrero et al. (2015) compared student's scores in the flipped classroom to the traditional classroom where the instructional strategies differ. While some concluded that there was no increase in students' grades when compared to the traditional classroom such as Peterson (2015), Carlisle (2018), Dixon (2017), and Guerrero et al. (2015), others proved significance in overall score comparison (Sickle, 2016; Bhagat et al., 2016). Yet, the results obtained in this study differed from the previous findings. Such a difference may be because the comparison in the previous research studies (Carlisle, 2018; Sickle, 2016) was between the flipped classroom and the traditional classroom. Another possible factor might be because the previous studies (Peterson, 2015; Dixon, 2017; Bhagat et al., 2016) were implemented over a twelve weeks period of time that compared students' scores in the pre-test versus the post-test. Unlike the current study that was conducted over a two weeks period of time and had compared students' scores in the post-test. Such a difference in the flipped classroom definition, time, and analysis procedure might be the reason why the results of the current study differ from the mentioned previous research studies.

Under other conditions, the current study's results aligned with Baytiyeh and Naja's (2017) findings, who reported that the flipped classroom results were slightly better than the traditional classroom with no significant difference in scores. Such a conclusion may be due to the similar implementations of the flipped classrooms. In other words, both studies compared students' scores in the post-tests and adopted a similar design of the flipped classroom. Baytiyeh and Naja (2017) focused on having interactive learning activities inside the class, similar to the implementation done in this study that focused on students' application and integration of knowledge (Merrill, 2002) through student-to-student and student-teacher interaction during class time.

This study did some further investigation of overall test scores according to Bloom's Taxonomy. Keeping in mind that the flipped classroom enhanced low achievers' understanding level in midpoint theorem, the present study's analysis procedure coincides with Morton et al.'s study (2017). Morton et al. (2017) aimed to determine if there existed any improvement in students' performance according to Bloom's taxonomy levels. The focus of their study was in the anatomy classroom. They showed that flipped classroom students outperformed the lecture-based classroom students in the analysis level. The results supported the claims of Jensen, Kummer, & Godoy (2015) who, in their study, showed no significant difference in Bloom's Taxonomy results. From this standpoint, the flipped classroom seems to impact the analysis level of students in a biology classroom, but the understanding level of low achievers in a math classroom. That implies that the flipped classroom's impact differs from one subject to another. This can be explained by Wasserman's (2017) claim. He claimed that for students to acquire mathematical understanding, they need to indulge in a meaningful mathematical practice through classroom discussion where students interact with their teacher or classmates. As well as receiving direct feedback while working on mathematical concepts (Muir & Geiger, 2016). Both factors, the classroom discussion and the direct feedback, are available in the implemented flipped classroom model.

As a conclusion, the understanding gained from implementing the flipped classroom in teaching the midpoint theorem demonstrated itself specifically in how low achievers are able to restate and discuss what they learn during the demonstration phase at home and in the application and the integration phases in the class. Thus, a possible explanation is that in the flipped classroom, low achievers get more support from the teacher as they discuss the related exercises to understand the midpoint theorem. Thus, the flipped classroom improves low achievers' understanding of mathematics.

5.2. The benefits gained and the challenges faced by students and the teacher who experienced the flipped classroom

The implemented flipped classroom is the flip in the teaching setting by which learning a new concept happens at home using technology as a tool and applying the concept in class (Peterson, 2016). Results in Chapter 4 showed that the flipped classroom helped students gain a flexible and a calm environment to learn a new concept. It also helped them become independent learners who are mathematically confident, as it increased class time and improved classroom communication and personalized instructions. Besides the mentioned benefits, there existed some challenges students and the teacher have faced in the flipped classroom. Students felt tensed to learn a new objective without having the teacher around. They considered the poor Lebanese infrastructure a challenge as well. The teacher found it an overwhelming experience. Thus, the discussion of the benefits gained and the challenges faced by students and the teacher who experienced the flipped classroom are discussed in terms of the four pillars of FLIP and Merrill's phases.

5.2.1. The Four Pillars of FLIP

Flexible Environment. In this study, the flexible environment establishes an adjustable space and time frame that is suitable for learning (FLN, 2014). The flexible environment is attained at home while students were able to isolate themselves, find a quiet place, and choose a room to work away from any distractions (Carlisle, 2018). In this study, high achievers gained their parents' support and the opportunity to study at their own pace feeling comfortable doing more than one task at a time. On the other hand, the flipped classroom provided low achievers with sufficient time to achieve the required outcome without worrying about following up with the teacher and copying notes concurrently. But unlike high achievers, few lacked parental support.

Like previous studies (eg. Fulton, 2012; Ayçiçek & Yanpar Yelken, 2018; Heo and Choi, 2014), the flipped classroom model allowed students to access the content whenever and wherever they wanted. The findings of this study showed that the flipped classroom model offered high achievers their parents' support and the opportunity to study at their own pace feeling comfortable doing more than one task at a time. Whereas for low achievers, the flipped classroom provided them with sufficient time to understand regardless of being able to follow up with the assigned tasks within a limited time. These findings supported Fulton's (2012) notion who differentiated between the point of view of high achievers and low achievers. He concluded that "A strong student can breeze through; others can watch it over and over as needed until the concepts become clear." Also, the results provided evidence to Wasserman et al. (2017) who explored the effect of the flipped classroom on students' performance and perception by comparing it with a non-flipped classroom setting. They concluded that the implemented flipped classroom unlike the non-flipped classroom offered students the opportunity to replay the content several times. It allowed them to access it when needed such as when studying for an exam or when reviewing notes (Bhagat et al., 2016). Likewise, results tied well with Carlisle (2018) who explored the differences between the mathematical achievements of high school students within the flipped classroom compared to a traditional classroom. She concluded that the flipped classroom allowed students to experience fewer peer distractions and decreased distraction when receiving instruction. Such consistency in findings verifies that the flipped classroom offers students, whether low or high achievers the opportunity to study at their own pace by choosing the place and the time that best suits their learning habits allowing them to focus more.

Besides, knowing that most parents engage in their kids' learning process (Civil et al., 2008) and that the flexible environment is attained at home, parents' point of view is discussed. In this study, high achievers' claim about having supportive parents gets along with Muir and Geiger's (2018) conclusion. They concluded that 84% of the parents who participated in his study preferred the flipped classroom model. Hamdan et al. (2013) supported such findings by arguing that parents are less pressured knowing that their child will have the opportunity to ask deep questions during class time. However, participants who had an opposing argument met with Fulton's (2012) findings. He explained that such resistance from parents towards the flipped classroom could be because parents might feel sceptical of the benefits offered by the flipped classroom which is considered odd compared to the way they used to learn. Such a difference between parents' point of view can only be attributable to the students' achievement level. However, since parents were not involved in this study, therefore it remains unclear and difficult to explain the reasons behind parents' perception towards the flipped classroom for their kids to learn mathematics.

In addition, although students expressed the benefit of learning in a flexible environment and the option of re-watching the lessons, they mentioned their concern towards the poor Lebanese infrastructure, internet slowness and electricity outages. This is justified by the current situation in Lebanon where people suffer from electricity and internet issues as reported (El-Ghali & Ghosn, 2019). "These technical issues present significant frustrations" for both teachers and students engaged in connected learning programs", added El-Ghali and Ghoson (2019). This made students feel tense when they were worried about not completing their tasks or missing the explanation before coming to class. The Lebanese infrastructure will remain a challenge to any model that relies on using technology such as the flipped classrooms.

Learning Culture. According to the second pillar of FLIP, the flipped classroom dedicates class time for students to engage in exploring the content of a lesson in greater depth by solving exercises and discussing them (FLN, 2014). To assure the existence of the second pillar, class time was divided into three phases, the activation phase, the application phase, and the integration phase. Results showed that the flipped classroom increased class time for students to discuss and apply the midpoint theorem, and improved class communication between the teacher and her students and between students themselves. In class, communication focused on asking more in-depth questions related to the midpoint theorem rather than wasting time repeating the explanation or waiting for the whole class to be on track.

