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Self-regulated math instructions for pupils with learning disabilities

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Abstract: In this research, we considered the different impact two methods of teaching had on pupils' ability to solve complex math problems. The methods considered were: self-regulated study and traditional teaching. We also examined the pedagogical consequences the differences made among the population of pupils with learning disabilities in special education classes within the standard elementary school system. In addition, we examined gender difference and its influence on the ability to solve complex math problems. The research assumption was that self-regulated learning will promote pupils' achievements more than the traditional approach because it presents pupils with word problems, research tasks, concept presentation using illustrations and mathematical representations; comprehension of math properties, terms and the conceptual connections between them. The self-regulated approach to learning consists of a process that puts an emphasis on pupils' active engagement with the study material wherein the traditional method of teaching, the emphasis is on the teacher and her frontal teaching time leaving pupils passive. There were forty (40) participants in the study, ranging in age from 9 to 10; all with learning disabilities and attending four different classes (grades 3 to 4). Two of these classes studied math using the self-regulated method, and the other two,

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PUBLIC INTEREST STATEMENT

In this research, we examined the ability to solve complex math problems using two methods of teaching: self-regulated study and traditional instruction. The pedagogical consequences of these methods for pupils with learning disabilities in special education classes in mainstream elementary schools were studied, as well as the influence of gender.

Forty grade 3–4 pupils with learning disabilities participated in the study. The ability to solve challenging math problems was examined using four challenge questions. In addition, teachers filled out a questionnaire concerning their teaching methods.

Findings demonstrated that pupils taught with the self-regulated method only were able to solve challenge problems better than pupils taught the traditional way. No gender differences were found.

The use of self-regulated learning is recommended because it is likely to improve strategic math thinking and have positive consequences for other phenomenon, such as reduced school dropout, pupil achievements, and improved social interaction.

the traditional method. The ability to solve challenging math problems was examined using a test that included four challenge questions from a collection of math skills evaluation tests. In addition, teachers were required to fill out a questionnaire that characterized the teaching method they used. The findings revealed that the ability to solve challenge problems in math among pupils that were taught using the self-regulated method was significantly higher than the ability of the pupils that were taught using the traditional method. No significant difference in the ability to solve challenge problems in math was observed based on gender influence. In addition, the differences in this ability did not vary based on gender influence while using either method of teaching. The research concluded with a recommendation to use the self-regulated learning approach in teaching math because it may contribute to the improvement of math strategic thinking and thus impact a variety of phenomena related to this pedagogical field such as reducing school dropout rates, promoting pupils' achievements, and improving social interaction.

Subjects: Social Sciences; Development Studies; Education

Keywords: teaching methods; self-regulated; traditional method of instruction; math instruction; challenge problems in math; learning disabilities

1. Introduction

Math is perceived as one of the most difficult fields of study in the school curriculum because it requires high level of competency in dealing with a variety of subjects such as: word problems, research tasks, concept presentation using illustrations and mathematical representations; comprehension of math properties, terms and the conceptual connections between them.

In math, a proficiency in the basics of the subject is necessary to understand more advanced concepts. The reasons for the difficulties and disinterest among pupils are the attributes of the subject and the way in which it is taught. Teaching math to pupils with learning disabilities is particularly difficult and the need to transfer the required content per the ministry of education's curriculum requirements makes the task even more challenging. This is where the need to use differential teaching methods comes from, to ease the difficulty for these pupils and help them meet the curriculum requirements (Gazit, 2004; Geary, 2004).

The new math curriculum (Israel Ministry of Education – Israel, 2006) emphasizes learning products and thinking skills. The perception at the base of the curriculum is that math is not just a rigid subject with specified rules that require one and only one solution but instead, a subject with a wide range of applications that allow pupils to approach tasks by incorporating introverted-algorithmic thinking with branched out creative thinking. This is where number comprehension is critically important because it combines consistently pre-planned and directed math thinking skills that allow pupils to deal with a wide range of mathematical content (Pintrich & de Groot, 1990).

