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The Effect of Flipped Classroom Model on Students' Achievement in the New 2016 Scholastic Assessment Test Mathematics Skills

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Abstract

The flipped classroom model has become more popular and one of the focus of many researchers and teachers in the recent years. The aim of current study is to explore the effect of flipped classroom model on students' achievements in the new SAT 2016 mathematics skills (Heart of Algebra, Problem solving and data analysis, and Passport to Advanced Math) for the eleventh grade Emirati female students in Al Ain, United Arab Emirates. Specifically, this study aims at determining whether there was a statistically significant difference in student achievements in the new SAT mathematics skills between two groups of grade 11 students. Thus, pretest/posttest quasi-experimental design was applied. The experimental group was taught by flipped classroom model, and the control group was taught by traditional instruction methods. The results revealed that there is a statistically significant difference between the pretest and posttest of the experimental group over the control group the new SAT mathematics skills. Furthermore, the findings suggest that teachers who teach mathematics standardized test skills like SAT can use flipped classroom model to enhance students' readiness and to improve their thinking skills to simulate the 21st-century skills.

Keywords: Flipped classroom; Standardized test; Traditional instruction methods; SAT.

1. Introduction

Educators are in continuous search for new and innovative pedagogical approaches to achieve and keep up with the 21st-century skills, creativity, critical thinking, communication, and collaboration, which are essential to prepare students for the future (Perry, 2012). To master these skills, students should be given opportunities to perform well in the learning activities done in and outside the walls of the classroom.

Teaching mathematics concepts in general, and standardized tests skills, in particular, needs much efforts and many useful activities to enhance student learning. Some of these activities are listening to lectures, solving homework, and preparing for tests. In the context of the United Arab Emirates (UAE), preparing for an international standardized test such as the newly-redesigned SAT 2016, is a serious matter. As such, the secondary math curriculum of the UAE incorporates SAT 2016 exam preparation courses as part of the common core standards in Mathematics skills. Thus, SAT preparation is part of the graduation requirements of every student.

The new 58-question SAT, which started in March 2016, is designed with no more tricks, and it is focused on real math skills, like algebra, data analysis, problem solving, and a complex connection. The new SAT was designed to measure the students' college readiness, and to give the students the opportunities to show what they have learned in the school. The 58 questions are divided into the following skills: 19 questions in Heart of Algebra skills, 17 questions in Problem solving and Data Analysis skills, 16 questions in Passport to Advanced Algebra skills, and 6 questions in additional topics in math (College Board, 2016).

In many schools in the UAE, including the research site for this study, students are already facing difficulties in understanding math skills with the added pressure of preparing for the SAT. Teachers should teach algebra 2 curriculum and SAT skills in seven periods only per week. Given this limited time, how then should the teacher accommodate the SAT exam preparation into the weekly plan without compromising the time alloted to learning the necessary math skills? Also, how then should the teacher use the face to face time effectively? And how does the teacher offer an effective support to students in their homework and practice for the SAT?

A variety of new teaching methods to meet the student's needs come into the picture; namely the flipped classroom, which in essence moves the lecture outside the classroom via technology and keeps homework and exercises with concepts inside the classroom via learning activities (Bergmann and Sams, 2012a; Brunsell and Horejsi, 2011; Tucker, 2012). The flipped classroom is a "flip" of the ordinary classroom, an instructional setting in which students (perceived as passive recipients of knowledge (Lave, 1988) receive instruction from a teacher during class time, and practice or another supplemental work is assigned to be completed by the student at home.

In the flipped classroom, the lecture delivered outside the class hours comes in the form of a podcast, which is usually created by the instructor. Podcasting refers to the "distribution of audio/video files in digital format" (McGarr, 2009). The podcast is then distributed online to the subscribers. Using the internet to provide podcast lectures of class lessons has a two-sided benefit for students. It allows some students who were absent from class due

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to illness, sports or many other reasons, a way to stay caught up with the class. The podcast also allows a student to watch the lecture as many times as needed.