The current study's results align with previous research studies that showed that the flipped classroom increased class time (eg. Vaezi, Afghari, & Lotfi, 2019; Ma et al, 2018; Clark, 2015; Millard, 2012; Ayçiçek & Yanpar Yelken, 2018). Clark (2015) examined the effect of the flipped classroom model on students' engagement and performance in the secondary mathematics classroom. He stated that students, whether low or high achievers, noticed an enhancement in the usage of class time. It allowed them to apply what they learned by working in the presence of the teacher, often in group work (Clark, 2015). During class time, students solved problems actively rather than listening to lectures, and they appeared to check their work with their peers before asking for help from the instructor (Guerrero et al., 2015). That seems to depend on class time that was managed according to Merrill's phases since students expressed that they benefited from class time by recalling, applying, and integrating what they have learned at home.

Davies et al. (2013) highlighted the fact that high achievers spent more time in class solving (application phase) and discussing (integration phase) assigned problems while Bhagat (2015) highlighted the fact that low achievers benefited from class time by recalling (activation phase) and solving better (application phase). A similar finding was established in this study. During class time, both high and low achievers spent more time practicing the objectives of the midpoint theorem lesson, gained direct feedback from the teacher when needed, and discussed their thinking strategy with both their peers and the teacher. As a result, the scores of the flipped classroom students were slightly better than the scores of the non-flipped classroom students, and low achievers in the flipped classroom understood better the midpoint theorem than those in the non-flipped classroom. The flipped classroom model enhanced class time more efficiently (Vaezi, Afghari, & Lotfi, 2019; Ma et al., 2018) where students had the chance to engage more in-class activities (Millard, 2012; Ayçiçek & Yanpar Yelken, 2018). Such an increase in-class time is justified by Bergmann and Sam (2015) who stated that unlike the non-flipped classroom, “time savers” come in the form of students helping each other while the teacher is helping another group of students at their level of understanding.

Moreover, Clark (2015) found out that when students work in isolation at home, class time is still effective because the teacher is available for further explanation and individual conferencing. In this study, participants have demonstrated that both the presence of the teacher and peer-interaction during class time helped them understand more, write better proofs, and resolve their misconceptions in midpoint theorem. In line with previous studies (eg., Wasserman et al., 2015; Patterson et al., 2018; Clark, 2015, and Ayçiçek et al., 2018), findings agreed that during class time, communication was enhanced.

The flipped classroom motivated students to cooperate and get encouraged to ask questions to their teacher (Patterson et al., 2018) more than it did in the non-flipped classroom, which yielded a positive contribution (Clark, 2015). In specific, the results of the current study were in alignment with the findings reported by Muir and Geiger (2016), who emphasized that the flipped classroom improved the students-instructor relationship. Heo and Choi (2014) reported that such an improvement was because the flipped classroom model enabled students to ask their teacher confidently. Besides, it is important to mention that students who expressed how the flipped classroom offered them the opportunity to communicate, cooperate, and interact with both their peers and the teacher have also declared that they gained self-confidence in themselves and their learning especially that they are supervised by their teacher. That might be a possible reason behind such an increase in communication.

These results go beyond previous studies showing that the flipped classroom allows high achievers to cooperate through interchanging ideas between each other and referring to the teacher as a mentor who helps them think in depth. Besides, the flipped classroom allows low achievers to recall what they learned at home and refer to the teacher to help them by orienting their thinking strategy towards the correct methods. As a conclusion, the flipped classroom allows students to engage more in the process of learning mathematics, where the teacher provides direct feedback to those who need it and allows those who do not need assistance to move efficiently (Carlisle, 2018), showing slightly better scores in the post-test than students in the non-flipped classroom.

Intentional Content. The third pillar of FLIP requires the teacher in the flipped classroom to decide what content to teach and what to make available to students (FLN, 2014). Results based on students' interviews made evidence that students who experienced the flipped classroom had a concern about the teacher's absence during the explanation of the lesson. Yet, they found that the content delivered at home was easy and clear, and they even felt confident about their mathematical knowledge.

In contrast to the non-flipped classroom, the time spent in class provided students the support needed to complete assignments rather than leaving them struggling on their own at home (Schmidt, 2016). The results of the current study showed that high achievers needed the teacher to clarify some concepts in the midpoint theorem by giving more examples. Whereas, low achievers needed the teacher to answer their questions and get direct feedback. As most students declared that the flipped classroom allowed them to spend more time with the teacher helping them during class time, several students stated that they were not able to ask questions nor get immediate feedback during the explanation at home (Lo & Hew, 2017). Similarly, in Carlisle's (2018) study, students expressed their concern over the inability to communicate with the teacher at home. However, when comparing our results to those older studies (Lo & Hew, 2017; Schmidt, 2016; Carlisl, 2018), it must be pointed out that the content sent home was not only based on lecturing but included embedded questions to help students keep track of their understanding.

Having the material in hand without the presence of the teacher allowed high and low achievers to depend on themselves more. They took advantage and watched again the video as they took their time answering the embedded questions that helped them focus more and tell whether they were on the right track or not. Sun et al. (2018) implemented a similar flipped classroom design. They sent students a lecture to watch at home, followed by online homework. They concluded that the students who did not find difficulty completing the online assignment were more confident about their abilities to participate and work in groups during class time. The current study assures that having self-assessment tools such as embedded questions in the video sent home has a major positive effect on students' learning confidence and confirms that students have completed their homework. Yet, further studies have to be done having different implementations in order to generalize such results..

Professional Educator. The responsibility of the teacher in the flipped classroom differs from that in the non-flipped classroom. At home, during lesson explanation, the teacher is not present. However, during class time, as students work together, the teacher continuously observes students, answers their questions, and provides them with direct feedback (FLN, 2014). During class time, Arauja et al. (2017) described the teacher in the flipped classroom as being "more responsive to students' needs and questions than steering the pace and content of the classroom."

In this study, the teacher claimed that the flipped classroom helped her focus on each student's needs and communicate effectively with each. That, in return, required her to exert more energy within a limited class time. By comparing the results of the current study to previous research studies (Siegle, 2014; Fulton, 2014; Bergmann & Sams, 2015; Roehl, 2013), it is noticed that teachers agreed that the flipped classroom offered them time to provide students with personalized support (Bergmann & Smith, 2017) and with material that is more appropriate to their needs (Siegle, 2014). Also, the flipped classroom allowed the teacher to gain valuable insights into students' abilities, difficulties, and understanding (Roehl, 2013; Fulton, 2014) that is difficult to attain in the non-flipped classroom. Similarly, Morgan (2014) concluded that unlike the non-flipped classroom, the flipped classroom permits teachers to help low achievers with the content in a more focused manner. Thus, allowing lessons to be appropriate to students' level (Fulton, 2014). For instance, the flipped classroom allowed the teacher to give more attention to low achievers through remedial assistance (Bhagat, 2016) and to interact with high achievers at high levels (Pring, 2012). It is important to note that the findings resulted by the teacher's interview are consistent with the findings resulted by the students' interview.

Although the flipped classroom enabled the teacher to interact more with students in an effective manner, the overall experience was described as overwhelming to the teacher. A similar conclusion was reached by Ford (2015). In the flipped classroom, Ford concluded that instructors find difficulty in finding a balance between clarifying the concept, and the group work to practice and deepen the concept. That is verified when the results showed that the teacher needs to work on an individual base rather than on a whole classroom base. Add to it, results are in line with Greenberg & Baron (2000) who explain why the teacher described the flipped classroom experience as overwhelming. Some instructors believe that it is easier to stick to their current successful ways of teaching instead of changing the habit which requires teachers to improve their current skills and strategies and developing new ones (Greenberg & Baron, 2000; Mumtaz, 2000). Such an agreement verifies that the flipped classroom demands a professional educator who is able to personalize instructions and focus on students' needs for better understanding.

