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PHD THESIS

**The effects of teaching applications of
mathematics in other disciplines in high school
teachers and students in Israel**

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Introduction

Mathematics is a very important subject, and it is used in various fields such as physics, chemistry, biology, economics, engineering, but also in daily life. Although mathematics is considered a crucial subject, it is perceived as a difficult, problematic subject among many high school students (Dulaney, 1994).

Cenberci (2019) stated in his article that Many students have difficulty with mathematics classes, and this creates increased levels of anxiety in them because they think they cannot succeed in math. This anxiety and low self-efficacy lead to the development of negative attitudes towards mathematics lessons. Such negative attitudes towards mathematics affect negatively students' achievement in mathematics (Kurbanoglu & Takunyacı, 2012).

Students' attitudes towards mathematics play a major role in the process of learning mathematics. It has a great influence on the students' achievements in mathematics, as students' positive attitudes lead to success in learning mathematics (Gallagher & De Lisi, 1994; Mechaels & Forsyth, 1978; Yasar, Çermik, & Güner, 2014). Students gradually develop negative attitudes toward math lessons in the learning process from the elementary school stage to the final grade of high school (Baykul, 1990). Generally, high-school students' attitude towards mathematics is on a medium level (Yasar, 2016).

Thus, improving attitudes of students towards mathematics at a lower level provides a basis for a higher level of mathematics studies and causes an impact on the achievements of high school students in mathematics (Ma & Xu, 2004).

In addition, the attitude of mathematics teachers towards teaching mathematics is a very important issue, as it influences the methods used by the teacher, which has impact on pupils' attitude towards mathematics (Relich & Way, 1994; Skemp, 1976; Tuimavana & Datt, 2017) and their mathematics achievement (Relich & Way, 1994). Skemp (1976) argued that the development of positive attitudes to mathematics is dependent on the type of teaching. As well as attitudes of teachers have a big effect on their way of teaching mathematics and on students' attitudes towards mathematics. In particular, the positive attitudes of teachers have a positive effect on teaching mathematics among students and among attitudes of students towards mathematics (Moreira, 1992; Karp, 1991).

Mathematics applications and the teaching of mathematics applications are the subject of international conferences and author articles (Stillman et al., 2013).

The present study aims to find out the effect of teaching applications of mathematics in other disciplines *on Israeli high school teachers and students' attitudes towards mathematics, students' involvement in the class activity, and the students' mathematical achievement* through experimental research. There are only a few studies presenting experimental research regarding teaching applications of mathematics (for example, Kasmin, Othman & Syed Ahmad, 2019; Yildirim & Sidekli, 2018), and most of them for higher education. Thus, this research tries to contribute to this subject filling in some gap in the scientific literature.

Key Words: attitudes towards mathematics, mathematical achievement, applications of mathematics, teaching applications of mathematics, teaching anxiety, confident and enjoyment in teaching, teachers' burnout, innovation in teaching.

The motivation of choosing this topic

- Mathematics is a difficult subject for many students, especially in high school. This difficulty leads to anxiety about mathematics in a considerable percentage of the students, and also creates boredom and failure in mathematics, the result of which is hatred of mathematics and negative attitudes towards mathematics among students.

- Teaching methods have an effect on the difficulty in the students and their attitudes towards mathematics.

Students don't see the utility of mathematics in everyday life or other study fields, as disciplines are taught separately. Also, in many cases, the application of mathematics in other disciplines are difficult for students, in particular in the subject of maximum and minimum problems, which pushed and motivated me to investigate this problematic.

-There are no mathematics teaching attitude questionnaires for post-primary school teachers and there are limited papers addressing teachers opinion and practice on teaching

applications of mathematics. This research examines an important topic in teaching mathematics with the aim of filling a gap in the scientific literature.

For this reasons, I am full of motivation, hope, and belief that I was able to develop a new practical learning model in the field that combines mathematics with the various fields of science, and I also believe that I was able to cause a positive change in teachers and students, a change that led to more curious, motivated students, who have positive attitudes towards mathematics, And an improved achievements. In addition, while teaching applications of mathematics, teachers also developed a more positive attitude towards teaching mathematics and their motivation to teach mathematics increased.

The structure of the thesis

The thesis contains five main chapters:

Chapter 1. Teaching applications of mathematics in other disciplines

Chapter 2. Attitudes toward mathematics and teaching of mathematics

Chapter 3. Preliminary studies on teachers attitudes toward teaching mathematics and mathematics applications

Chapter 4. Research on teaching applications of mathematics in other disciplines for the topic: maximum-minimum problems

Chapter 5. Summary and Discussion

Chapter 1. Teaching applications of mathematics in other disciplines

Mathematics is a very important subject in our daily lives in general and in the disciplines studied in school in particular. It is used in many fields such as: physics, chemistry, biology, economics, engineering, and other various fields. Mathematics is important for every student and especially among high school students.