The flipped classroom strategy, which partly depends on technology, is a viable option since the UAE is one of the leading countries in the use of technology in education. In particular, using flipped classroom instruction in teaching SAT exam skills may help teachers to reduce lecture time, and increase the time in improving the students' critical thinking and problem solving skills through collaboration with their colleagues. This study can be the base of the new system of international exam training courses in the UAE, which will encourage students to be more involved in the process of learning. This study is significant as there are no published studies related to the new SAT skills in the UAE, and few studies in flipped classroom instruction as well. The results of the study may help teachers in using the best practice of flipped classroom in teaching, including identifying the situation of students' level of preparedness in the new SAT 2016 skills, and those skills which need extra time and effort. Finally, findings of this study may help curriculum developers in the UAE to improve on the existing educational framework. Specifically, this research investigated if grade 11 students, who are taught using the flipped classroom instruction, perform better than those, who will be taught using traditional instruction methods, in the new SAT skills through seeking answers to the following research questions:

1. Is there a significant difference in the New SAT overall achievement between students in the experimental group who were taught using flipped classroom model and students in the control group who were taught using traditional instruction methods?
2. Is there any significant difference in the New SAT- HEART OF ALGEBRA skills achievement between students who studied in the flipped classroom strategy compare to the ordinary way of teaching math?
3. Is there any significant difference in the New SAT- PROBLEM-SOLVING AND DATA ANALYSIS skills achievement between students who studied in the flipped classroom strategy compared to the ordinary classroom?
4. Is there any significant difference in the New SAT- PASSPORT TO ADVANCED MATH skills achievement between students who studied in the flipped classroom strategy compared to the ordinary classroom?

2. Literature Review

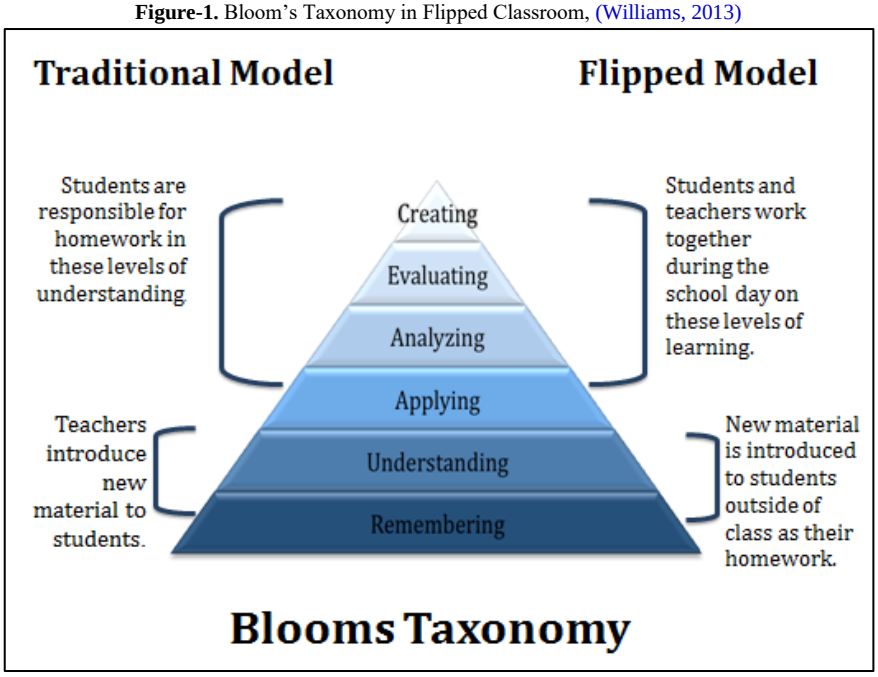
This literature review spots the light on the theoretical framework of the current study. It shows how the flipped classroom is anchored on Vygotsky's social constructivism and Bandura's social learning theories, and how it inverts Blooms taxonomy. Finally, an overview of some previous studies regarding the flipped classroom is also presented.

