Investigating the Impact of Flipped Learning on Mathematics Performance and Math Anxiety

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Abstract. Education system, whose aim is to prepare students for their future life, always lags behind changes at the societal, economic and personal levels and has difficulty in meeting their expectations. Educators must be challenged to discover new ways of thinking about education and they must be encouraged to apply new methods and techniques in the classroom. Traditional forms of classroom instruction limit the interaction between students, favoring only student-teacher interactions and students struggle with learning the content. Flipped classroom offers a solution for the issue, as its practice incorporates well with the new learning expectations. This study is an attempt to answer the following major questions: Do students learn more in flipped mathematics classrooms? Does flipped classroom decrease the math anxiety level of the students? The one semester study was conducted with 82 first year high school students from four classes divided in a control and an experimental study groups. The classes in the control group were taught by traditional method and the classes in the experimental group were taught according to flipped classroom strategy. After the experiment, the results reveal statistically significant difference of the mathematics achievement test scores between the experimental and the control groups, in favor of the experimental group, and statistically significant reduction of the math anxiety level only in the experimental group.

Key Words: Flipped Learning, Mathematics Performance, Math Anxiety

INTRODUCTION

Newer research on future students’ skills and concerted attention from policy makers, researchers and practitioners, finds the following students' skills the most important and challenging: critical thinking, creativity, metacognition, problem solving, collaboration, motivation, self-efficacy, conscientiousness, and grit or perseverance, [1]. All these desired skills, changes on students’ behavior and innovation in technology have caused teachers to look for new pedagogical strategies to instruct their students. Students are expected to develop problem solving skills and apply these skills to develop a stronger conceptual understanding of math and mastery of the skills. The issue for today’s teachers is that using traditional classroom teaching strategies will not satisfy the learning expectations of the new standards that require teachers to provide instruction and classroom time in order for students to develop a deeper level of understanding of content so that they may develop a stronger mastery of essential math skills, [2]. Traditional forms of classroom instruction limit the interaction between students, favoring only student-teacher interactions and students struggle with learning the content.

Flipped classroom offers a solution for the issue, as its practice incorporates well with the new learning expectations. Teachers have opportunity to incorporate multiple instructional strategies to address 21st century skills. Internet and mobile technology create a link between what is occurring in class and what is occurring at home and vice versa. Analysis of the impacts also shows that flipped classroom brought positive impacts toward students' learning activities such as achievement, motivation, engagement, and interaction. As a result a better mathematics performance and reducung the math anxiety is espected. Some of the papers that explore the effects of flipped classroom on math achievements or math anxiety are [3-5].

The results of this research can be particularly useful for raising teaching effects. In this artificial intelegence (AI) century while everything is changing very fast and take effect very quickly, teaching process cannot be think outside of this. The research results are going to be useful for the teachers for who are looking for new methods and techniques in their lessons and the administrators might wish to use it to make their institute more selectable.

Learning Models

One way to classify the educational learning objectives is using the Bloom's taxonomy. Bloom's taxonomy was created in 1956 under the leadership of educational psychologist Dr. Benjamin Bloom in order to promote higher forms of thinking in education, such as analyzing and evaluating concepts, processes, procedures, and principles, rather than just remembering facts (rote learning), [6]. According to it, the educational lerning objectives are classified in three domains: cognitive (mental skills, knowledge), affective (growth in feelings or emotional areas) and sensory (manual or physical skills). The cognitive domain categories (remebering, understanding, applying, analysing, evaluating, creating) has been the primary focus of most traditional education and is frequently used to structure curriculum learning objectives, assessments and activities.

It is inevitable to note that, many teachers in many classrooms spend the majority of their time in the basement of the taxonomy, never really addressing or developing the higher order thinking skills that kids need to develop. As a result, we cannot reach valuable and effective lessons but only boring classrooms. Of course the effect and pressure of the curriculum on teachers cannot be ignored. Much of today’s standardized testing rigorously tests the basement, further anchoring the focus of learning at the bottom steps, which is not beneficial for our students, [7].

Traditional Learning

Traditional learning is globally defined as teacher-centered delivery of instruction to classes of students who are the receivers of information. Teachers use lecturing as a tool to teach their subjects in traditional learning. The quality of traditional learning is directly related to the quality of the teacher. A good teacher asks questions and consider answers, engage students with active learning atmosphere during class time. Interactions with good teachers help motivate students to achieve higher marks. But more importantly it causes the students to develop a special interest and love for the subject he is teaching. Traditional classes are more suitable for young children, teenagers, and young adolescents who are yet to join the workforce. Regular attendance in classes helps them interact with other individuals of their own age, be better disciplined, follow a regular schedule, and improve their physical fitness and mental alertness. In a traditional classroom, students can directly share their views and clarify their own queries with the teacher, thus getting their questions answered right away. Also, classroom learning is more helpful due to a continuous interaction between students and teachers, as it helps students to get rid of their fears regarding exams, which can rarely happen with online guidance.