Mathematics has applications not only in the various fields of knowledge such as physics, chemistry, economics, biology, etc., but in our everyday lives, such as in selling and buying, in building, in business, in bank services, in salary calculations, in real estate and more. The application of mathematics in our lives is considered an essential and very important issue.

Also, in this chapter I showed the effect of the teaching methods of the mathematics teachers on the students' learning of mathematics and I will focus on teaching applications of mathematics in other disciplines and its effect on both teachers and students.

Students graduate from high school and yet are unaware that mathematical knowledge, mathematical skills, and mathematical applications are necessary for success in life, in their future studies, and in designating their careers. This can be explained by the teaching strategies used which neither expose to the student the relevance of mathematics, nor develop his thinking and understanding of the subject. By using these strategies, the student learns in an algorithmic and procedural way of solving exercises from the textbooks. Many students study math because they must study and pass exams.

Clark (1990) noted that mathematics for many students has a negative image. Well because of this image, it is difficult for these students to improve their mathematical understanding at the expense of their attitudes.

Then, the motive behind investigating the effect of teaching applications of mathematics on the aforementioned factors was on the one hand that few studies have investigated this phenomenon and secondly teaching applications of mathematics in other disciplines is significant issue, it increase the motivation of students to learn mathematics, interest the students and show them the importance of mathematics in the various fields of science and in his daily life and so it helps the student to improve the mathematical understanding of

his environment and correlate mathematics to life and to the various fields of science, such as physics, chemistry, technology, etc., which help many students solve the problematic in teaching mathematics and designate his future career (Asli & Zsoldos-Marchis, 2021).

As well as teaching applications of mathematics in other fields has many benefits and advantages. It helps the student to improve the mathematical understanding of his environment and to correlate mathematics to life and the various fields of science, such as physics, chemistry, economics, technology and more. So that teaching applications of mathematics allows the student to see the use of mathematics, and this allows the student to visualize mathematics, to understand it and to see the beauty of mathematics (Asli & Zsoldos-Marchis, 2021) which makes the student enjoy learning mathematics, which helps the student to designate his future career.

Many articles, like (Chick and Stacey, 2013; Asli & Zsoldos-Marchis, 2021; Asli & Zsoldos-Marchis, 2022) showed positive effects and benefits of teaching applications of mathematics in other disciplines: on students and teachers, on their attitudes toward teaching mathematics and on teaching mathematics in general. For example, teaching applications of mathematics enhances the learning atmosphere in math classes and turns a routine atmosphere into an active one for both teachers and the students as well as students' attitudes towards teaching mathematics have changed for the better and this led to a significant improvement in student achievement (Asli & Zsoldos-Marchis, 2022).

As we mentioned above, several articles and studies, like: (Clark, 1990; Karp, 1991; Burton & Shelton, 2010; Sweeting, 2011; Tabuk, 2018; Tuimavana & Datt, 2017) dealt with teachers' attitudes towards teaching mathematics and the importance of teaching applications of mathematics in other disciplines, but none of them dealt with the relation between teachers' attitudes and teaching applications of mathematics. This study is new in the field because it examines the effect of a new factor "teaching applications of mathematics in other disciplines" on students' attitudes towards mathematics and teachers' attitudes towards teaching mathematics.

Despite the importance and benefits of learning applications of mathematics, studies have shown that there are some obstacles in learning applications of mathematics; some of these obstacles are related to the teachers, some to the students, and some to the organizations

and administrators. Some of the obstacles are related to lack of preparedness of the teachers and students. Students have poor background in sciences thus they do not appreciate or understand the applications (Pinker, 1978; Clark, 1990; Asli & Zsoldos-Marchis, 2021).

In this regard, the present study intends to reveal students and teachers' opinion and practice on teaching applications of Mathematics in other disciplines. The research focuses on students and teachers' view about the benefits and obstacles of teaching applications of mathematics, plans to find out if teachers use applications of mathematics in their teaching, and to collect those teachers' methodological ideas, who use applications.

Chapter 2. Attitudes towards mathematics and teaching of mathematics

2.1. Attitudes. Definition and Concept clarification

There are many definitions of the concept “attitude” in the literature. For example, Eagly & Chaiken (2007) defined an attitude as “a psychological tendency expressed by evaluating a certain entity to a certain degree positively or negatively.