In short, the findings resulted by students' interview and that of the teacher were consistent. They verified that students benefit most when the implemented flipped classroom allows students to choose when and where to learn (flexible environment), allows class time to incorporate topics of greater depth (learning culture), requires the teacher to decide what to make available and what to teach (intentional content), and requires a teacher who is able to integrate different teaching strategies that suit all students (professional educator).

for the flipped classroom to be effective needs to abide the four pillars that were suggested by the FLN (2014).

5.2.2. Merrill's Framework

In this study, the implemented flipped classroom model is based on Merrill's phases. At home, students undergo the activation phase, the demonstration phase and then the application phase. While in class, students undergo the activation phase, application phase, and then the integration phase. The benefits gained and the challenges faced by both the teacher and the students who experienced the flipped classroom show that Merrill's framework impacts the implementation of the flipped classroom positively. The discussion of the benefits gained and the challenges faced during the four phases follows.

Activation phase. In the current study, the activation phase outside the class allowed for the revision of ideas and concepts, while in class activation helped students understand what they missed at home, clarify any misconception, and double-check their understanding. A similar pattern of results was obtained by Muir and Geiger (2016), Carlisle (2018), and Bergmann and Smith (2017).This also aligns with Munson and Pierce's (2015) recommendation, a summary having the key concepts presented in the video can help as a starter of class. As it brings to an agreement with Clark's findings (2015), the flipped classroom increased class communication and added a positive contribution to students' experience.

Demonstration Phase. Only at home, the demonstration phase took place when the video sent revealed the new lesson objectives to students. Students had to follow instructions to learn on their own without the presence of the teacher nor the interaction with their peers. Whereas in the non-flipped classroom, the demonstration phase took place under the teacher's supervision and peer interaction. Students who experienced the flipped classroom stated that despite working alone without the presence of the teacher, factors such as the flexible environment at home, video access anytime and anywhere, the repetition, the embedded questions, and the supportive parents contributed well to lesson explanation. In both the non-flipped and the flipped classroom, the demonstration phase holds the same instructional methods where the teaching instructions were similar to the instructional videos. However, the benefit of implementing the demonstration phase at home was making class time revolve around students applying and discussing the concepts taught under the teacher's supervision who can provide immediate and direct feedback. This is consistent with what has been found by Bishop and Verleger (2013) and Conte et al. (2015). Thus, the current study proves that the flipped classroom gives students the opportunity and the appropriate materials to demonstrate the new concept on their own. That results in making them feel more comfortable and self-dependent. It enhances class time to become more efficient by focusing more on students' needs and understanding.

Application Phase. Due to the settings changes in the flipped classroom, the application phase was held at home and in class. At home, it helped students assess their understanding. It was assessed through the embedded questions that track students' attention and keep them on track where students had to apply the concept through a direct application and then check their work. That was confirmed by Lim (2018) who highlighted the fact that the application phase at home enhances students' learning of the newly delivered concepts and assesses students' understanding at home. Then in class, students worked in groups and solved exercises related to what they learned at home. The resulted benefits in this study, the efficient time spent in class, the improved student-student and student-teacher interaction, and the confidence felt by students during class time can be explained by Lo and Hew's (2017) study. They found that when solving problems during the application phase the setting is supported with peer interaction and teacher's guidance. Students gained more attention from the teacher (Bhagat, 2016) who provided them with personalized feedback (Bergmann & Smith,

2017) as they worked together that helped them work at an appropriate pace (Morgan, 2014).

On the other hand, Sickle (2016) compared the settings in the flipped classroom versus that in the non-flipped classroom. In the non-flipped classroom, students in class follow up with the teacher's thinking and perceive that they are understanding. Then, when they go home and solve on their own, they have difficulty (Sickle, 2016). Sickle (2016) believes that when students face difficulty solving a problem at home, they recall the difficulty felt in class thus they feel stuck and tense. Such a comparison supports the fact that when the application phase is done in class and is supervised by the teacher, this makes the students feel more comfortable and confident about the concept they learned. Thus, this introduces a possible confound that the flipped classroom's setting, having the application phase in class, opens the opportunity for students to build on each other's knowledge and gain mathematical confidence under the guidance of the teacher.

Integration Phase. During the integration phase, students engage in solving more advanced problems or discuss their findings and interpret their work (Merrill, 2002). In the implemented flipped classroom, teachers are actively engaged with students as they think, discuss, and solve related exercises, enabling them to provide instantaneous feedback to those who need it, assistance to others, and more in-depth questions to high achievers. Similar results were obtained by Carlisle (2018) and Bhagat et al. (2016). On the contrary, Morgan (2014) highlighted the fact that in a non-flipped classroom, students do the higher-level tasks on their own and wait for class time for the teacher to observe their work and errors, and assess them accordingly. That implies that students in the non-flipped classroom, unlike those in the flipped classroom, miss out on valuable feedback from both the teacher and the students themselves that might help them understand better and more efficiently. This is indicative of why the low achievers who experienced the flipped classroom understood the midpoint theorem better. The increased communication during class time and the instant feedback during the integration phase may be the cause behind why students in the flipped classroom obtained higher scores than those in the non-flipped classroom.

In conclusion, adopting Merrill's framework while implementing the flipped classroom contributed in helping students understand mathematical concepts better, clarify any misconceptions, obtain personalized instructions, and benefit from class time by interacting with their classmates under the teacher's guidance. They gained valuable feedback from the teacher that helped them understand the midpoint theorem better.

5.3. Conclusion

The current study examines the effectiveness of the flipped classroom model on grade eight students' performance in midpoint theorem. It also identifies the benefits gained and the challenges faced by the teacher and the students who experienced the flipped classroom. At this stage of understanding, implementing the flipped classroom as a flip in the teaching settings and following Merrill's phases as a framework to design the flipped classroom shows that the teacher and the students benefited from this approach.

The quantitative results mostly indicated that there was no significant difference between the flipped classroom and the non-flipped classroom scores. But, low achievers in the flipped classroom outperformed low achievers in the non-flipped classroom in the understanding level. Students in the flipped classroom were able to understand and write a proof that flows logically using the correct mathematical terms and notations unlike those in the non-flipped classroom who had difficulty identifying in which triangle to apply the theorem or which theorem to use to prove parallels. Such significance was elaborated and confirmed in the interview results when low achievers showed preference to the flipped classroom.

Moreover, the interviews conducted with the teacher and the students revealed that participants gained a fruitful experience at home and in class. As noticed, the benefits gained out weighted the challenges faced. Students showed a positive attitude towards learning the midpoint theorem in a flipped classroom model. Class time became more efficient by which more time was dedicated to collaborations, communication, and exploration. At home, students were able to learn in a flexible environment that helped them feel comfortable, focus more, and be more self-dependent while learning new concepts. Yet, there existed no significant difference in students' overall scores in the post-test between students in the flipped and the non-flipped classrooms that reflects such a positive qualitative outcome. That is because the quantitative findings are only indicators due to the relatively small number of participants in the Quasi-experiment and the limited time provided in the study.

In other words, the implemented flipped classroom model developed the teacher's role to become more focused on students' needs. Her role was not to only provide students with information as in the non-flipped classroom, but to guide, support, and supervise their discussion and work. To students, the main challenges faced were the teacher's absence during lesson explanation, the internet slowness, and electricity outages.

Although the teacher sensed students' engagement and interest in the subject, yet the setting was new to her and needed more adaptation time. In addition, the experience was hectic for her knowing that she has to provide feedback to students individually. Yet, she clearly declared enjoying teaching in a flipped classroom model and repeating the model more often.