2.1. Theoretical Framework

Vygotsky, regarded as the proponent of constructivism, believed that students obtain new knowledge through social interaction with others by supporting learners to scaffold their learning, and providing them with suitable activities (Saunders, 2014). This scaffolding is showed clearly with flipped classroom, by using the class time to support students with their difficulties with homework through group discussion & increase the level of student's thinking skills by the teacher's probing questions. Thus, the teacher gives metacognitive support and ensures that students are responsible for their learning (Bergmann and Sams, 2012b; Johnson and Renner, 2012).

Bandura's social learning theory provided another theoretical framework for the use of flipped classroom instruction in teaching. Social learning theory shows the effectiveness of the environmental and cognitive factors which interact to shape the learning and behavior. Students can learn from each other, by modeling, and observation (Abbott, 2007). Students in flipped classroom, acquire learning after seeing lessons through videos, as verified by Miller (2011), that "older children, by observing a model, are expected to learn complex new skills quickly, with a minimum of verbal instruction" (p. 251). So in flipped classroom instruction, the social learning theory of Bandura was clearly displayed, since effective modeling of concepts is presented via online videos (Khan Academy new SAT training course videos, and teacher-made videos). Sams and Bergmann (2013), believes that one emphasis of the flipped classroom lies in inverting Bloom's taxonomy so that students have the opportunity to apply and maximize interactions between student and instructor and student and peer (See Figure 1). The teacher's role is to support and guide students through the higher-order thinking skills of applying, analyzing, evaluating, and creating in the classroom (Hamdan *et al*., 2013).

Figure-1. Bloom's Taxonomy in Flipped Classroom, (Williams, 2013)



2.2. History of Flipped Classroom

The new generation of flipped classroom with online videos followed by the face-to-face instruction is often credited to Bergmann and Sams (Pink, 2010). In 2007, they were both science teachers at Woodland Park High School in Colorado. Some critical reasons like the remote location of their school increased the number of absent students in their school, and they were finding that many students needed to leave early in the day to attend athletic events or other school related activities. Bergmann states that the early recordings were only for students who missed class (Bergmann and Sams, 2012a).

In March 2011, Salman Khan used the term "flipping the classroom" in his TED talk (Khan, 2011). Salman Khan has endorsed the flipped model and has stated that his videos allow the teacher to focus on higher-level learning activities, such running simulations, and labs with students, doing individual interventions and facilitating peer-to-peer learning (Fink, 2011; Gojak, 2012). From that date, interest in the flipped classroom instruction has grown exponentially with new articles, and blogs on the flipped classroom teaching method.

2.3. Impact of Flipped Classroom Instruction on the Students' Achievement in Mathematics

In spite of the spread of the flipped classroom instruction around the world, there are few studies showing a positive impact of using flipped classroom instruction on the achievement of the students in mathematics.

Love *et al.* (2013), conducted a study which focused on the achievements of the students taught by flipped classroom and ordinary classroom, for their linear algebra course. They found out that the average change in exam scores for those in the flipped classroom section was significantly greater than for those in the ordinary section.

Unal and Unal (2017), inferred that in most cases, the flipped classroom model showed higher student learning gains, more positive student perception, and higher teacher satisfaction compared to the traditional model.

Another study by Quint (2015) showed that the use of flipped classroom teaching method increased student learning and more effective at preparing students for exams.

On the other hand, a study conducted by Martin (2015), showed no significant impact of flipped classroom instruction on middle school mathematics achievement. The inconsistent effect of flipped classroom on student's performance may be attributed to certain factors including students' satisfaction, which significantly depends on prior learning experience and personalized learning climate, according to Young *et al.* (2017). In a related study, Boevé *et al.* (2017), concluded that, "some students may benefit from the flipped design, but it may also be a source of frustration for others." They also found out that some students were not willing to change their study behavior even though this change is expected in order to benefit from the flipped classroom.