Bizer, Barden & Petty (2003) in their article “Attitudes” they said: attitudes are considered one of the foundational concepts of psychology because they help explain human actions and decisions. An attitude is an ongoing evaluation of the person or any other object.

Also, attitude is defined as an individual's evaluation for or against a certain object (Zeiv, 2001). The object to which attitude refers may be of different types - a specific object such as a mathematics lesson that was conducted today, a general one such as the subject of mathematics in general, an abstract object such as the subject of education.

As well as, there are several definitions of the attitude towards mathematics in literature. In this study the multidimensional definition of Neale (1969) was selected, based which attitude towards mathematics is “a liking or disliking of mathematics, a tendency to engage in or avoid mathematical activity, a belief that one is good or bad at mathematics, and a belief that mathematics is useful or useless” (p. 632).

As seen from the above definition, attitude towards mathematics has several components. In some literature three components are identified: enjoyment of mathematics, value of mathematics, and confidence in mathematics (Mullis et al., 2020). Other research identified four components: motivation, enjoyment, self-confidence, and value (Davadas & Lay, 2017; Tapia, 1996).

2.2. Attitudes of teachers towards teaching mathematics

Attitudes of mathematics teachers towards teaching mathematics are very important issues and greatly affect the quality of teaching mathematics, affects the student and his attitudes towards mathematics. Students' attitude towards mathematics is in correlation with their mathematical achievement. Also, different teaching methods have different impacts on the learning outcomes.

Attitudes of mathematics teachers and students is a common issue in the literature of mathematics education. many studies, like: (Moreira, 1992; Baturu & Nason, 1996; Keller, 2001; Marchis, 2014; Tuimavana & Datt, 2017) have investigated the attitudes of mathematics teachers and students and the effect of the attitudes of the teachers and students towards teaching mathematics among teaching methods of the teachers and the motivation and achievements of the students. These studies have shown that attitudes towards teaching mathematics have a tremendous effect on teachers and students alike, so positive attitudes of teachers towards teaching mathematics have a positive effect on the teachers themselves, on the teaching methods of the teachers, in addition the teachers will be highly motivated to teach mathematics.

As well as positive attitudes of teachers affect the students positively, so that the motivation of the students towards learning mathematics increases, the self-confidence of the students increases and their success in mathematics increases, and the opposite is true.

2.3. Attitudes of Students towards mathematics

The attitudes of students towards mathematics have a great influence on the learning process for the students and on the students' achievements, and in particular the influence is greater for the students' attitudes on the achievements.

So positive attitudes have a positive effect on learning mathematics among students and among attitudes of students towards mathematics (Skemp, 1976; Ernest, 1989; Karp, 1991; Moreira, 1992; Wilkins, 2002; Tuimavana & Datt, 2017).

There are many reasons why students show negative attitudes towards math lessons, such as: students can't understand mathematics, students are insecure, students feel anxiety about mathematics and teachers are one of the most important factors. Teachers are actually a major reason that causes students to exhibit negative attitudes toward mathematics (Clark, 1990; Dulaney, 1994; Nkhase, 2002; Peker, 2016).

Positive attitude towards mathematics has many benefits for learning, it decreases anxiety (Aiken, 1976), ensures active involvement in the learning process (Singh, Granville & Dika, 2002).

It has long been known that there is a connection between successes in mathematics and students' attitudes towards mathematics. Studies in the field so far have shown that students with a highly positive attitude towards mathematics also have higher levels of success (Yasar, Çermik & Güner, 2014).

Aysun (2017) said that students who are successful in mathematics with high scores have positive attitudes towards mathematics and vice versa.

Also, students' attitudes towards mathematics has a great influence on the achievements of the students in mathematics, So that positive attitudes of students towards mathematics lead to successes of students in mathematics. Improving attitudes of students towards mathematics at a lower level provides a basis for a higher level of mathematics studies and also causes an impact on the achievements of high school students in mathematics (Ma & Xu, 2004).

Chapter 3. Preliminary study on teachers' attitudes towards teaching mathematics and mathematics applications.

The aims of this research are the following:

1. Developing post-primary school teachers' attitudes toward teaching mathematics scale and teaching applications of mathematics (by questionnaire that examines teaching applications of mathematics).
2. Identifying the factors which are assessed by the teachers' attitudes toward teaching mathematics scale.
3. Investigating post-primary school teachers' attitudes toward teaching mathematics.
4. Investigating post-primary school teachers' opinion and practice regarding teaching applications of mathematics.