5.4. Limitations

Various limitations were encountered while developing this research which should be considered. It is worth mentioning that the dominant ones were time and sample considerations. The implementation of the study consisted of five sessions which may not be enough to show the effect of the flipped classroom on students' scores. Students may need more time to react with the flipped classroom model. Despite the short period of time, the flipped classroom had a significant impact on low achievers' understanding level. As for the sample, the size is relatively small and was only girls, so it was difficult to find a significant relationship between the data of the flipped classroom versus the non-flipped classroom. Statistical tests usually necessitate a greater sample. Besides, passing through a lock down due to the covid-19 pandemic made it difficult for the researcher to follow up with the participants for further data collection.

Moreover, the literature tackled the effect of supportive parents. Yet, the research method used (semi-structured interviews) lacked a direct question about their effect. Thus, the results of this issue couldn't be generalized. In addition, the research had only evaluated one math geometry lesson for grade eight math class where the material sent home was only based on videos. However, caution is needed to avoid generalizing the results of the experiment but repeating it to include sending content to students in different file formats such as documents, lecture video, audio etc. as well as choosing other grade levels and subjects.

5.5. Future Recommendations

This research resulted in promising findings which adopted Merrill's phases as a based framework for the flipped classroom. Yet, this study had many vital findings that should be considered in future studies. First, the flipped classroom model must be implemented within other school subject and not just mathematics to check whether its employment generate the same results. The research can include other grade levels as well. Second, in order to clearly understand the effects of using the model on students' performance, the study must be rather a longitudinal one to ensure valuable and significant effects. Third, one should investigate parents' perspectives around the flipped classroom since their opinion is vital for the students' learning. Fourth, it is advised to compare a flipped classroom built based on Merrill's to another flipped one based on a different framework especially that the research field lacks studies comparing the effectiveness of different models of flipped classrooms. Finally, it is suggested to try the flipped classroom not just by sending videos home, but by sending content to students having different file formats such as document readings, recorded lectures or online games.

Educational technology is continuously developing and growing making it inevitable that this development will constantly provide new improvements to the education sector (Nguyen L., Barton, & Nguyen L. T., 2014). With these research findings and results, and the suggested future research work, more exploration is needed in this field. Education is crucial to promote the society's stability and unity. By improving and enhancing the quality of education provided to the new generation using the latest information technologies, we can build hopefully a well-developed generation able to shape a stronger and a healthier community in the long run.

APPENDIX 1

Geometry Pre-requisite objectives

Lesson	Objectives
Parallelogram	A.1. Define a parallelogram A.2. Recall properties of a parallelogram A.3. Construct a parallelogram A.4. Verify a quadrilateral is a parallelogram using: a. Quadrilateral having 2 pair of opposite side parallel b. Quadrilateral having 2 pair of opposite sides equal c. Quadrilateral having 1 pair of opposite sides parallel and equal d. Quadrilateral having 2 pair of opposite angles equal e. Quadrilateral whose diagonals have same midpoint A.5 Calculate the area and perimeter of a parallelogram
Rectangle	B.1. Recall properties of a rectangle B.2. Define a rectangle B.3. Construct a rectangle. B.4. Verify a quadrilateral is a rectangle using: a. Quadrilateral having 3 right angles b. Parallelogram having 1 right angle c. Parallelogram whose diagonals are equal d. Calculate the area of a rectangle B.5. Conclude that in a right triangle, the median relative to hypotenuse = ½ hypotenuse B.6. Prove a right triangle by showing that in any triangle if the median is half the relative side then the triangle is right
Rhombus	C.1. Recall properties of a rhombus C.2. Define a rhombus. C.3. Construct a rhombus. C.4. Verify a quadrilateral is a rhombus using: a. Quadrilateral having 4 equal sides b. Parallelogram having 2 equal consecutive sides c. Parallelogram whose diagonals are perpendicular d. Calculate the area of a rhombus
Square	D.1. Recall properties of a square D.2. Define a square. D.3. Construct a square. D.4. Verify a quadrilateral is a square using: a. Rectangle with perpendicular b. Rhombus having 1 right angle

	c. Rectangle having 2 = consecutive sides d. Rhombus having = diagonals D.5. Calculate the area of a square using both diagonals or sides
Trapezoid	E.1. Define a trapezoid E.2. Verify a quadrilateral is a trapezoid E.3. Distinguish a right and an isosceles trapezoid. E.4. List properties of an isosceles trapezoid E.5. Prove an isosceles trapezoid using: a. Trapezoid + = non-parallel sides b. Trapezoid + = angles adjacent to one of the bases c. Trapezoid + = diagonals d. Trapezoid + bases having same perpendicular bisector E.6. Prove a right trapezoid using trapezoid having one right angle. E.7. Calculate the area of a trapezoid

APPENDIX 2

Flipped Classroom Unit Plan_ Midpoint Theorem

Unit Title	Midpoint Theorem in a triangle
# of Lessons	4
Lesson Title	1_ Introduction to Midpoint Theorem in a Triangle 2_ Midpoint Theorem in a Triangle Application 3_ Introduction to Converse of Midpoint Theorem in a Triangle 4_ Midpoint Theorem in a Triangle and its Converse
Duration	45 min./lesson (in class) – open at home, depends on each student
Learning Outcomes	2.1 State the midpoint theorem in a triangle. 2.2 Prove the midpoint theorem in a triangle. 2.3 Apply the midpoint theorem in a triangle. 2.4 State the converse of midpoint theorem in a triangle 2.5 Prove the converse of midpoint theorem in a triangle. 2.6 Apply the converse of midpoint theorem in a triangle. 2.7 Differentiate between the midpoint theorem in a triangle and its converse.
Exercises	booklet pg. 11 # II, I book pg. 113 # 3 book pg. 114 # 5, 7, 10 and pg. 115 # 11, 13 book pg. 116 # 15 Worksheet (1) & (2)

<table>
<tr><td colspan="2">Lesson 1</td></tr>
<tr><td colspan="2">Learning Objectives</td></tr>
<tr><td colspan="2">- At the end of the lesson, students will be able to:
• State the midpoint theorem in a triangle
“in a triangle, the segment joining the midpoints of two sides is parallel and equals to half the third side”
• Prove the midpoint theorem in a triangle
• Apply the midpoint theorem</td></tr>
<tr><td colspan="2">Students’ Learning Resources at Home</td></tr>
<tr><td colspan="2">Uploaded video on Edpuzzle</td></tr>
<tr><td colspan="2">Students’ Learning Strategies at Home</td></tr>
<tr><td colspan="2">- Building Knowledge
- Application</td></tr>
<tr><td colspan="2">Procedure at home → watch the attached video that includes the following:</td></tr>
<tr><td>Activation Phase</td><td>Introduction of the lesson, thus nothing to recall.</td></tr>
<tr><td>Demonstration Phase</td><td>- Students follow instructions in the attached video
- Instructions:
o Draw any triangle MID
o Locate points P and T the midpoints of $[MI]$ and $[MD]$ respectively
o Using a ruler, find the relation between the length of $[PT]$ and $[ID]$
o Using the protractor or a ruler, find the relative position of (PT) and (ID). Justify
o What can you conclude?
- Let us prove the theorem like mathematicians
- Instructions:
o Use the attached Geogebra file (midpoint theorem proof)
o Write down the givens
o Locate point E the symmetric of M with respect to R
o What can you say about the nature of quadrilateral $MAEC$? Prove it
o What about the nature of quadrilateral $MECB$? Prove it
o What is the relation between the length and relative position of $[MR]$ and $[BC]$? Justify
Instructions in the video require students to draw and measure and critically think about their work. It also, includes the use of GeoGebra, a mathematics application. It helps students visualize the proof more accurately. In this lesson, students use it to write proofs on their copybook and prove what the midpoint theorem states.</td></tr>
<tr><td>Application Phase</td><td>- Worksheet (1) # I and II
- The two exercises direct the students to illustrate the midpoint theorem.</td></tr>
<tr><td colspan="2">Classroom Strategies</td></tr>
<tr><td colspan="2">- Recall Concepts
- Group Interaction
- Application</td></tr>
</table>

Classroom Procedure	
Activation Phase	- The teacher asks students about what they have learned at home, state the theorem, what are the conditions to apply the theorem? - In groups of four students discuss the results they got at home under teacher's supervision. Then, they check # I and II in the worksheet - This allows students to recall what they learned at home and make sure that they understood the concept
Application Phase	- In pairs, solve booklet pg. 11 # II - The teacher passes and check students work and provide them with direct feedback - The exercise allows students apply the midpoint theorem.
Integration Phase	- In pairs, students solve booklet pg. 11 # I - The teacher continues to pass by and provide feedback as she listens to students' reflection and analysis.