However, one of the main problems of traditional education is the lack of student motivation. Most of the time, students feel that the education system is not giving them a chance to express their skills and interests. Student participation in traditional education is another major problem. Students merely absorb information and they are passive listeners. The teacher is the sole source of information, the students are expected to listen and their participation is usually reduced to asking questions. According to Freire, a Brazilian educator and philosopher best known for his attack on what he called the "banking" concept of education, in which students are viewed as empty accounts to be filled by teachers, clames that the traditional education mirrors the society as a whole, [8].

Blended Learning

Blended learning is an education program (formal or non-formal) that combines online digital media with traditional classroom methods. It requires the physical presence of both teacher and student, with some element of student control over time, place, path, or pace. Blended learning represents all teaching models that are integrated with technology, such as e-mails, streaming media, social media, learning management systems, the Internet and mobile technology, and can be combined with traditional teaching methods, [9]. Teachers don't have to adapt all their lessons to a new method or technique when they are using blended learning and they cannot use the same method for every lesson, every subject. There are many factors that affect the productivity of a lesson. So, teachers are free to choose the right method up to aims of their lessons and students' level and this flexibility and freedom makes blended learning one of the most popular and easily applicable.

Within blended learning, numerous different pedagogical approaches exist including student centered learning, active learning, problem based learning and *flipped classroom*. Flipped learning was started by Bergmann and Sams (high school chemistry teachers in USA and developers of the "flipped classroom" model of teaching) when they recorded all of their chemistry and Advanced Placement (AP) chemistry lectures during the 2007/2008 school year for students to view at home, taking notes on what they learned and to practice more on topic in the classroom, [10].

Flipped classrooms, are one way of implementing active student centered learning, and a pedagogical method that helps educators to utilize the technology as a tool to increase the quality of the student learning experience, [11]. The basic concept of the flipped learning is to deliver teacher-created short video lectures to students before class time. It is not a new phenomenon for teachers to ask their students to be prepared for class. Reading the subject in advance from the textbook before come to the class or to do research about the new topic has been always among preferred methods. But with the convenience of new technologies, this phenomenon is more concentrated on video lessons. Students can watch and learn the video content in their free time, usually at home. During class time, students work on their classwork with teacher's more personalized guidance.

A flipped classroom offers students the benefit of greater control over their learning. They use class time for discussions to ask teachers for clarification, so their needs guide class time. When conducting hands-on experiments and practicing new skills in class, students can have more autonomy. They can explore new concepts in their own way, at their own pace, in a controlled and supportive environment. Another benefit is that teachers don't have to flip their entire class to benefit from this pedagogy. They can instead flip a single lesson to introduce their students to the concept, see how it works out, and go from there. The downside to flipped classroom is that, if not all students watch the videos or cannot understand the concept and so don't come to class with basic knowledge they need of the given topic, teacher may not focus on practice questions and cannot manage the class time well. And of course all students must access the internet for at-home learning.

Math Anxiety

Anxiety about performing well is a common experience for many students in math or math-based science courses. Often people experience math anxiety while participating in exams. Both math avoidance and poor performance on math tests can create more anxiety about math. A cycle of anxiety and avoidance can occur, which only increases the problem. People develop anxiety around math and math-related sciences for a number of reasons: receiving messages that you are not good at math, or that math is a hard and intimidating subject that can only be mastered by certain students; societal views about math that suggest that it is harder than other subjects and that competence in math should be valued more than competence in other disciplines; internal and external pressures to excel in math-based fields; the lack of explanation of the sub-steps of mathematical procedures; huge number of activities and drill exercises in a lesson; time limits on tests etc.

In his research, Mutodi claimed that it is actually the traditional mathematics classroom practices that cause the great anxiety among many students, [12]. These said traditional practices include imposed authority, public exposure and time deadlines. He added that the best way(s) to reduce anxiety and probably, a sense of competition and tension among students, is to apply teaching methods which include less lecture, more student directed classes and more discussions.