3.1. Development of a teachers' attitudes toward teaching mathematics scale and teaching applications of mathematics (by questionnaire that examines teaching applications of mathematics).

The research instrument was a questionnaire developed for this study based on scientific literature like: Muthohir, Lowrie and Patahuddim (2018), Moreira (1992), Tuimavana and Datt (2017) and Mofet Institute in Israel (1999).

The questionnaire is designed for the purpose of surveying teachers' opinions and practice on teaching and integrating applications of Mathematics in other disciplines.

The questionnaire consists of two main parts: a demographic part and questions related with the research topic. The demographic part contains 10 questions, most of them closed. The second part consists of two groups of items. The first group contains of 31 closed items, with the aim of assessing post-primary school mathematics teachers' attitudes towards teaching mathematics. These 31 items are affirmations measured on a 5-level Likert scale from 1 = strongly disagree to 5 = strongly agree. The second group contains 18 questions on teaching applications of Mathematics in other disciplines, from which 15

are closed questions (multiple choice, check box, scale, affirmations measured on a 5-level Likert scale) and 3 open questions.

The questionnaire developed uses items from the scales of Nisbet (1991) and Relich, Way and Martin (1994), but also some items from the mathematics anxiety scale presented by Hunt and Hari (2019). There are also some items formulated by the author based on surveys related to instructional practices or attitude towards teaching practices.

The scale is included into Annex Number 6

3.2. Data collection and participants

The scale was filled out in 2021 by 221 mathematics teachers from post primary schools from Israel. The scale was sent as a Google Form to participants. The participation was voluntary. All participants answered all questions of the questionnaire.

The mean age of the participants was 41.1 years and the mean teaching experience 16 years.

The demographics of these participants are listed in Table 1.

Table 1. Demographic characteristics of participants

Variable		Frequency	Percent
Gender	Male	82	37%
	Female	139	63%
Nationality	Arab	201	91%
	Jewish	20	9%
Degree	BSc degree	99	44.8%
	MSc degree	119	53.8%
	PhD degree	3	2.4%
Level of class they teach	Middle school teachers	99	44.8%
	High school teachers	122	55.2%
Type of school in which they teach	Theoretical	183	82.8%
	Religious	3	1.4%
	Technology	23	10.4%
	Private	12	5.4%

3.3. Factor analysis for the post-primary school mathematics teachers' teaching mathematics attitude scale

Methodology

The research was conducted in 2021 in Israel. It focuses on the 2nd aim: Identifying the factors which are assessed by the teachers' attitudes toward teaching mathematics scale. The research instrument used is the post-primary school mathematics teachers' teaching mathematics attitude scale presented in subchapter 3.1 and in Annex Number 6. The participants are described in subchapter 3.2.

Results

Initially, the scale consisted of 31 items.

-Performing factor analysis and analyzing the reliability of the obtained factors, a solution of 5 factors containing 20 items was created.

The obtained factors are the following:

- Mathematics teaching anxiety.
- Confident and enjoyment of teaching mathematics.
- Burnout as a mathematics teacher.
- Innovation in teaching.
- Confidence in mathematics.

3.4. Israeli post-primary teachers' attitude towards teaching mathematics

Methodology

The research was conducted in 2021 in Israel. It focuses on the 3rd aim: Studying post-primary school teachers' attitudes toward teaching mathematics. The research instrument used is the post-primary school mathematics teachers' teaching mathematics attitude scale described in subchapter 3.1 and presented in Annex Number 6. The participants are described in subchapter 3.2.

For the data analysis only those 20 items were taken into consideration, which was obtained by the factor analysis presented in subchapter 3.3. (see Annex Number 7) with the following factors: Mathematics teaching anxiety, Confident and enjoyment of teaching mathematics, Burnout as mathematics teacher, Innovation in teaching, Confidence in

mathematics, and Feeling Support. The obtained data were quantitatively analyzed using SPSS program. The results include descriptive statistics (frequency, percentage, mean (M), and standard deviation (SD)), comparisons and correlations between the factors. Statistical test that are use: T test, F test, One Way ANOVA, and correlations.

Results

The results showed in table number 2 indicate that teachers are confident in mathematics and in teaching. The highest mean is for confident in mathematics and confident and enjoyment in teaching (the means are 4.75, respectively 4.61), from which can be concluded that the attitudes of most teachers in Israel to mathematics teaching are positive.

It could be observed that the highest mean (4.75) is for confidence in mathematics and the lowest mean is for burnout (2.45). The mean for mathematics teaching anxiety is quite high (3.43).