Lesson 2	
Learning Objectives	
- At the end of the lesson, students will be able to: • Apply the midpoint theorem in a triangle	
Students' Learning Resources at Home	
Uploaded quiz on Edpuzzle + attached answer key of booklet pg. 11 # I and II	
Students' Learning Strategies at Home	
- Recall Concept - Application - Questioning	
Procedure at home → watch the attached video that includes the following instructions:	
Activation Phase	- Questions that allow students recall the essential understanding needed to apply the theorem - Check detailed answer key of booklet pg. 11 # I, II (attached)
Demonstration Phase	- Complete worksheet (1) # III, IV - The worksheet includes questions that allows students to describe and explain the midpoint theorem note: the video includes the questions and the discussion related to # III and IV in the worksheet - As students complete the worksheet, the video helps them relate and demonstrate what they have learned.
Application Phase	- Request students to solve book pg. 113 # 3 to apply the midpoint theorem
Classroom Strategies	
- Recall Concept - Application - Group Interaction - Questioning	
Classroom Procedure	
Activation Phase	- The teacher asks students the following to recall and summarise the midpoint theorem in a triangle • State the midpoint theorem • What does the midpoint theorem in a triangle helps us prove? • What are the givens needed to apply the midpoint theorem? • Give an example on the midpoint theorem. - Discuss the correction of # 3 (a detailed answer key will be provided to students)
Application Phase	- In pairs, students discuss and solve book pg. 114 # 10 to apply the theorem - The teacher passes by to check and provide students with direct feedback
Integration Phase	- Individually, students solve book pg. 115 # 11 to analyse and apply the theorem - The teacher passes by each and provide students with direct feedback, and listen to students reflection on their work

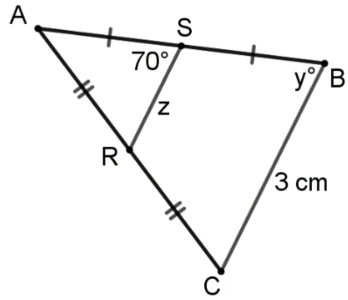
<table>
<tr><td colspan="2">Lesson 3</td></tr>
<tr><td colspan="2">Learning Objectives</td></tr>
<tr><td colspan="2">- At the end of the lesson, students will be able to:
• State the converse of midpoint theorem in a triangle
“in a triangle, the line passing through the midpoint of a side and parallel to another cuts the third side at its midpoint”
• Prove the converse of midpoint theorem in a triangle
• Apply the converse of midpoint theorem</td></tr>
<tr><td colspan="2">Students’ Learning Resources at Home</td></tr>
<tr><td colspan="2">Uploaded video on Edpuzzle</td></tr>
<tr><td colspan="2">Students’ Learning Strategies at Home</td></tr>
<tr><td colspan="2">- Recall concepts
- Building Knowledge
- Application</td></tr>
<tr><td colspan="2">Procedure at home → watch the attached video that includes the following instructions:</td></tr>
<tr><td>Activation Phase</td><td>Recall of of the midpoint and what does a converse of a theorem means as a foundation for the targeted objective.</td></tr>
<tr><td>Demonstration Phase</td><td>The second part of the video ask the student to follow the following instructions:
o Draw any triangle CON
o Locate points P he midpoint of $[CO]$
o Through P, draw (d) parallel to (CN) cutting $[ON]$ at S
o Using a ruler, what does S represent to $[ON]$?
o What can you conclude?
- Let us prove the theorem like mathematicians
- Instructions:
o Use the attached Geogebra file (converse of midpoint theorem proof)
o Write down the givens
o The parallel through P to (CN) cuts $[ON]$ in S
o The parallel through N to $[CO]$ cuts $[PS)$ in I
o What can you say about the nature of quadrilateral $PINC$? Prove it
o What about the nature of quadrilateral $POIN$? Prove it
o What does point S represent to $[ON]$? Justify
Instructions in the video require students to draw and measure and critically think about their work. It also, includes the use of GeoGebra, a mathematics application. It helps students visualize the proof more accurately. In this lesson, students use it to write proofs on their copybook and prove what the converse of the midpoint theorem states.</td></tr>
<tr><td>Application Phase</td><td>Solve worksheet (2) # I and II</td></tr>
<tr><td colspan="2">Classroom Strategies</td></tr>
<tr><td colspan="2">- Recall concepts
- Group Interaction
- Questioning
- Application</td></tr>
<tr><td colspan="2">Classroom Procedure</td></tr>
</table>

Activation Phase	- In groups of four students discuss the results they got at home under teacher's supervision.
Application Phase	- In pairs, solve book pg. 116 # 15 and worksheet (2) # III to apply the converse of midpoint theorem - The teacher passes by each pair to check their work and provide them with direct feedback
Integration Phase	- Solve worksheet (2) # IV to analyse and apply the converse of midpoint theorem - The teacher passes by each pair to check their work and provide them with direct feedback and listen to students reflect on their work

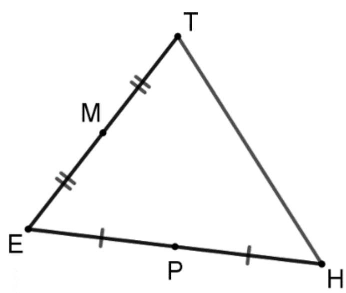
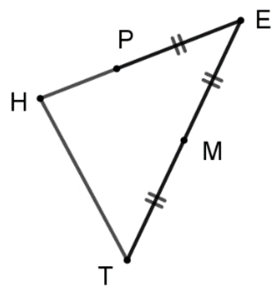
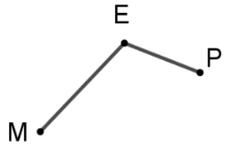
Lesson 4	
Learning Objectives	
- At the end of the lesson, students will be able to: • Differentiate between the midpoint theorem in a triangle and its converse	
Students' Learning Resources at Home	
Uploaded video on Edpuzzle	
Students' Learning Strategies at Home	
- Recall concepts - Questioning - Application	
Procedure at home → watch the attached video that includes the following instructions:	
Activation Phase	Questions that help students state both theorem and tell the purpose of each
Demonstration Phase	Students are asked to write a summary on the midpoint theorem in a triangle and its converse on their copybook. This allows students to demonstrate the targeted objective
Application Phase	Solve book pg. 115 # 13 to apply both theorems when appropriate.
Classroom Procedure	
- Recall concepts - Application - Group Interaction	
Classroom Strategies	
Activation Phase	Recall the theorems by discussing the exercise solved at home
Application Phase Integration Phase	In pairs, discuss and work on book pg. 114 # 5 The teacher passes by each pair to check their work (applying the theorem) and to listen to their reflection and analysis of their work to provide them with the appropriate feedback