The measurement of mathematics anxiety has become increasingly important for identification of math-anxious individuals and evaluation of treatment programs for mathematics anxiety. One large-scale attempt to evaluate math anxiety across different countries was undertaken for data collected in the PISA 2003 program in 41 countries, [13]. Importantly, there are also approaches that still assume a uni-dimensional structure of Math anxiety based in the claim that asking a single question on how math anxious an individual is, may be also a valuable way of math anxiety assessment, [14]. Núñez-Peña et al. systematically tested the possibility of assessing math anxiety by using a single item measure called Single Item Math Anxiety Scale (SIMA), [15]. Although researches and debates are still going on about structure of math anxiety and effective questionnaires, the most widely known and commonly used questionnaires for the assessment of math anxiety are: Mathematics Anxiety Rating Scale (MARS), [16] and Abbreviated Math Anxiety Scale (AMAS), [17]. The MARS has one of the most comprehensive questionnaires concerning the inclusion of different facets of math anxiety, but it has 98 or 30 items. The AMAS is a shorter 9-item scale that mostly focuses on math test anxiety and numerical anxiety and it is characterized by very good psychometric properties. A detailed psychometric evaluation of the AMAS is done, examining internal consistency, test-retest reliability and several validity measures, [17]. In this study, measuring the math anxiety is done with the AMAS questionary, [18].

The Current Study

The aim of this study is to answer the following major questions: Do students learn more in flipped mathematics classrooms? Does flipped classroom decrease the math anxiety level of the students? In order to answer these questions, math achievement and math anxiety results before and after the experiment with a flipped classroom are compared to the respective results from a traditional classroom.

METHODS

The study was conducted among the first year high school students from the Yahya Kemal Private College in Skopje, Macedonia, to find out how one semester flipped learning in mathematics class impacts their mathematics performance and math anxiety in comparission to traditional learning, [18]. Thus, the experimental method was used for designing two groups, experimental and control, where the experimental group was taught through flipped classroom strategy, while the control group was taught in the traditional way. Tools applied in this study were: Achievement Tests conducted for measuring academic level of the students adhering to the Bloom principles and AMAS Questionnaire for measuring the math anxiety.

Participants

The population of the study consisted of 82 students from the first year in Yahya Kemal Private College in Skopje, Macedonia, in the first term of the academic year of 2018/2019. Classes 1A and 1B with 41 students (21 male and 20 female) are selected for the traditional teaching (control group), while 1C and 1D classes with 41 students (22 male and 19 female) are selected for the flipped classroom (experimental group). Among the participants, gender is roughly evenly distributed (i.e., male 52% and female 48%). Separation of these four classes as control and experimental groups is made after the Pre-Achievement Test and answering the Math Anxiety AMAS Questionnaire at the beginning of the semester, thus making sure that there is no significant difference between the two groups in terms of both mathematics pre-achievement score ($p=0.201>0.05$) and overall math anxiety level ($p=0.813>0.05$).

Design of Study

Before the experiment, the both experimental and control groups were given a Pre-Achievement Test (prepared based on primary school curriculum) and AMAS Questionnaire.

During the experiment, students in the flipped clasroom were given assignments for each lesson using an interactive online courseware posted on Schoology, [19]. This courseware contains lecture videos and learning activities (e.g., worksheets, questions), selected and put by the teacher. Students were required to watch the numbered videos and take notes in their notebooks. At school, math classes in the flipped classroom were different from traditional lectures as they involved group studies and focused on practice. Students didn’t have any homework after the lessons but they had to come to class ready by watching videos and to take notes. During the classes, the teacher's role is to visit each group several times and to manage the process.

Students in the control group had traditional lectures in the school. They did not have to watch video or come to class ready for the new lesson, but they had to complete their homework for the next class. Students in the flipped and traditional classes used the same books and took the same individual quizzes and exams. Both traditional and flipped class students had access to these videos which were posted on the learning management system Schoology. In contrast to the flipped class students, traditional class students used the time in classroom to review the previous class material rather than to work on new material.

After the experiment, the both goups took an Achievement Test (prepared based on the topics studied during the first semester of 2018/2019 educational year), and again AMAS Math Anxiety Questionnaire.

Statistical Analysis

Numerical data colected from Achievement Tests and AMAS Questionnaires were statisticaly analysed. Kolmogorov-Smirnov and Shapiro-Wilk test of normality for the data from the achievement test are applied, nonparametric Mann-Whitney U Test is used to determine if there is any significant difference in results from achievement tests of the experimental and control group. Paired samples t-test is used determine if there is any significant difference in math anxiety levels before and after the experiment in the both groups, experimental and control. For the statistical analysis, the SPSS software platform is used.