Table 2. Descriptive Statistics of the six factors

	N	Minimum	Maximum	Mean	Std. Deviation
Anxiety	221	1.17	5.00	3.4382	.89397
confident and enjoyment in teaching	221	3.00	5.00	4.6161	.41541
Burnout	221	1.00	5.00	2.4525	.98771
Innovation in teaching	221	1.00	5.00	4.1109	.73247
confident in mathematics	221	2.00	5.00	4.7579	.46122
Feeling Support	221	1.00	5.00	4.0837	.85467
Valid N (listwise)	221				

There are also correlations between the age and teaching experience variable with the anxiety and feeling support factors. The older teachers are more experienced in teaching mathematics, also they feel more supported. Teachers with little experience and young age feel more anxiety in teaching math than teachers with greater experience and older age. Younger teachers are more innovative in teaching mathematics than older age teachers.

In addition, there are some correlations between the factors of the scale:

- Teachers with more teaching anxiety are feeling more burnout.
- Teachers with less teaching anxiety are feeling more support and they are more innovative in teaching mathematics.
- Teachers with confidence and enjoyment in teaching mathematics are confident in mathematics, more innovation in teaching mathematics, feels more supported, also teachers with little confident and enjoyment in teaching mathematics feels more burnout.
- Teachers with excellent level of computer and technology control are more confident and feel more enjoyment when teaching mathematics than teachers with middle and low level of computer control.
- Teachers with excellent level of computer and technology control are more confident in mathematics than teachers with middle and low level of computer control.
- Teachers with excellent level of computer and technology control are more innovative in teaching than teachers with middle and low level of computer control.

3.5. Preliminary study on teachers' opinion and practice on teaching applications of mathematics in other disciplines.

The present study intends to reveal the teachers' opinion and practice on teaching applications of Mathematics in other disciplines. The research focuses on teachers' view about the benefits and obstacles of teaching applications of mathematics, plans to find out if teachers use applications of mathematics in their teaching, and to collect those teachers' methodological ideas, who use applications.

Methodology

The research was conducted in 2021 in Israel. This study focuses on the 4th aim: studying post-primary school teachers' attitudes toward teaching applications of mathematics. More precisely, the aim is to find out teachers' opinions and practice regarding teaching applications of Mathematics in other disciplines. The research instrument used is the teaching application of mathematics questionnaire developed for this study, described in subchapter 3.1 and presented in Annex Number 6, The participants are described in subchapter 3.2.

Research instrument and participants

The research instrument was a questionnaire as described in subchapter 3.1 (see subchapter 3.1).

Data Analysis

The closed questions were quantitatively analyzed using SPSS program. The results include frequency, percentage, mean (M), and standard deviation (SD).

Open-ended questions were qualitatively analyzed using categorical data analysis.

Results

Teachers' opinion about the benefits of teaching applications of Mathematics

Teachers consider important the teaching applications of Mathematics ($M = 4.24$, $SD = 0.52$). They were asked to measure on a 5-level scale some benefits of teaching applications of Mathematics (Table 3). All the listed benefits are considered valid by the participants: the mean for each one is above 4 and the standard deviation is below 0.80. The highest mean was obtained for expanding students' horizon and showing students the importance of Mathematics.

Table 3. Teachers' perception about some benefits of teaching applications of Mathematics

Benefit	Mean	Standard deviation
arising students' interest for Mathematics	4.16	0.72
motivating students for learning mathematics	4.19	0.69
showing students the importance of mathematics	4.33	0.66
exercising mathematical knowledge	4.20	0.70
developing competency of using a mathematical knowledge in different context	4.31	0.60
improving achievement of students in mathematics	4.10	0.72
expanding the horizon of the student	4.34	0.63
developing a positive attitude towards mathematics	4.26	0.72

In another closed questions respondents were asked to select the most important two advantages of teaching applications of Mathematics from a given list. The three most selected advantages were the following: arising students' interest for Mathematics (98

participants - 44.3%), motivating students for learning mathematics (77 participants - 34.8%), and showing to students the importance of mathematics (21 participants - 9.5%).

Teachers' practice in teaching applications of Mathematics

42.5% of the participants teach applications of Mathematics.

Table 4. Comparing age, teaching experience and computer user skills of those don't teaching applications with those teaching applications according T test by SPSS program.

Variable	Don't teach applications			Teach applications			t	p
	M	df	SD	M	df	SD		
Age	40.3	208	9.6	42.1	219	8.9	1.3	.170
Teaching experience	15.4	207	9.6	16.9	219	9	1.1	.230
Computer user skills	1.9	203	0.66	1.5	219	0.64	-3	.002

Note: computer user skills measured on 4-level scale (1=Excellent, 2= Good, 3=Medium, 4=Low).