To develop math thinking skills it is necessary to teach pupils solutions to challenge problems in math that are based on self-directed learning while emphasizing the importance of the process to arrive at a solution instead of the final solution. The process to a solution based on the self-directed learning method involves varied use of thinking strategies and develops the ability to arrive at the correct answer independently, using the shortest and most effective way. In addition, self-regulation in learning develops in pupils the ability to deal with a variety of challenge problems even if they were not demonstrated in class (Hakim & Gazit, 2011).

This article focuses on a population of pupils with learning disabilities. Learning disability is defined as having difficulty in acquiring basic learning skills due to neurological factors. Children with

learning disabilities usually possess an average or above average cognitive potential but have trouble in one or more academic skills: reading, writing, spelling, comprehension, or math. These difficulties can lower the academic functioning in all subjects learned. The decreased academic functioning is usually a result of difficulty with one or more basic cognitive systems: perception and visual processing, perception and phonological processing, visual and auditory memory, language, attention and deficit disorder, sensory processing, motoric and sensory-motoric functioning, deficiency in time/space orientation. The population researched in this article studies in special education classes that are part of a heterogeneous elementary school and learn math based on their relative ability. The subject is taught using special aids and various illustrative methods to simplify the material learned. The article examines the traits unique to the learning disabilities population and the ways in which math teaching methods are differentiated to serve their needs. Proper teaching that makes use of self-directed learning may improve math thinking skills and the performance and achievements of pupils with learning disabilities in math.

2. Self-directed learning in the instruction of math: definitions and attributes

"Self-directed" is defined as the pupil's ability to become aware of his thought process, feelings, and behavior, to supervise and manage them while learning (Gibbs, 2003; Michalsky & Kremarsky, 2008). It relates to a circular, corrective process that includes four elements: cognition, meta-cognition, motivation, and context; where cognition relates to simple strategies, problem-solving and critical thinking; meta-cognition relates to the ability to understand and exercise control over cognitive processes; motivation relates to beliefs and perception of the learner regarding his learning ability, the value he places on the task and the level of interest present; and context relates to the actions of the pupils toward his learning environment (Cohen & Kremarski, 2010; Eyni, 2008; Schraw, Crippen, & Hartley, 2006).

Self-regulation in learning is evident by the presence of fluency, flexibility, establishment of new connections, use of imagination and alternative means, self-generated queries. Self-regulation facilitates making connections between elements that are not necessarily related; identifying important issues, asking curiosity generated questions, openness to new ideas, rejection of conventional norms alongside flexibility and originality in arranging them into a new order (Israel Ministry of Education – Israel, 2006; Michalsky & Kremarsky, 2008).

Self-regulation in math instruction is evident by the resulting independent definition of uncomplicated math problems, in finding ways and alternative means to solving these problems, and in discovering original ways to solve uncommon problems (Hakim & Gazit, 2011).

Self-regulation in math instruction leads to nurturing a pupil who demonstrates flexible thinking, is curious and capable of dealing with a variety of problems in a wide range of ways; able to make assumptions, prove, persuade, build an argument and justify mathematical ideas as well as demonstrate proficiency in algorithm (Gazit & Patkin, 2009; Yee, 2005).

On the other hand, the traditional method of teaching math emphasizes algorithmic operations and precise results of calculations using pencil and paper. It relates to pupils homogeneously. The teacher instructs the entire class with no regard to the differences between pupils. The curriculum is rigid; imposed on the pupils from the top-down while the use of illustrative means is minimal. Pupils that learn using this method acquire a causal environment centered around the teacher; they perceive the teacher as the central source responsible for the learning in the classroom (Kashti, Arieli, & Shlasky, 1997; Yisraeli, 2008).

Social studies deal with gender distinction in math learning and teaching. The characteristics of self-regulation emphasize a social and humanitarian attitude that puts the learner at the center while developing an instructional curriculum compatible with his needs. Such approach may contribute to closing the gender gap and advancing both genders equally.