2.4. Studies Related to the UAE and the Regional Context

The impact of using flipped classroom instruction on the writing performance of twelfth grade female Emirati students in the applied technology high school (ATHS) (Doctoral dissertation, The British University in Dubai (BUiD)) (Farah, 2014).

A study done in Saudi Arabia focused on the impact of using flipped classroom instruction on the promotion of students' creative thinking. The findings of the study suggested that the flipped classroom may promote students' creativity (Al-Zahrani, 2015). Finally, a study, conducted in Qatar, showed that the flipped classroom method improved quiz scores (Syam, 2014).

2.5. Studies in Flipped Classroom Related to Different Subjects

Zappe *et al.* (2009), and Pierce and Fox (2012), used a flipped classroom instruction in an Undergraduate Architectural Engineering Course and a Renal Pharmacotherapy Module, respectively. Both studies found positive implications of the teaching approach on students' learning and improved performance.

Ruddick (2012), used the flipped classroom instruction teaching in one of her chemistry courses. The results showed that the students in the flipped class did better than the ordinary (lecture) students with higher final exam scores and overall success in the class. On the other hand, Johnson and Renner (2012), studied the effect of the flipped classroom model on a secondary computer applications course in a high school setting in Kentucky. The results of a *t*-test comparing the post-test scores of students who did and did not participate in the flipped classroom found no significant difference.

In summary, we see that there are a variety of the results when flipped classroom instruction is used as a teaching method, few studies have been conducted in the UAE context, and no studies were conducted in the use of flipped classroom as teaching method for international exams, like SAT.

3. Resrach Design

This six-teaching-week study done in the second term of the academic year 2015-2016, used a quantitative quasi-experimental design to investigate the effect of using flipped classroom instruction in teaching the New SAT mathematics skills. The participants were divided into two groups:

- The experimental group (1) was taught the New SAT skills using the flipped classroom instruction; (N= 39) contains classes B and D.
- The control group (2) was taught the New SAT skills using the ordinary teaching method; (N=40) contains classes A and C.

A pretest (New SAT Practice test) was given to test the equivalency between the two groups before starting the study. After six weeks, the posttest (new version of the New SAT practice test) was given to the two groups, in order to compare between the achievements of the two groups after the implementation of the flipped classroom instruction.

3.1. Participants

Participants of the current study were 79 eleventh-grade female students who were divided into two groups: the experimental group (Group 1) and control group (Group 2), as shown in Table 1. Both groups were taught by the same teacher. The control and experimental groups were academically and demographically equivalent, and all have the same nationality and gender.

Table-1. Number of students per section, and type of cluster

Section	Number of students	Cluster
Section A	23	Applied Engineering
Section B	21	Applied Engineering
Section C	17	Health Science and Technology
Section D	18	Health Science and Technology
Total	79	

As shown above the sampling consists of two different clusters. Students who are in the first cluster, Applied Engineering, are studying different types of courses in grade 11 like Computer Aided Drafting, Electrical Principles and Applications, Pneumatics and Hydraulics, and Fundamentals and Applications of PLC. The outcome benchmark for this cluster consists of IELTS 6.0, IC3, and SAT Reasoning (Math). The students who are in the second cluster, Health Science and Technology, are studying different types of courses in grade 11 like Biology 1 and 2, Human Health 1 and 2, and Health Care. The outcome benchmark for this cluster consists of IELTS 6.0, IC3, AP Biology and SAT Reasoning (Math). In addition to that they are studying Math, Arabic language, English, and Islamic studies.

3.2. Instruments

To attain the aims of the study, the instruments utilized in this quantitative quasi-experimental study were a pretest and posttest, with the evaluation instrument (new SAT test answer key). Learning materials like online videos created by the teacher were also designed and reviewed.