The conclusion drawn from table number 4 above is that teachers who teach applications of mathematics in other disciplines have a higher skill of computer than teachers who do not teach applications of mathematics in other disciplines.

Also, Physics is the discipline in which applications are mostly integrated (47% of those respondents who teach applications). Almost half of the respondents who teach applications (47,9%) integrate them in their lessons a few times a semester.

asked how they teach applications Participants were. Half of the surveyed teachers present it to their students (52.1%), the other half give students some tasks through they discover how they can apply the mathematical knowledge (45.7%).

Obstacles of teaching applications of Mathematics

Teachers who are not integrating applications in their lessons, were asked in an open question the reason why they not. The responses were qualitatively analyzed, and categories were identified in table 5 below.

Table 5. Categories analysis about the reasons why responses not integrating applications in their lessons

Category	Frequency for the Category	Subcategory	Frequency for the Subcategory
Time-related issues	33%	-There is no time for it in the classroom. -Time for preparing lots of study materials.	70% 30%
Problems related to the background of the teachers and the students.	31%	- Students have a poor background in the sciences to understand the applications. - Students have a poor background in the sciences to appreciate the applications. - Teachers are unable or have no skills to teaching mathematical applications in other disciplines. - Teachers have no confident in teaching it.	36% 20% 40% 4%
Problems related to the curriculum.	30%	- It is not included in the curriculum of Mathematics. - Applications of math not required in the exams.	79% 21%
Planning and budget related issues	6%	- Some applications require equipment and demonstrations. - Applications a number of mathematical skills which are normally attained at the end of the mathematics program.	83% 17%

Also, participants had to select from a given list the two main important obstacles of using applications in teaching Mathematics. The 3 most frequently selected obstacles are the

following: time constraints (30.8%), lack of methodological or pedagogical content knowledge of the teachers (24.6%), and curriculum constrains (15.5%).

Chapter 4. Experimental research on teaching applications of mathematics in other disciplines for the topic: maximum-minimum problems.

Research Methodology

The research was conducted in 2021-2022 in Israel.

Aim of the research

This study aims to check the effect of the intervention with teaching applications of mathematics on:

- Students mathematics achievement and their attitudes towards mathematics.
- Teachers` attitudes towards teaching applications of mathematics.

The Research instruments

The research instruments are: Questionnaire, Observation criteria, Mathematics Tests and Interviews.

The questionnaire developed for this study is based on the scientific literature. The questionnaire is designed for the purpose of surveying students' attitudes towards teaching mathematics and teaching applications of mathematics in other disciplines.

The questionnaire contains 40 questions, all of the questions are closed questions (affirmations measured on a 5-level Likert scale, from 1 = strongly disagree to 5 = strongly agree).

Observation criteria

Observations were made during four months before and after the intervention with documentation and description of the teaching methods of the teachers, the atmosphere in the classroom and the learning motivation of the students.

Mathematics Tests

- For pretest and posttest;

- were constructed together with the teachers.
- **The Interviews:** The Interviews include 16 questions about teachers' attitudes toward teaching mathematics.
- The teachers in the control group were only interviewed once before the intervention.
- The teachers in the experimental group were interviewed three times, the first was before the intervention which is the same interview as the control group that included 16 questions.
- The second interview was during the intervention and the last one was after the intervention.
- The interviews during and after the intervention were different from the interview before the intervention;
- They consisted of five questions related to teaching applications of mathematics in other disciplines.

Participants

The study involved 4 classes and 4 teachers from Israel high school. two 11th classes and two 12th classes, each class is divided into two groups: a control group and an experimental group.

The experimental group included 50 students, 25 students from 11-1 and 11-2 classes and 25 students from 12-1 and 12-2 classes

The control group included 51 students, 25 students from 11-1 and 11-2 classes and 26 students from 12-1 and 12-2 classes.

The division of classes and teachers as in table 6 follows:

Table 6. The division of participants classes and teachers in the research.

Teacher	Class	Group type
R	11-1 first half	Control
E	11-1 second half	Experimental
K	11-2 first half	Control
E	11-2 second half	Experimental
R	12-1 first half	Control
Re	12-1 second half	Experimental
K	12-2 first half	Control
Re	12-2 second half	Experimental

Data Analysis

- **Questionnaire data:** the questions were quantitatively analyzed using SPSS program.

The analysis includes Descriptive, frequency, percentage, mean (M), and standard deviation (SD), comparisons and correlations between the factors.

The Statistical test that are use: T test, F test, One Way ANOVA and correlations.