Research literature questions the existence of gender gaps in math achievements. Rab (2014) checked for math achievement gap between boys and girls among elementary school pupils in schools that teach using the Hebrew language and schools that teach using the Arabic language. The findings demonstrated that in Hebrew-speaking schools, boys' math achievements were better than girls' whereas in the Arabic-speaking schools, the girls' achievements tended to be better than boys. The degree of the gap and its direction among pupils in Hebrew-speaking schools is what we see in Western countries while among pupils in Arabic-speaking schools the degree of the gap and its direction is what we see in Arab countries. Based on the other, environmental method, boys and girls are born with identical, predetermined math intellectual potential and the gaps we observe are the result of education-generated, socio-cultural influences, perceptions, expectations and various social and parental messages, the influence of subject as well as homeroom teachers (Rab, 2014; Spelke, 2005).

3. The use of self-regulation to forward math thinking

Self-regulation is demonstrated by intuitive perception of mathematical structures and their connection to algebraic operations, in the ability to gather information and access previous experience to develop solution strategies; in understanding different ways to arrive at solutions and openness to new ways of doing things. Creating different paths to solution provides a feeling that math is not such a rigid subject with absolute rules that impose only one way to a solution. Instead, math is characterized as having a wide range of aspects that allow access to completing tasks using creative thinking. Developing original ways to solve problems provides pupils with control over the process of learning the subject of math and contributes to their self-confidence, a critically important factor to continued academic success when dealing more complex math problems (Gazit & Patkin, 2009; Kramarski & Michalsky, 2009).

Self-regulation provides the pupil with the ability to deal with numbers in a flexible manner; the ability to understand the connections between numbers and the different algebraic operations, to use measuring skills and determine number values; the ability to test the answer's logic against reality. To arrive at a solution to a challenging mathematical problem requires proficiency in number comprehension. Self-regulation has to do with various math proficiencies that are learned at school such as: the solution to word problems, geometry, and measuring (Bannert, 2008; Giron, 2009; Hakim & Gazit, 2011; Zohar, 2004).

4. Self-regulation in solving complex math problems

One of the ways to create situations that require self-regulation in learning is to present the pupils with open-ended questions to which there is no single, absolute solution (Yee, 2005).

The solving of problems is at the core of math learning and includes solution to problems that do not include a predetermined, agreed upon algorithm. The purpose of dealing with challenging questions is to focus on the process to solution thereby expanding the perception field of the pupils to observe the wide range of mathematical subjects and ideas (Giron, 2009).

Complex math problems are characterized by the following criteria:

(a) Questions that match a wide range of solutions.
(b) Questions that allow for extracting all available options and encourage methodical research.
(c) Questions that provide an opportunity to find validity.
(d) Questions on subjects that were not directly covered in class.
(e) Questions that encourage research and arriving at various ways to solution.

Math challenge questions are the kind that can be solved in several ways and have several solutions. In solving math challenge questions, arriving at the final solution is as important as the process leading to it. These questions are characterized by the fact that those attempting to solve them

do not have a predetermined algorithm to the solution, instead, they must find strategies and arrive at the solutions by relying on previously acquired knowledge only before proceeding to find the correct solution (Gazit & Patkin, 2009).

A mathematical problem consists of a situation description that contains in it vital data, the word problem usually describes an everyday life issue and deals with mathematical objects such as numbers, shapes, and repetitive structures. To arrive at a solution, the pupil is usually required to represent the situation and the given data using a familiar mathematical model (Giron, 2009). Presenting a challenge math problem to a pupil provides an opportunity to assess that pupil's ability to apply the material learned at levels that do not include recreating an algorithm or procedure that was practiced in class. As per Gazit (2004), the use of riddles and thinking challenges in school does not only improve thinking skills but also acts as a motivational and engaging factor for pupils at all levels of learning (Markovitz, 2003; Zohar, 2004).

In terms of content, math challenge questions are not focused on a specific subject such as defining terms and content or explaining either of them. These questions involve a variety of subjects such as numbers and operations, percentages, equations, fractions, word problems, and geometry (Zimmerman, 2008).

