BAR-ILAN UNIVERSITY

Three Teaching Methods of Solving Equations in Middle School: the Relational Thinking Form, the Multi Representative Form and the Algorithmic Form,and the Relation to Achievement and Study Motivation

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Submitted in partial fulfillment of the requirements for the Master's Degree
in the School of Education, Bar-Ilan University

Ramat Gan, Israel 2017

Abstract

This study researched the influence of teaching methods of solving equations on achievement improving and study motivation in middle school students, according to three directed thinking teaching methods: teaching in the form of relational thinking (Skemp 1991a, 1991b, Skemp 1976, Carpenter,Levi, Franke & Zeringue 2005); teaching in multi representative form and teaching in algorithmic form. According to the study premise, thinking types in the base of equation teaching are expected to influence achievements and motivation.

Mathematics are an essential part of every student's curriculum in the Israeli educational system, and worldwide. The need for change in teaching mathematics and science occurred to the British Association of Science more than 150 years ago (British Association for American Studies BAAS, 1864). The BAAS's attitude toward the subject was expressed in the understanding of scientific processes and their importance in everyday life in economic, social and political aspects, while emphasizing teaching methods and process analysis.

Starting in the 1990's, many countries appointed committees to overlook math studies and efforts were made to improve achievements while searching for the means which would enhance study motivation, reduce the feeling of personal failure and improve the student's mathematical understanding (National Council of Teachers of Mathematics, 2000). Over the last few years changes were made in the Israeli Mathematics study curriculum, as in many other countries in the world.

The teaching method recommended by the Ministry of Education is dealing with the same educational content being learnt anyway, but through teaching methods that emphasize structuring of knowledge and not transferring information. Instead of dealing with educational contents on low cognitive levels that require mostly memorization, it is recommended to deal with these materials on high cognitive levels that require activating high level thinking strategies. The method of learning thinking strategies through teaching material is called the "Integrating Approach" (Swatrz & Parks, 1994). The middle school curriculum is a continuation of the primary school one, but nonetheless offers a clear transition

to more advanced mathematic thinking strategies. In addition to that it establishes the basis to the continuation of mathematic learning in high school, in terms of thinking methods (Ministry of Education, 2010).

In the mathematics curriculum, the subject of Equation Solving plays a central part as a base to understanding more advanced mathematics, and therefore there is an importance to be taught more usefully.

The goal is to give the students chances to enhance their point of view and to deepen their mathematic thinking and understanding, in order to raise their grades, as well as develop their study motivation so that they make the required effort to develop and implement their skills and knowledge due to internal motives, and to develop long term learning obligations.

Studies show that learning through understanding, combining thinking processes, enhances study motivation and improves achievements (Beyer, 2001; Flavian, 2002, 2005). In this study, the assumption is that teaching equation solving in a way of directing thinking will impact motivation and achievements positively.

In order to choose the best form of teaching we should test the influence of each specific teaching method. In order to do this, an array of research was conducted, in which 141 students from eight grade 7 classes in four different schools took part. The classes were divided into four groups of two classes. In each group the teachers taught equations differently. Eight math teachers took part in this study- each class being taught by a different teacher. In three of the groups the teachers taught in one of the methods being researched and the fourth group was a control group in which the teachers taught according to the textbook, with no intervention, according to the following distribution: Group #1: Teaching in the relational method, concentrating on a relational mathematical expression, meaning that concepts and ideas are verbalized in order to understand the logic, connections and affinities between them and discover a set of rules behind them.

Group #2: The multi representative method which concentrates on a variety of expressions of different situations: verbal expressions, numeral expressions, graphic expressions and expressions in a symbolic language, the ability to implement the transitions between them and utilize them in algebraic activity (N=41).

Group #3: The methodic algorithmic method, using mathematical procedures and general equations (N=34).

Group #4: Control group- teaching according to textbook in traditional, accepted methods, teaching in a non-distinctive method (N=33).

All of the teachers have a math teaching certificate with an average seniority of nine years teaching math. The teachers received an instruction session regarding the teaching methods, which included detailed recommended lesson plans and worksheets. Also, they received instructions regarding writing on the blackboard and conversations with students ("Thinking Language"). In order to insure the teaching was based mostly on one teaching method, the intervention included lessons which the researcher gave in the control groups, and observation of the teachers.