Worksheet (1)
Midpoint Theorem in triangle

I. What does the midpoint theorem in a triangle helps us prove?
II. What are the givens needed to apply the midpoint theorem?
III. Find z the length of $[RS]$ and y the measure of $A\hat{B}C$

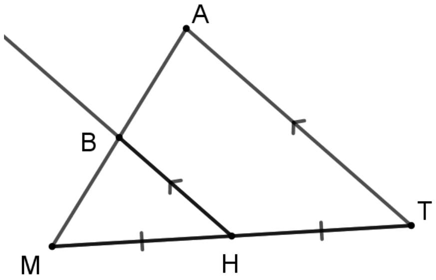


IV. Tell whether in each of the following cases $[MP]$ is parallel to $[TH]$ and $MP = \frac{1}{2}TH$

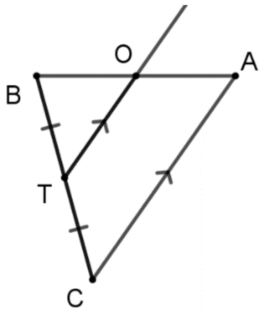
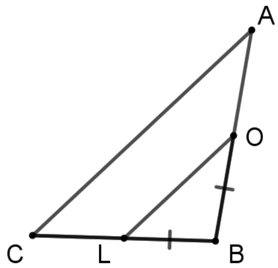
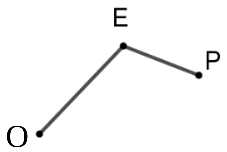
<table>
<tr>
<td>Case 1:
Given the adjacent figure

</td>
<td>Case 2:
Given the adjacent figure

</td>
</tr>
<tr>
<td>Case 3:
Given the adjacent figure
Locate H the symmetric of E with respect to P and point T the symmetric of E with respect to M

</td>
<td>Case 4:
Given triangle ETH and points M and P are on $[EH]$ and $[ET]$ respectively such that $EM = EP$</td>
</tr>
</table>

Worksheet (2)
Converse of Midpoint Theorem in triangle

I. What does the converse of midpoint theorem in a triangle helps us prove?
II. What are the givens needed to apply the converse of midpoint theorem?
III. Knowing that $MA = 4cm$, find the length of $[MB]$



IV. Tell whether in each of the following cases O is the midpoint of $[AB]$. Justify

Case 1: Given the adjacent figure  	**Case 2:** Given the adjacent figure 
Case 3: Given the adjacent figure Locate H the symmetric of E with respect to P and the parallel through H to $[OP]$ cuts $[EO)$ in M  	**Case 4:** Given square $MOAL$ of center F, the perpendicular through M to $[AM]$ cuts $[AO)$ in B

APPENDIX 3

Non-Flipped Classroom Unit Plan_ Midpoint Theorem

Unit Title	Midpoint Theorem in a triangle
# of Lessons	4
Lesson Title	1_ Introduction to Midpoint Theorem in a Triangle 2_ Midpoint Theorem in a Triangle Application 3_ Introduction to Converse of Midpoint Theorem in a Triangle 4_ Converse of Midpoint Theorem in a Triangle Application 5_ Midpoint Theorem in a Triangle and its Converse
Duration	45 min./lesson (in class) – open at home, depends on each student
Learning Outcomes	2.1 State the midpoint theorem in a triangle. 2.2 Prove the midpoint theorem in a triangle. 2.3 Apply the midpoint theorem in a triangle. 2.4 State the converse of midpoint theorem in a triangle 2.5 Prove the converse of midpoint theorem in a triangle. 2.6 Apply the converse of midpoint theorem in a triangle. 2.7 Differentiate between the midpoint theorem in a triangle and its converse.
Exercises	booklet pg. 11 # I and II book pg. 114 #7 and pg. 115 # 13 Worksheet (1) & (2) book pg. 114 # 5 and pg. 116 # 15

Lesson 1	
Learning Objectives	
- At the end of the lesson, students will be able to: • State the midpoint theorem in a triangle "in a triangle, the segment joining the midpoints of two sides is parallel and equals to half the third side" • Prove the midpoint theorem in a triangle • Apply the midpoint theorem in a triangle	
Classroom Strategies	
- Building Knowledge - Group Interaction - Application	
Classroom Procedure -in computer lab-	
Activation Phase	Introduction of the lesson, thus nothing to recall.
Demonstration Phase	Students follow instructions distributed to them - Instructions: ○ Draw any triangle MID ○ Locate points P and T the midpoints of $[MI]$ and $[MD]$ respectively ○ Using a ruler, find the relation between the length of $[PT]$ and $[ID]$ ○ Using the protractor or a ruler, find the relative position of (PT) and (ID). Justify ○ What can you conclude? - Let us prove the theorem like mathematicians - Instructions: ○ Use the attached Geogebra file (midpoint theorem proof) ○ Write down the givens ○ Locate point E the symmetric of M with respect to R ○ What can you say about the nature of quadrilateral $MAEC$? Prove it ○ What about the nature of quadrilateral $MECB$? Prove it ○ What is the relation between the length and relative position of $[MR]$ and $[BC]$? Justify - Conclude and write the theorem on the board
Application Phase	- In pairs, students solve worksheet # I and II - The teacher passes by and provide students with feedback
Homework	
- Study notes + solve booklet pg. 11 # II then I	
Strategy at Home	
- Recall concept - Application	
Procedure at Home	
Activation Phase	Students study the summary of the lesson
Application Phase	- Solve booklet pg. 11 # II
Integration Phase	- Solve booklet pg. 11 # I

<table>
<tr><td colspan="2">Lesson 2</td></tr>
<tr><td colspan="2">Learning Objectives</td></tr>
<tr><td colspan="2">- At the end of the lesson, students will be able to:
• Apply the midpoint theorem in a triangle</td></tr>
<tr><td colspan="2">Classroom Strategies</td></tr>
<tr><td colspan="2">- Recall concepts
- Application
- Group Interaction</td></tr>
<tr><td colspan="2">Classroom Procedure</td></tr>
<tr><td>Activation Phase</td><td>- The teacher asks students the following to recall and summarise the midpoint theorem in a triangle
• State the midpoint theorem
• What does the midpoint theorem in a triangle helps us prove?
• What are the givens needed to apply the midpoint theorem?
• Give an example on the midpoint theorem.</td></tr>
<tr><td>Demonstration Phase</td><td>- In groups of four, students explain to each other their work done at home (booklet pg. 11 # I and II)
- The teacher passes by the groups to provide them with feedback</td></tr>
<tr><td>Application Phase</td><td>- In pairs, solve book pg. 113 # 3
- The teacher passes by each pair to check their work and provide them with feedback</td></tr>
<tr><td colspan="2">Homework</td></tr>
<tr><td colspan="2">- Study well + solve book pg. 114 # 10 + pg. 115 # 11</td></tr>
<tr><td colspan="2">Students' Learning Strategies at Home</td></tr>
<tr><td colspan="2">- Recall concept
- Application</td></tr>
<tr><td colspan="2">Procedure at home</td></tr>
<tr><td>Activation Phase</td><td>Study notes summary and check detailed answer key of # 3</td></tr>
<tr><td>Application Phase</td><td>Solve book pg. 114 #10</td></tr>
<tr><td>Integration Phase</td><td>Solve book pg. 115 # 11</td></tr>
</table>