- **Observations' data:** Qualitatively analyzed by categorical analysis.

- **Mathematics Tests' results:** comparison was made between the Scores of the students in the two groups at pretest and posttest.

The Interviews: The data obtained with the interviews before the intervention were analyzed identifying categories and themes (Shkedi, 2007).

In the case of the teachers who participated in the intervention, their answers at the three interviews (before, during, and after intervention) were presented as case studies.

intervention program

The intervention program focuses on maximum and minimum problems and teaching the applications of maximum and minimum in other disciplines such as: Physics, Construction, Economics, and everyday life. Problems from daily life were illustrated through drawings and sometimes through videos or computer simulations. The intervention program given to teachers contained the proposed examples of applications of mathematics in other disciplines for the taught topic. The program also gave the recommendation to use active teaching methods.

For more detail, the material studied during the research period (during the observations before, during, and after the intervention) is “differential and integral calculus”, in particular the following subjects: the equation of the tangent of functions, extreme points, sketching graphs of various functions, as well as maximum and minimum problems. It is important to note that the same subjects were taught in both groups (control and experimental) for 11th and for 12th grades were the same subjects and in full coordination between the teachers. The 11th and 12th grades studied the same topics of differential and integral calculus, but for different types of functions: 11th grades for polynomial, rational, and root functions, and 12th grades for logarithmic, trigonometric, exponential, and power functions.

During the intervention both groups studied maximum and minimum problems, but the students in the control groups just solved mathematical problems (i.e. calculation of minimum and maximum points of different functions), while the students in the experimental group also solved applications of maximum and minimum in other disciplines (they got a problem from another discipline or everyday life, they had to model the problem by a function, then to calculate the minimum or maximum points of that function).

The intervention program was built in coordination and agreement with the teachers involved in the experimental research. The program took in consideration the study topics before, during and after the intervention, the curriculum requirements, and the matriculation exam requirements. The aim was to achieve the maximum in teaching applications of mathematics that do not interfere with the exams and not to waste too much time and lessons.

The intervention program contains three stages:

1. Observation period (before the intervention)

This period is for one month whose purpose is to observe and document the teaching methods of the teachers, the learning atmosphere in the classes, the students' motivation to learn mathematics, the students' participation in the lessons, about the activity of the students in the lessons, whether the teacher is the central figure in the class or the students, etc.

2. Intervention period for two Months

It was decided together with the teachers that the intervention period would be for two months and that the teachers would teach the subject of maximum and minimum problems. This subject was determined because it is perceived as difficult by many students and the teachers are interested in checking whether the intervention will have an effect and help them in solving the students' difficulties in the subject of maximum and minimum problems.

3. After the intervention for one Month

The goal of this period is to continue for observation and documentation of the teachers and students in both groups on the topic of maximum and minimum problems and to continue comparing the two groups with practices and marathons in preparation for the matriculation exams. In addition to check the effect of the intervention and whether the students in the experimental group continue to solve maximum and minimum problems in a better way as a comparison before the intervention and with comparison the control group.

Results

The questionnaire analyzed using SPSS program according to four categories. the categories are:

1. Self_confidence (Self_confidence in mathematics).
2. Value (The value of mathematics).
3. Enjoyment (Enjoyment in mathematics).

4. Motivation (Motivation to learning mathematics).

The results in table 7. showed that in the control group the attitudes of the students towards teaching mathematics and teaching applications of mathematics in other disciplines did not improve (see table No.7 below).

Table 7. Descriptive statistics of the control group: before and after the intervention (PREPOST)

Control group, before and after the intervention	N	Before		After		Mean		Std.	
		Min	Max	Min	Max	Before	After	Before	After
Self_Confidence (self confidence in math)	51	1.60	5.00	1.73	4.93	3.8120	3.7767	.93660	.86919
Value (The value of math)	51	2.00	5.00	2.00	5.00	3.7824	3.6980	.74772	.71568
Enjoyment (Enjoyment in math)	51	2.00	5.00	2.00	5.00	3.6804	3.6314	.82000	.79536
Motivation (Motivation to learn math)	51	1.20	5.00	1.20	5.00	3.5333	3.4824	.85573	.79416
Valid N (listwise)	51								

As a comparison between the control and the experimental groups:

In the experimental group:

-There was a difference in the students` attitudes towards teaching mathematics and it`s applications before and after the intervention.