The research took place during the 2014 school year, in the equation studying period. The research lasted approximately two and a half months. **Before the intervention**, the teachers and students received motivational questionnaires, and the students also received a mathematical knowledge pre-test to examine their level of knowledge. **After the intervention,** the students filled out motivational questionnaires and mathematical knowledge summetive exam (post test).

The process of hypothesis testing and statistical analysis was done through a statistic program (spss version 21).

The study researched the separate effects of the study method on achievements and student motivation. Four research hypotheses were tested:

- The first research hypothesis regarded the differences between the study groups on their math knowledge test achievements as a result of intervention. Previous studies show that study

through understanding combined with thinking processes contributes to student achievement (Beyer, 2001; Kramarski, Weiss & Kololshi-Minsken 2010). Therefore, the research hypothesis was that the students' grades in the intervention groups would be higher than those of the students in the control groups. The differences between the control groups could not be estimated, according to the theoretical background. According to the study findings, clear differences were found in students' grades in the different intervention groups, as the grades in the group studying in the multi expression teaching method were very high compared to the other groups.

- The second research hypothesis regarded the differences between the research groups in the extent of learning motivation. Studies showed that learning through understanding and thinking processes, contributes to motivation (The National Authority of Survey and Evaluation in Education. 2016; Flavian 2002, 2005). Therefore, the study hypothesis was that study motivation in the students participating in the intervention groups would be higher than in the control groups, the differences between the intervention groups could not be estimated, according to the theoretical background. In practice, no clear difference regarding motivation was found between the research groups after intervention. Testing by factors revealed that students belonging to the multi expression group had much higher control of the target after intervention, than before the intervention.
- The third research hypothesis regarded the connection between study motivation and achievements. Motivation is a driving force, aimed at investing physical, intellectual and emotional effort (Bar Haim, 2002). Studies show that there is a positive connection between motivation and achievements (Assor, 2001; Portman 1999; Linnenbring &Pintrich 2002). Therefore, the study hypothesis was that a positive connection between motivation and achievements will be found in the present research. Study findings showed that similarly to the previous mentioned researches, there is a connection between the level of motivation in

students and their achievements in the mathematics knowledge exam taken after the intervention, so that as motivational levels got higher, so did the students' grades.

- The fourth research hypothesis regarded the connection between the level of teachers' teaching motivation and the level of the students' learning motivation. Studies show that high levels of teaching motivation contribute to high motivation in students (Budden 2009). The research hypothesis was that a similar connection would be found in the present research as well. Research findings show that only the feeling of self-capability, which is one of the components of teaching motivation, is a factor that clearly affects study motivation in students. According to the findings there is a clear positive connection between the teachers' self-capability measure and the level of study motivation in the students, so that as the feeling of teachers' self-capability got higher, so did the level of student study motivation. These findings support the previous researches findings, which show that high levels of self-capability feelings in teachers can predict high motivation in students. (Martin, Sass & Schmitt 2012; Thoonnen, Sleegers, Peetsma & Oort 2011).

In conclusion, the new mathematics program set a main goal of developing mathematical thinking and understanding as goals in themselves, and as a way of achieving high motivation and student grades (RAMA 2016).

The Contributions of this research are:

1. Defining three thinking directed teaching methods and developing teachings and curriculums according to these methods in a way that will allow their application in this particular subject and in other mathematical subjects.
2. Examining students' achievements and study motivation in the research groups on teaching equations, and examining the way in which to realize the teaching goals optimally

3. Examining the connection between motivation and achievements and between teachers' motivation and students' motivation regarding equation teaching.

The educational implication deriving from this research findings coincide with the need to develop a curriculum for middle-school students that will encourage thinking directed teaching, as well as the need to cultivate the teachers' feeling of self-capability which is directly connected to the students' motivation. According to the research findings, the recommendation is that teaching should be in a multi representative environment, and expose students to various expressions in equation solving, and in general algebraic studies in the future.