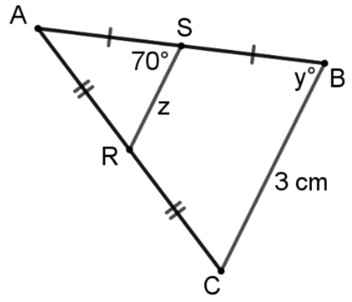
Lesson 3	
Learning Objectives	
- At the end of the lesson, students will be able to: • State the converse of midpoint theorem in a triangle "in a triangle, the line passing through the midpoint of a side and parallel to another cuts the third side at its midpoint" • Prove the converse of midpoint theorem in a triangle	
Classroom Strategies	
- Recall concept - Building Knowledge - Application - Group Interaction	
Classroom Procedure -in computer lab-	
Activation Phase	- The teacher recalls the midpoint theorem and recalss the meaning of a converse of a theorem as a foundation for the targeted objective (converse of midpoint theorem)
Demonstration Phase	Students work in groups of four to complete the assigned activity - Distribute activity worksheet that contains the following instructions: - Instructions 1: o Draw any triangle CON o Locate points P he midpoint of $[CO]$ o Through P, draw (d) parallel to (CN) cutting $[ON]$ at S o Using a ruler, what does S represent to $[ON]$? o What can you conclude? - Let us prove the theorem like mathematicians - Instructions 2: o Use the attached Geogebra file (converse of midpoint theorem proof) o Write down the givens o The parallel through P to (CN) cuts $[ON]$ in S o The parallel through N to $[CO]$ cuts $[PS)$ in I o What can you say about the nature of quadrilateral $PINC$? Prove it o What about the nature of quadrilateral $POIN$? Prove it - What does point S represent to $[ON]$? Justify - Conclude and write the theorem on the board
Application Phase	Students solve worksheet (2) # I and II The teacher passes by each to provide them with feedback.
Homework	
Study well + solve book pg. 116 # 15 + worksheet (2) # III, IV	
Students' Learning Strategies at Home	
- Recall concepts - Application	
Procedure at home	

Activation Phase	Study notes and check detailed answer key of worksheet # I and II - It helps students describe the theorem to be able to apply it later.
Application Phase	Solve book pg. 116 # 15 and worksheet (2) # III - The exercises allow students apply the converse of midpoint theorem.
Integration Phase	Solve worksheet(2) # IV - The exercise helps students analyse and reflect when is the theorem applicable and when it is not

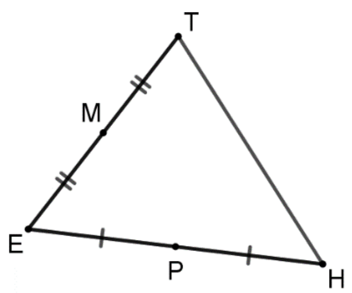
Lesson 4	
Learning Objectives	
- At the end of the lesson, students will be able to: • Differentiate between the midpoint theorem in a triangle and its converse	
Classroom Strategies	
- Recall concept - Group Interaction - Application - Questioning	
Classroom Procedure	
Activation Phase	The teacher asks students to : - State the midpoint theorem - Why is the midpoint theorem applied? - State the converse of midpoint theorem - Why is the converse of midpoint theorem applied?
Demonstration Phase	In groups of four, write the summary of both theorems under the teacher's supervision and feedback. Writing a summary helps students demonstrate and describe both theorems and even relate between the two theorems (how are they similar and how are they different)
Application Phase	Solve book pg. 115 # 13
Homework	
Study well the summary written + solve book pg. 114 # 5	
Students' Learning Strategies at Home	
- Recall concept - Application	
Procedure at home	
Activation Phase	Study the written summary
Application Phase	Solve book pg. 114 # 5
Integration Phase	Correct # 5 and reflect on their work by referring to the detailed answer key of #5

Worksheet (1)
Midpoint Theorem in triangle

V. What does the midpoint theorem in a triangle helps us prove?
VI. What are the givens needed to apply the midpoint theorem?
VII. Find z the length of $[RS]$ and y the measure of $A\hat{B}C$



VIII. Tell whether in each of the following cases $[MP]$ is parallel to $[TH]$ and $MP = \frac{1}{2}TH$

<table>
<tr>
<td>Case 1:
Given the adjacent figure

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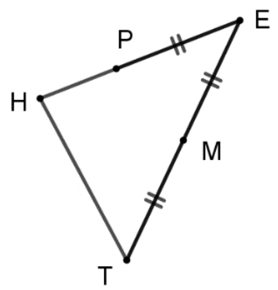
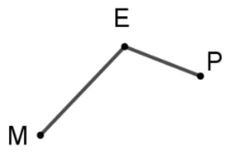
<td>Case 2:
Given the adjacent figure

</td>
</tr>
<tr>
<td>Case 3:
Given the adjacent figure
Locate H the symmetric of E with respect to P and point T the symmetric of E with respect to M

</td>
<td>Case 4:
Given triangle ETH and points M and P are on $[EH]$ and $[ET]$ respectively such that $EM = EP$</td>
</tr>
</table>

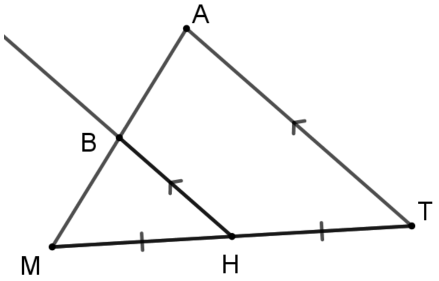
Worksheet (2)

Converse of Midpoint Theorem in triangle

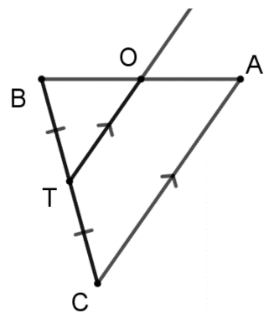
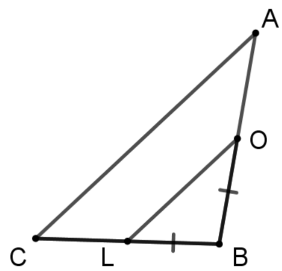
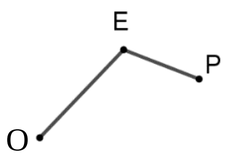
V. What does the converse of midpoint theorem in a triangle helps us prove?

VI. What are the givens needed to apply the converse of midpoint theorem?

VII. Knowing that $MA = 4cm$, find the length of $[MA]$



VIII. Tell whether in each of the following cases O is the midpoint of $[AB]$. Justify

Case 1: Given the adjacent figure 	**Case 2:** Given the adjacent figure 
Case 3: Given the adjacent figure Locate H the symmetric of E with respect to P and the parallel through H to $[OP]$ cuts $[EO)$ in M 	**Case 4:** Given square $MOAL$ of center F, the perpendicular through M to $[AM]$ cuts $[AO)$ in B

APPENDIX 4

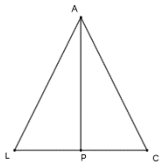
Grade 8

Name:

Date:
Duration: 45 minutes
Grade: /10

Math Achievement Test
Pre-test

<table>
<tr><th>Question</th><th>Bloom's Taxonomy</th><th>Learning Outcome</th><th>Score</th></tr>
<tr><td>I. Choose the correct answer and justify
<table>
<tr><td colspan="3">1) In a rectangle of length $L = 2cm$ and perimeter $P = 18cm$ then its width W is</td></tr>
<tr><td>a) $7cm$</td><td>b) $9cm$</td><td>c) $4cm$</td></tr>
<tr><td colspan="3">2) In a parallelogram $ABCD$, if $(AB) \perp (BC)$, then</td></tr>
<tr><td>a) Its diagonals bisect the angles</td><td>b) It has 4 equal sides</td><td>c) its diagonals are equal</td></tr>
<tr><td colspan="3">3) a quadrilateral whose diagonals bisect each other and are perpendicular is a</td></tr>
<tr><td>a) square</td><td>b) rectangles</td><td>c) rhombus</td></tr>
</table></td><td>1) Analyzing
2) Analyzing
3) remembering</td><td>I.
1) B.4.d
2) B.4.b
3) C.4.c</td><td>1) 0.75
2) 0.75
3) 0.5
2 points</td></tr>
</table>