3.3. Pretest and Posttest

The pretest and posttest are provided by the College Board. Both tests consist of two sections. The first section contains 20 questions in 25 minutes, which included the heart of algebra skills and passport to advanced math skills. The second section contains 38 questions in 55 minutes, which included the heart of algebra skills, problem solving and data analysis skills, and passport of advanced math skills. In the first section of the exam, students were not allowed to use the calculator as a new instruction in the new SAT exam, but in the second section they were allowed to use calculator. The evaluation of both tests was done through the provided model answer. The pretest and posttest question distributions are presented in Tables 2 and 3, respectively.

Table-2. The New SAT Pretest Questions Distribution

Sections /skills	Heart of Algebra	Pproblem Solving and Data Analysis	Passport to Advanced Math
Section 1 (No Calculator)	Questions 1-3; 6; 8-9; 16; 20	No Questions	Questions 4-5; 7; 10;12-15; 17
Section 1 (Calculator)	Questions 1; 3; 6; 8-9; 12; 21; 25; 28; 34-35	Questions 2; 4-5; 11; 13-20; 27; 31-32; 37-38	Questions 7; 10; 22-23; 26; 29; 33

Table-3. The New SAT Posttest Questions Distribution

Sections /skills	Heart of Algebra	Pproblem Solving and Data Analysis	Passport to Advanced Math
Section 1 (No Calculator)	Questions 1-3; 7-8; 12; 19-20	No Questions	Questions 4-6; 9-11; 13; 15; 18
Section 1 (Calculator)	Questions 1-2; 6; 8; 16-17; 19; 26; 29; 32; 34	Questions 3-5; 7; 9-11; 13-15; 20-23; 27; 31; 33	Questions 12; 25; 28; 30; 35; 37-38

Both tests were validated by a panel of local math experts. A reliability analysis using SPSS was conducted on the test items, and the results are as shown in Table 4. The obtained Cronbach's Alpha values in Table 4 show the high reliability of the test items.

Table-4. Cronbach's Alpha Coefficients for Subsets and Total Test Items

Skill	Cronbach's Alpha
Heart of Algebra	.63
Problem Solving and Data Analysis	.58
Passport to Advanced Math	.51
Total	.71

3.4. Procedure

Before starting the implementation of the study, the researcher received a local permission from the site administrators to conduct the study. The procedure of the study was explained clearly to the participants in the study. Each participant was treated with the greatest confidentiality. The control group received normal teaching instruction, while the experimental group received instruction using the flipped classroom teaching method. In the ordinary class setting, students were taught concepts during the allotted class time and homework was assigned accordingly.

In the flipped classroom, students received instruction at home (via Khan Academy New SAT course, teacher made videos, Office mix, etc.) using their laptops, iPad, sand smart phones and completed homework in class. During class time, students were able to discuss the assigned New SAT skill with their teacher and classmates. Before implementing the flipped classroom, the researcher ensured that each student had access to the New SAT materials through Khan Academy New SAT course or the teacher made videos through Office mix. Every teaching week students in the experimental group received a new link to a new mix. The videos contained a short quiz to check their understanding. The teacher was able to receive a full report about including the students' duration of viewing the videos before the new class (see Appendix D).

4. Results

4.1. Pretest

After the pretest was given to participants, the researchers graded each student's pretest, and entered the data into IBM's SPSS Statistics, Version 23. An independent *t*-test was analyzed on the control and experimental groups, and it was determined that the control group and experimental group were comparable in ability level, as shown in table 5.

Table-5. Descriptive Statistics of the Pretest Total Score

Pretest Total Score	Group	N	Mean	Std. Deviation
	Experimental	39	18.56	4.506
	Control	40	16.68	4.833

As seen in Table 6, there was homogeneity of variances for pretest scores for both groups, as assessed by Levene's test for equality of variances (p = .472).

Table-6. Independent Sample t-test for Student Pretest

Pretest Total Score	Group	F	Sig.	t	df	Sig.(2-tailed)
	Equal variances assumed	.52	.47	1.8	77	.08
	Equal variances not assumed			1.8	76.85	.08

4.2. Posttest

To determine if there was a statistically significant difference in the mean posttest results in student academic achievement in the new SAT overall test, and in each part of the new SAT skills (Heart of Algebra, Problem Solving and Data Analysis, and Passport to Advanced Math) between the two groups, posttest data were compared. Table 7 shows that the experimental group obtained higher mean scores in all skills than the control group.