The new elementary education curriculum emphasizes the development of math thinking skills to arrive at a correct solution in the shortest and most efficient way. To solve math challenge questions requires pupils to work in small groups to facilitate a conversation among the participants, the weighing of options and collaboration. The teacher in this case can expand the pupils' thinking process by asking questions such as: "what happens if we change one piece of data? How would it affect the solution to this problem?" When pupils deal with the question on their own, it tends to develop their thinking skills and expand their perception (Geary, 2004; Schraw et al., 2006).

5. Self-regulation in solving complex math problems among pupils with LD

Learning disability is a developmental deficiency that affects basic learning functions (reading, writing, comprehension and math skills) and thereby significantly interrupts a person's ability to acquire and express knowledge and proficiency at the level of his peers, his natural intelligence and education. The definition of National Joint Committee on Learning Disabilities (NJCLD, 2013) includes two conditions for diagnosis:

(1) There is a significant and continuous learning gap between the pupil's academic achievements and what is expected of a pupil at his age and grade level.
(2) There is a significant gap between his academic achievements and his intellectual achievements as indicated by objective assessment tests.

Therefore, the acceptable definitions base a diagnosis of learning disability on two gaps: the first is the gap between actual achievements and those expected based on age and grade level as specified in the curriculum. The assessment therefore must be based on the math curriculum. The second is the gap between achievements and ability. Nonetheless, there is an ongoing criticism in regards to relying on that gap (Fischbein, 1997; Geary, 2004). Lack of progress in learning can also be a result of lack in developmental stimuli, low motivation to learn, speech deficiency, slow reaction time, etc.

Using self-regulation to solve challenge questions in math may ease the process of learning math for pupils that have trouble and speed these pupils' comprehension and mastery of mathematical subjects such as: fractions, percentages, or geometric shapes. The use of appropriate learning aids with which the subject can be easily illustrated and decoded is vital to the learning process. The teacher therefore must create a supportive and encouraging learning environment for the pupil and evaluate him based on his abilities (Kashti et al., 1997). The challenge is to create an environment

that makes it possible for each pupil with a learning disability to learn math and fulfill his personal potential (Grolnick & Ryan, 2000; Scarpati, Malloy, & Fleming, 2000).

To sum up, there are many challenges in the educational aspects of math instruction of pupils with learning disabilities. In addition to the differences in pupils' attributes, there are also environmental factors that impact math instruction among LD pupils. The development of math thinking skills by these pupils will provide them with flexibility in dealing with mathematical terms and in choosing and using ways to solutions that are not common. Self-regulation becomes part of the math culture and includes a quality, intuitive perception of the subject that is likely to assist LD pupils in dealing with arriving at solutions to math problems in a much better way (Agran & Wehmeyer, 1999; Margalit, 2003; Ross, 1995).

6. Research questions and assumptions

(1) Differences will be found in the ability to solve Complex Math Problems among pupils with LD according to the method of teaching: self-regulated and traditional. Among pupils that will learn using the self-regulated method, the level of math achievements will be higher as compared with pupils that learned using the traditional method.

(2) Will there be differences in the ability to solve Complex Math Problems among pupils with LD according to participants' gender?

(3) Will there be an interaction between the teaching and the gender in the propensity of the ability to solve complex math problems.

7. Participants

Four classes (Grades 3–4), ages 9 to 10 from various elementary schools around the central region of the country were chosen for the research. For pupils to participate in the research, consent forms were filled out and signed by their parents; official approval by the Israeli Ministry of Education was also granted. These classes included pupils with learning disabilities. Two classes learned math using the self-regulated method and the other two classes learned according to the traditional method. Each class had 10 pupils in it so the total pupil population used for the research included 40 pupils, 23 of them boys (57.5%) and 17 girls (42.5%). The range of ages was between 8 and 10 ($M = 9.2$, $SD = 1.45$). The rate of the girls using self-regulated learning (45%) was similar to the rate of girls using the traditional method (40%), $x^2(1) = .00$, $p = 1$.