II. Given isosceles triangle ALC of base $[LC]$ and median $[AP]$ such that $AP = LC$. The parallel through A to $[LC]$ and that through P to $[AL]$ meet in M  1) Complete the figure 2) What is the nature of quadrilateral $LAMP$? Justify 3) What is the nature of quadrilateral $AMCP$? Justify 4) D is the orthogonal projection of L on (AM) Deduce the nature of $LDMC$	1) applying 2) Analyzing 3) Analyzing 4) Analyzing	**2) A.4.a** **3) A.4.c** **4) E.6** **5) A.2**	**1) 0.5** **2) 1** **3) 0.75** **4) 0.75** **3 points**

The Taxonomy Table

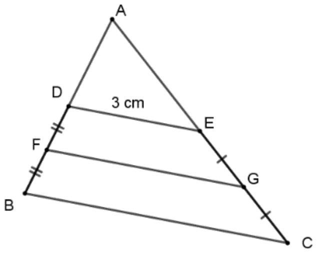
Knowledge Dimension	Cognitive Dimension						
		Remember	Understand	Apply	Analyse	Evaluate	Create
	Factual Knowledge	I(3)					
	Conceptual Knowledge		II(2)		I(1,2), II(3,4,6), III(2,3,4, 5)		
	Procedural Knowledge			II(1), III (1)	II (5)		

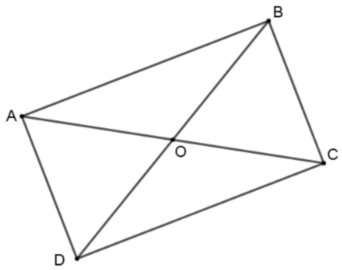
	Metacognitive Knowledge						

APPENDIX 5

Grade 8 | Date:
Name: | Duration: 45 minutes
Grade: /10

Math Achievement Test
Post-test

Question	**Bloom's Taxonomy**	**Learning Outcome**	**Score**
I. State the 1) midpoint theorem in a triangle 2) converse of midpoint theorem in a triangle	**Remembering**	1) 2.1 2) 2.4	1) 0.25 2) 0.25 **0.5 point**
II. Given triangle ABC such that D and E are the respective midpoints of $[AB]$ and $[AC]$, and (FG) // (BC) 1) Find the length of $[BC]$ and  deduce the nature of $DECB$. Justify 2) $[DC]$ cuts $[FG]$ in T. Show that T is the midpoint of $[DC]$.	**Applying**	1) 2.3 & E.3 2) 2.6	[FG] 0.5 $DECB$ is a trapezoid 0.5 Midpoint 0.5 **1.5 points**

III. Given rectangle $ABCD$ of center O such that $BC = 2BD$ E is the symmetric of C with respect to B 1) Show that $EBOA$ is an  isosceles trapezoid 2) The parallel through O to $[CE]$ cuts $[AE]$ in F a) Show that F is the midpoint of $[AE]$ b) Deduce the nature of $FOBE$	1) Analyzing 2) a)Applying b)analyzing	1) 2.3 2) a) 2.6 b) C.4.b & 2.3	1) parallel 0.75 half of =s 0.5 2) a- 0.75 b- 1 **3 points**

The Taxonomy Table

Knowledge Dimension	Cognitive Dimension						
		Remember	Understand	Apply	Analyse	Evaluate	Create
	Factual Knowledge	I					
	Conceptual Knowledge			IV(2)	III(1), IV(3,4)		

	Procedural Knowledge		IV(1)	II, III(2)	III(3), IV(5)		
	Metacognitive Knowledge						

APPENDIX 6

Students' Interview Questions

I. Based on your experience, define the flipped classroom.

1. What did you do in class?
2. What did you do at home?
3. How was the lesson explained?

II. Describe how watching the video before coming to class has **influenced your learning** experience **at home**? List the benefits and the challenges you faced.

1. What did you do at home? How did you study math? Please give examples.
2. Who helped you complete your math homework?
3. How did you find the video? Did it help you understand more? How did you feel towards it?
4. Did you need help while learning the new idea?
5. How did you study for the test?
6. Describe how you feel about yourself in midpoint theorem.

III. Describe how watching the video before coming to class has **influenced your learning** experience **in class**? List the benefits and the challenges you faced.

1. How did you find the work done in class?
2. How did you feel about your understanding of the midpoint theorem?
3. How did you spend the time in class? Describe how you felt. Give examples.

IV. In general what is your opinion in the flipped classroom?

1. Do you recommend applying it more often? In what subjects?

APPENDIX 7

Teacher’s Interview Questions

I. At the beginning of the session, you had to recall the learnt concept. Describe this phase

II. After recalling, students worked in pairs/groups to apply the concept taught. Describe this phase

III. At the end of the session, students discussed and explained their work. Describe this phase

APPENDIX 8

Rubric

Posttest Rubric				
Item	**Correct**	**Incomplete**	**Wrong**	
1.1	Students state: - The midpoint theorem in the form of a conditional statement. - The needed givens for the theorem to be true. (triangle, midpoints of two sides, segment joining the midpoints) - The aim of the theorem. (parallel and =s half)	Students state: - Unconnected and unclear, mostly true statement - The aim of the midpoint theorem without mentioning the needed givens.	- No answer - Do not mention the aim of the theorem. - Do not mention the givens for the theorem to be true. - misuses of notation	Remembering
1.2	Students state: - The converse of the midpoint theorem in the form of a conditional statement. - The needed givens for the theorem to be true. (triangle, midpoint of a side, segment passing through the midpoint and parallel to another side) - The aim of the theorem. (midpoint of a segment)	Students state: - The aim of the midpoint theorem without mentioning the needed givens. - The theorem in an unclear statement. - Miss a keyword (triangle, midpoint, parallel)	- No answer - Do not mention the aim of the theorem. - Little or no sense of how the theorem is true	Remembering
2.1	- Apply the midpoint theorem to prove parallels and find measure. • Use the correct triangle and midpoints. (Triangle ABC and midpoints D and E). - Prove a trapezoid by one pair of opposite sides are parallel.	The proof is nearly correct and logically coherent but students: - Miss a reason - Have a calculation mistake - Find the length of [BC] only. - Find the nature of quadrilateral DECB only.	Students - Use wrong triangle or midpoints to apply the midpoint theorem.	Understanding

2.2	- Apply the converse of midpoint theorem. • Use the correct givens (triangle DCB and midpoint F)		- Wrong application of the theorem - No answer	Applying
3.1	- Apply the midpoint theorem to prove parallels. • Use the correct triangle and midpoints. (Triangle ECA and midpoints B and O).	The proof is nearly correct and logically coherent but students: - Miss a reason		Analysing
3.2	The proof is correct and flows logically. The presentation uses correct mathematical grammar and uses notation correctly. The structure of the proof is apparent and the bulk of the details are easy to follow.	The proof is nearly correct and logically coherent but students: - Miss a reason - Write statements of the proof that are not connected - Do not present a significant chunk of the solution. - Still need to fill in some details that should have been explained or justified.	Students write a proof that contains serious logical flaws, and lacks adequate justification or explanation.	Analysing
3.3a	- Apply the converse of midpoint theorem. Use the correct givens (triangle DCB and midpoint F	-	Students - Use wrong triangle or midpoints to apply the midpoint theorem. - No answer	Applying
3.3b	The proof is correct and flows logically. The presentation uses correct mathematical grammar and uses notation correctly. The structure of the proof is apparent and the bulk of the details are easy to follow.	Students: - Still need to fill in some details that should have been explained or justified. - Miss a reason - Write statements of the proof that are not connected. - Did not end the proof with a concluding statement.	- Students write a proof that contains serious logical flaws, and lacks adequate justification or explanation. - No answer	Analysing

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