Table-7. Descriptive Statistics of the Posttest Score

	Group	N	Mean	Std. Deviation
Total Score of Posttest	Experimental	39	25.26	3.330
	Control	40	20.78	5.47
Total Score of Heart of Algebra	Experimental	39	10.85	2.33
	Control	40	8.60	2.26
Total Score of Passport to Advanced Math	Experimental	39	9.79	1.87
	Control	40	7.85	2.33
Total Score of Problem Solving and Data analysis	Experimental	39	4.62	1.25
	Control	40	4.33	1.70

4.3. Research Question 1

Is there any significant difference in the New SAT achievement between students who studied in the flipped classroom compared to the ordinary classroom? Table 8 shows that there exists a significant difference in the mean between the experimental (*Mean* =25.26, *N*=39, *SD* 3.33) and the controlled group (*Mean*=20.78, *N*=40, *SD* 5.47) in the Posttest overall score, $t(79) = 4.39$, $p = .00$.

Table-8. Independent Samples t-test for Student Posttest

		Levene's Test for Equality of Variances				
		F	Sig.	T	Df	Sig. (2-tailed)
Total Score of Post test	Equal variances assumed	5.03	.028	4.39	77	.000
	Equal variances not assumed			4.41	64.73	.000

The size effect, $d = 0.98$ represents a large effect size using Cohen's *d* criteria (Cohen, 1988).

4.4. Research Question 2

Is there any significant difference in the New SAT- HEART OF ALGEBRA skills achievement between students who studied in the flipped classroom strategy compared to the ordinary classroom?

Table-9. Independent Samples t-test for Student Posttest in Heart of Algebra skills

		Levene's Test for Equality of Variances				
		F	Sig.	t	df	Sig. (2-tailed)
Total Score of Post test	Equal variances assumed	.502	.48	4.34	77	.00
	Equal variances not assumed			4.34	76.75	.00

Table 9 shows that there exists a statistically significant difference in the mean between the experimental and the controlled group in the Posttest Heart of algebra skills score since $p = .00$.

4.5. Research Question 3

Is there any significant difference in the New SAT- PROBLEM-SOLVING AND DATA ANALYSIS skills achievement between students who studied in the flipped classroom strategy compare to the ordinary way of teaching math.

Table-10. Independent Samples t-test for Student Posttest in Problem Solving skills

		Levene's Test for Equality of Variances				
		F	Sig.	t	df	Sig. (2-tailed)
Total Score of Post test	Equal variances assumed	3.113	.082	.863	77	.39
	Equal variances not assumed			.867	71.59	.39

Table 10 shows that scores of the two groups did not differ statistically since $p = .39$, which is greater than .05.

4.6. Research Question 4

Is there any significant difference in the New SAT- PASSPORT TO ADVANCED MATH skills achievement between students who studied in the flipped classroom strategy compare to the ordinary way of teaching math?

Table-11. Independent Samples t-test for Student Posttest in Passport to Advanced Math skills

		Levene's Test for Equality of Variances				
		F	**Sig.**	**t**	**df**	**Sig. (2-tailed)**
Total Score of Post test	Equal variances assumed	2.840	.096	4.092	77	.00
	Equal variances not assumed			4.104	74.266	.00

Table 11 shows that is a statistically significant difference in mean Posttest hear of algebra skills score between the two groups, $t(79) = 4.104$, $p = .00$.

5. Discussion

5.1. Overall Posttest Scores

There was a significant difference in the posttest scores in favor of the flipped classroom group, a result similar to previous studies such as those in Love *et al.* (2013), Farah (2014), Quint (2015), and Martin (2015). The difference may be because the experimental group had the chance to practice more and they had the chance to interact more with their teachers and their friends. They shared their experience in each SAT question during the face to face class time. The variety of the online videos also helped students to understand more and practice more inside the class.