Self_confidence	51	3.8/3.6	.90/.70	51	3.7/4.4	.86/.38	51	0.036	2.14
Value	51	3.7/3.4	.74/.80	51	3.6/4.3	.71/.40	51	0.00	4.86
Enjoyment	51	3.6/3.4	.82/.90	51	3.6/4.2	.79/.49	51	0.012	2.59
Motivation	51	3.5/3.4	.85/.90	51	3.4/4.2	.79/.40	51	0.079	1.79
Valid N (listwise)	51			51					

About the observation:

The teachers in both groups (control and experiment) before the intervention learned without applications in other disciplines of the studied mathematical content.

This method also continued in the control group after the intervention.

Many students had boring and mathematics lessons were routine and they are passive , which caused them boredom and hatred of mathematics and even they have negative attitudes towards mathematics.

As a comparison with the experimental group:

During and after the intervention, there are significant differences in the learning atmosphere and in the motivation of the students.

Students love to learn mathematics, Students active in classes, more interesting, with high motivation to learn and The atmosphere of the lessons more active

The teaching method of the teachers changed and there is a positive effect on the teachers and students.

The attitudes of the teachers and students changed positively towards teaching mathematics.

About Mathematics Tests: The results showed that teaching applications of mathematics in other disciplines led to an improvement in students' achievements.

in the control group (did not teaching applications of mathematics) there was no improvement in the achievements.

in the experimental group (teaching applications of mathematics) there was great improvement in the achievements of the students.

About The Interviews:

The main conclusion that can be drawn is that:

- Teaching applications of mathematics in other disciplines have a positive effect on teachers.
- Before the intervention the teachers used to teach according to the standard methods.
- Most of the teachers didn't teach applications of mathematics.
- After the intervention, an important change was noticed in teachers' attitudes and teaching.
- Teachers have positive attitudes towards mathematics and teachers became well qualified and were able to teach applications of mathematics.
- The level of confidence of the teachers to teach applications of mathematics increased significantly.

Chapter 5. Summary and Discussion

5.1. Summary and main findings

Teachers considered valid all of the listed benefits of teaching applications of Mathematics, as the mean for each one of the possible benefits is above 4 on a 5-level scale and the standard deviation is below.

The three most benefits and advantages of teaching applications of mathematics in teachers' view are:

1. Arising students' interest in Mathematics.
2. Motivating students for learning mathematics.
3. Showing students the importance of mathematics.

In addition to the benefits and advantages of teaching applications of mathematics, there are also some obstacles. The participants selected from a given list the main important obstacles of using applications in teaching Mathematics. The most three frequently selected obstacles are the following:

1. Time constraints - not enough time to teach applications of mathematics in other disciplines.
2. Lack of methodological or pedagogical content knowledge of the teachers.
3. Curriculum constrains - the teachers must be taught the material required for the matriculation exams in Israel.

According to the results of the research that conducted on the effect of an intervention with teaching applications of mathematics in other disciplines on the attitudes and achievements of students, the main findings can be summarized as follows:

1. Teaching applications of mathematics in other disciplines develops a positive attitude of students towards mathematics.
2. Teaching applications of mathematics in other disciplines makes students more motivated for learning and students become an active participant of their learning. Also, the students enjoy learning mathematics and learn with fun and love of the subject.

3. Teaching applications of mathematics in other disciplines led to a significant improvement in students' mathematics achievement.

And according to the results of the research that conducted on the effect of an intervention with teaching applications of mathematics in other disciplines on the participating teachers, the main findings summarized as follows:

1. The interviewed teachers reported advantages and benefits, difficulties and obstacles in teaching applications of mathematics in other disciplines.
2. All the interviewed teachers reported that there is difference between lessons with teaching applications of mathematics and lessons without teaching applications of mathematics (in favor of lessons with teaching applications of mathematics).
3. The confidence of the interviewed teachers for teaching application of mathematics in other disciplines has significantly increased after the intervention compared to before the intervention
4. Teachers' attitudes towards teaching mathematics and its applications changed for the better, teachers became more self-confident to teach mathematics and their success in teaching applications of mathematics rose from a mediocre level to very good.

5.2. Conclusions

The findings of this study showed that teaching applications of mathematics in other disciplines has a great effect on several points and levels on both students and teachers.

Teaching applications of mathematics enhances the learning atmosphere in mathematics classes and turns a passive atmosphere into an active atmosphere for both teachers and students, rising the motivations of the students for learning mathematics. And also teaching applications of mathematics in other disciplines led to a better change in: the methods of teaching mathematics, on the attitudes of both teachers and the students towards mathematics and what is very most important is that the method led to a significant improvement in the students' achievements.

We can conclude and say that the intervention and the method in general was successful. The goals of the research were achieved, and the research produced very good and new results in the field of teaching mathematics.

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