RESULTS

Descriptive statistics shows that all 82 students took the both tests, Pre-Achievement and Achievement Test. For the both tests, the minimum test score is 10, and the maximum test score is 100, which is the maximum possible score. The Pre-Achievement Test results are with M=48.34, SD=31.989, and the Achievement Test results are with M=65.62, SD=30.407. The box-plots with the summary of the test results in the control (AB) and the experimental (CD) groups are shown on Figure 1. The box-plots on Figure 1 indicate improvement in mathematics achievement in the flipped classroom (the experimental group). To test if this improvement is significant, first, tests of normality are made. The both tests of normality, Kolmogorov-Smirnov and Shapiro-Wilk, failed to find statisticaly significant normaly distributed data among the results from the Pre-Achievement and Achievement Tests, on the significant level α=0.05, [18].

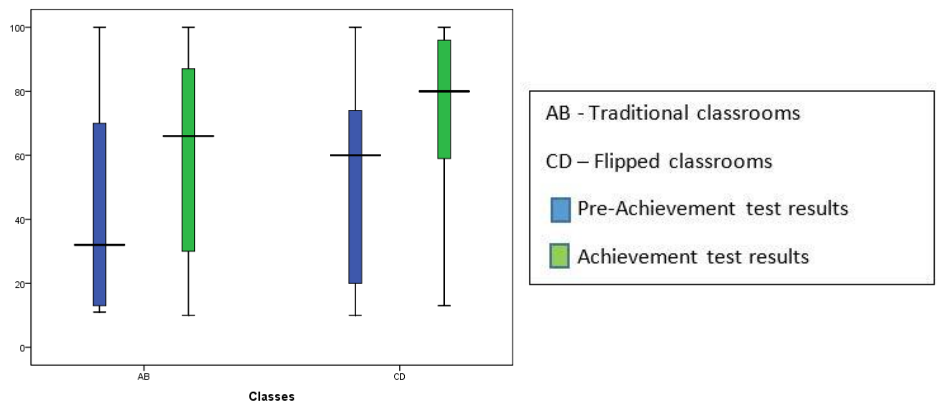

FIGURE 1. Box-plots for Pre-Achievement and Achievement test results for the control (AB) and the experimental (CD) groups.

To test the hypothesis that the flipped learning increase the academic achievements in mathematics, the results from the achievement tests of the experimental group are compared to the results from the achievement tests of the control group using the nonparametric Mann-Whitney U Test (Table 1). According to these results, there is no significant difference in Pre-Achievement Test results between the experimental and the control groups (p=0.181>0.05), but there is a significant difference in Achievement Test results between the groups (p=0.043>0.05). We can summarize that students' knowledge learning performance significantly improved in the experimental group, so they achieve better test score with flipped classroom rather than control group taught with traditional method.

	Pre Achievement Test Results	Achievement Test Results
Mann-Whitney U	696.500	622.500
Wilcoxon W	1557.500	1483.500
Z	-1.337	-2.023
Asymp. Sig. (2-tailed)	**.181**	**.043**

TABLE 1. The Mann-Whitney U Test results for the control and the experimental group according to their achievement test results.

To test if the flipped classroom decrease the math anxiety level of the students, the scores from the AMAS Questionnaires for the both groups, the experimenatal and the control, before and after the experiment are analysed. The maximum score on an AMAS Math Anxiety Questionnaire is 45, which is declated as the highest math anxiety level.

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	ABallfirst	18.15	41	8.404	1.312
	ABalllast	17.41	41	6.046	.944
Pair 1	CDallfirst	18.56	41	7.352	1.148
	CDalllast	15.32	41	5.298	.827

TABLE 2. Paired Samples Statistics of the experimental and the control groups on the math anxiety, before and after the experiment.

Table 2 shows that the mean math anxiety scores of the experimental group before and after the flipped classroom experiment are 18.56 (SD=7.352) and 15.32 (SD=5.298) respectively, that indicates a decrease of the math anxiety level among the students in the flipped classroom. The mean math anxiety scores of the control group at the beginning and the end of the first semester are 18.15 (SD=8.404) and 17.41 (SD=6.046) respectively, that indicates that the math anxiety level among the students in the traditional classroom has decreased slightly. To find if these decreases in the math anxiety scores are significant, the Paired Samples t-Test is taken (Table 3).

		Paired Differences					t	df	Sig. (2-tailed)
					95% Confidence Interval of the Difference				
		Mean	Std. Deviation	Std. Error Mean	Lower	Upper			
Pair 1	ABallfirst - ABalllast	.732	9.384	1.465	-2.230	3.694	.499	40	**.620**
Pair 1	CDallfirst - CDalllast	3.244	7.797	1.218	.783	5.705	2.664	40	**.011**

TABLE 3. Paired Samples t-Test between the experimental and the control groups on the math anxiety, before and after the experiment.