In contrast, the control group couldn't cover more questions at home since they already have another homework related to the algebra 2 curriculum, and they have different tasks for other subjects. When the teacher gave them some questions as a homework, the majority of the students left these unanswered and returned to the teacher for explanation.

5.1.1. Posttest Scores –Heart of Algebra Skills

The significantly higher mean of the flipped classroom students showed that their recall of the Heart of Algebra skills concepts was better that those in the ordinary classroom since the former used the videos to refresh their minds with the previous algebra 1 concepts like (solving, interpreting, graphing linear of equations and inequalities – system of linear equations and inequalities). Another reason could be that the level of the questions presented through the videos were easy to understand.

5.1.2. Posttest Scores –Problem Solving and Data Analysis

There was no significant difference between the two groups' mean scores in the Problem Solving and Data Analysis. This result can be explained as the problem solving skills need more practice. The six-weeks intervention was not enough to reinforce these skills. A similar result was obtained in a study by Johnson and Renner (2012). Another possible reason may be gleaned from the study of Mazza (2015), who also found out that that using online videos in a flipped classroom, may not help the students to understand the hard concepts at home, which need an instructor-modeled problem on the board. Seeing math videos online at home will create a lack of face-to face interaction, which will affect the students' understanding.

5.1.3. Posttest Scores–Passport to Advanced Math Skills

The significant difference in the Passport to Advanced math scores may be attributed to the fact that Passport to Advanced Math covers mostly the algebra 2 concepts like solving, and interpreting quadratic equations, operations with polynomial and rational functions, exponential functions, which were taught to the students recently in grade 11. Thus, they had the chance to practice more before the implementation of the study.

6. Conclusion and Recommendations for Further Research

As mentioned before, some studies showed that flipped classroom instruction could improve students' achievements compared with the ordinary classroom instruction, while some studies showed that the flipped classroom couldn't. As a conclusion from the research study and the literature review of flipped classroom studies, there are many factors which could affect the result of applying flipped classroom instruction, like the teacher's readiness and teacher's qualifications, the content, the quality of the videos, the in-class activities, and the student's commitment of seeing the videos before the lesson. This study may help teachers in the research site for planning and flipping some of their lesson to catch up with curriculum pacing. It may help also in the intervention plans of the lower achieving students. Teachers can use flipped classroom to improve the level of students, at the same time teachers teaching international exam concepts like SAT, AP calculus can use flipped classroom instruction to increase the amount of practice questions.

Educators who implement a flipped classroom can benefit from the following suggestions:

- **Teacher may use flipped classroom instruction as a part of intervention plans:** Teachers can use a flipped classroom instruction or in-class flipped classroom instruction to help lower achieving students, or students who usually fail in any exam, understand the concepts and also to review the lessons before their exams.
- **Schools can create an international exam committee, to prepare students for any international exam using flipped classroom instruction:** This committee will consist of members who are teaching international exams practices like SAT, AP and encourage them to prepare their videos and put it in a video bank, which will allow any teacher to use them in flipped classroom instructions.
- **Provide a professional development course for the teachers and students before applying the flipped classroom instruction**: Teachers should be ready for creating videos and activities, and students should have been trained how to get the main ideas from videos and how to use the content delivered by the video in understanding the main concepts.
- **Increase the communication between the administrators, teachers, students, and parents**: Before the implementation of any flipped classroom instruction teachers should explain to the administrators, parents, and students the purpose of using flipped classroom instruction in teaching.
- **Increase the duration of the study**: Implementation of flipped classroom periods should be increased, students will be familiar with flipped classroom and even the result will be more reliable.
- **Use flipped classroom in teaching the basics**: For the curriculum developers, when they are creating the curriculum documents, which include the unit plan and activities (curriculum mapping), they can assign the flipped classroom instructions as a choice of teaching the basics in each unit, or during the review lesson, in order to save more time for teaching the higher order thinking skills in mathematics.

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