The pupils have undergone a psychological assessment during grade 2. The assessment was conducted by their local psychological service using Vaxler test during which the assessing psychologist determines the type of learning disability and intelligence quotient of each pupil. In addition, the pupils have undergone a deductive assessment by certified professionals using a battery of tests in academic fields: reading, reading comprehension, and math. Also in developmental fields such as: visual motor and visual proficiencies, audible, language, memory, thinking skills, attention and focus. As a result of these assessments, the pupils passed an evaluation committee that determined their eligibility to study in separate, special education classes (pupils with learning disabilities) within schools in the standard education system. Pupils in these classes learn all the subjects separately, while the learning material is prepared by the teacher based on the individual ability and learning disability of each pupil.

Per data obtained from the local social welfare department, the socioeconomic condition of these pupils was classified as middle class. Their mothers were mostly housewives and their fathers were employed in jobs that paid an average wage. The participating pupils were assessed as learning disability pupils. Cognitively, these pupils were within normal range in terms of their thinking ability but demonstrated difficulty with attention and focus, easily distracted and slow in executing and completing tasks. In terms of language, their vocabulary was limited, they identified letters, read short words but made distinctive spelling errors. In math, they mastered the four basic operations:

addition, subtraction, multiplication, and division and were also proficient in the decimal structure of numbers. At the same time, in spite of their proficiency with the multiplication and division rules, they demonstrated difficulty executing calculations connected with these basic proficiencies. They also had difficulty with abstract thinking and in solving word problems.

In classes where self-regulated learning and traditional learning was used, there was an attempt to choose classes in which the teachers were at the same level of experience and training in math instruction. All the teachers participating in the research had a bachelor's degree in the field of traditional education.

8. Research tools

Research data were gathered using a test selected from a collection of various ministry of education tests designed for general evaluation (Israel Ministry of Education – Israel, 2012). This test was checked in advance for relevance and reliability by expert teachers in the field who worked in schools where the pupil population was similar to the research population and located in areas with similar socioeconomic background. The test questions were selected based on the compatibility with the special characteristics of the research population, pupils with learning disabilities and based on their compatibility with the 3rd and 4th grade curriculum and the previous knowledge required to solve them.

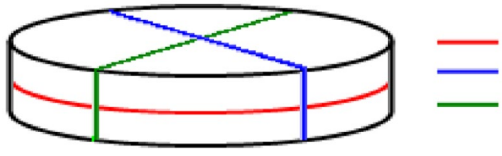
The test included four challenge problems: (a) the cake question; (b) measuring; (c) the clock question; (d) choosing a math operation. There was a grade for each question and a grade for the entire test. The grade range was between 0 and 100, the higher the grade, the higher the ability to solve Complex Math Problems.

Examples of challenge questions pupils were presented with:

Question 1:

The following is an illustration of a circular chocolate cake. It must be divided into 8 equal slices. Three knives must be used when cutting it but each knife must be used only once. You must present the process of division.

The solution to question 1:

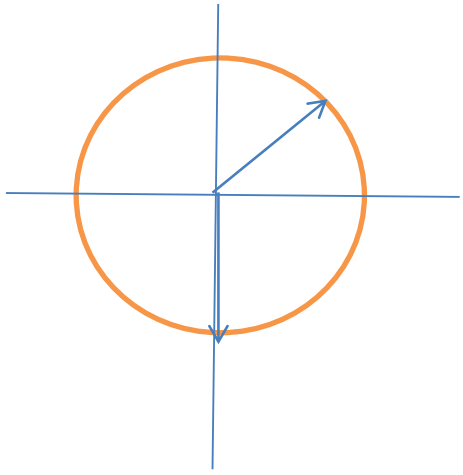


Based on the illustration and the colors, the first knife will be used to cut the cake horizontally and then the two other knives will cut the cake vertically.

Question 2:

If the time now was 1:30. What is the value of the small angle found between the two hands of the clock?

The solution to question 2:



If we divide the clocks into four sections, there will be a total of 90 degrees in each section. The small, hour hand of the clock that is now located on the number 1 divides its quarter into two equal parts, that is 45 degrees in each part. The sum of the value degrees between the two hands of the clock, the hour and the minutes (45 + 90) is 135. The calculation was possible without measuring the angles geometrically but instead using number comprehension that involves looking creatively at the data.