According to the results presented in Table 3, the decrease in math anxiety score is significant ($p=0.011<0.05$) in the experimental group, before and after the flipped classroom experiment, while there is no significant decrease in math anxiety score ($p=0.620>0.05$) in the control traditional learning group, at the beginning and the end of the semestar. So, the flipped learning significantlly reduced students' math anxiety scores.

CONCLUSION AND DISSCUSION

This study aimed at investigating the effects of flipped classroom method among first grade high school students on their math achievements and math anxiety level. To this end, two study groups were formed: an experimental group including students learning through the flipped classroom model, and a control group including participants taught through traditional classroom model. At the beginning of the experiment, an independent sample t-test was applied in both groups' pre-Achievement test results, and it was found out that there were no statistically significant differences ($p=0.201>0.05$) in mathematics academic levels between the groups. No significant differences ($p=0.813>0.05$) were found between math anxiety scores of the experimental and the control group at the beginning of the experiment.

During the experiment, the students in the experimental group were expected to watch online videos in the Schoology portal and write down the content of the videos in their notebooks. They were also provided with online practice problems. To reveal the impacts of the flipped classroom model on the students' academic achievement, a non-parametric Mann-Whitney U test was used to see whether there were significant differences between the Achievement test results of the experimental group and control group at the end of the experiment. The results indicated that there is statistically significant difference between the Achievement test results between the groups. Namely, the findings showed that the use of the flipped classroom yield significant impacts ($p=0.043<0.05$) on increasing the students' academic achievement in experimental group. The results of this study showed that the flipped classroom method was more effective than traditional classroom in terms of improving attitude toward mathematics.

The results of math anxiety questionnaires in both groups indicated that the attitudes of the experimental group were significantly ($p=0.011<0.05$) positively changed, whereas the control group failed to show a significant result ($p=0.620>0.05$) in lowering the math anxiety scores.

From the teacher's experience during the experiment, flipped classroom’s design of classroom instruction proved beneficial in creating an atmosphere where students feel positive towards math classes and math as a whole. The teacher decided to let students in the flipped classroom peer-to-peer learning during classroom time. Peer-to-peer learning helps to build an active and cooperative learning environment. While improve communication skills, achievement, and productivity, it also promotes ownership of learning and deeper understanding of new concepts.

The results from our study are encouraging when it comes to maximizing the potential of the flipped classroom to positively impact student performance and course satisfaction, and to allow teaching load to be spread between teachers.

Future studies may include more methods of data collection, such as interviews and self-reports, examining gender and grade differences, to achieve greater validity of the data and a deeper understanding of the relationships among students’ academic achievement, math anxiety level and flipped classroom method.

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Истражување на влијанието на методот на превртено учење врз постигнувањата по математика и анксиозноста од математика

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Апстракт. Образовниот систем, чија цел е да ги подготвува учениците за нивниот живот во иднина, секогаш заостанува зад промените на социјално, економско и лично ниво и се соочува со потешкотии да ги задоволи нивните очекувања. Наставниците треба да се охрабруваат да откриваат нови начини на кои ќе размислуваат за образованието и треба да бидат охрабрувани да применуваат нови методи и техники на своите часови. Традиционалните форми на настава ја ограничуваат интеракцијата меѓу учениците, фаворизирајќи ја само интеракцијата ученик-наставник, па учениците се соочуваат со потешкотии при совладување на материјалот. Методот на превртено учење нуди едно решение на овој проблем, бидејќи сосема добро се вклопува во новите очекувања за учењето. Спроведовме истражување во обид да најдеме одговори на следните прашања: Дали учениците може да научат повеќе математика со методот на превртено учење? Дали методот на превртено учење го намалува нивото на анксиозност од математика кај учениците? Истражувањето беше спроведено во текот на едно полугодие, во него беа вклучени 82 ученици од прва година средно училиште од четири класа кои беа поделени во две истражувачки групи, контролна и експериментална. Класовите од контролната група учеа според традиционалниот метод, а класовите од експерименталната група учеа според методот на превртено учење. По спроведеното истражување, резултатите открија статистички значајна разлика во постигнувањата по математика на завршниот тест на знаење меѓу експерименталната и контролната група, во корист на експерименталната, и статистички значајно намалување на нивото на анксиозност од математика само во експерименталната група.

Клучни зборови: превртено учење, постигнувања по математика, анксиозност од математика