In addition to presenting the questions, teachers of participating pupils were asked to fill out a questionnaire describing the attributes of the teaching method used. The goal was to identify the teaching approach used by the teacher, regulated or traditional, then classify the classes and the pupils accordingly.

The questionnaire was based on the Yisraeli questionnaire (2008). It was adjusted to the needs of the research and included two parts: part A—personal and professional background variables, and part B—questions regarding the characteristics of the teaching method used. The last part is divided into seven areas:

(a) Use of stimuli and multi-directional, varied material during the lesson (Questions 1, 2, 3, 4, 7, 16).

(b) Team work in class (Questions 5, 6, 8).

(c) Use of alternative learning, teaching and evaluation methods that are clearly defined that way (9, 10, 18, 19).

(d) Promotion of inter-cultural understanding and mutual conversation (Questions 14, 15, 17).

(e) Parents' involvement (Question 13).

(f) Teaching goals—developing mutual support and decrease competitiveness among the pupils (Question 11).

(g) Goals of instruction—transferring study material (Question 12).

During the internal consistency and reliability test (Cronbach's alpha), the 19 items in the teaching method questionnaire revealed a very high reliability coefficient (α = .95). In addition, high reliability coefficients were found for sub-scales (the range of the coefficients .88–.92) Based on the reliability coefficient, a total grade in the teaching method questionnaire was calculated for each teacher by adding and summing up the classification of each item in the questionnaire.

The range of the grades was 19–73. We noticed that the higher grades were obtained in the class where self-regulated learning was used more than the traditional method. Grades for the seven subdomains were also calculated. The total grade in the teaching method questionnaire was used to divide the teachers into two groups based on the external median value (median = 51).

The self-regulated group included participants whose grade was higher than the external median. It is worth noting that there was absolute congruence between classifying the participants based on the general value of the external median and classifying them based on their direct answer to the question regarding the teaching method they are using, $x^2(1) = 36.1$, $p < .001$. In other words, when asked directly, all the participants that were classified in the self-regulated group based on the median value of the index "characteristic of teaching method", went on to characterize the teaching method they are using as self-regulated.

9. Research process

The research was conducted in four special education classes for pupils with learning disabilities at two standard elementary schools in the central part of the country. The researcher arrived at each school separately and met with the pupils. Each one of them was asked to answer the test questions in the presence of the researcher so they can explain and assist if necessary. The assistance received by both groups was identical and included verbal terms and test instructions.

The test was 45 min long. In addition, the teachers of the classes participating in the research were asked to fill out a questionnaire that examines the characteristics of the teaching method used in the classroom.

10. Findings

10.1. Statistical tests

The statistical tests included a pretest in which the unique pedagogical characteristics of both teaching methods were examined against independent samples. The dependent variables were seven sub-indices in the *t* approach characterization questionnaire using a series of teaching tests based on teachers' report. The independent variable was the classification of the teachers per the two teaching methods they directly reported to have used in the classroom. To examine the differences in the ability to solve challenge questions in math based on method of teaching (first research question), a *t* test for independent samples was conducted. The dependent variable was pupils' grade in the math competency test and the independent variable was type of teaching method used (self-regulated or traditional).

To examine for gender differences in math competency (second research question), a *t* test for independent samples was conducted. The dependent variable was the pupils' grade in the math competency test and the independent variable was pupil's gender.

To examine differences in math competency per gender and method of teaching (third research question) a two-way ANOVA analysis was conducted in setting 2 (gender) * 2 (method of teaching). The dependent variable was the grade the pupils earned in the math competency test. The independent variables were the pupils' gender and the types of teaching method the teachers used (self-regulated or traditional).

10.2. Unique pedagogical characteristics of the two teaching methods

During the pretest, the unique pedagogical characteristics of the two teaching methods, self-regulated and traditional, were examined in each of the seven sub-indices. For that purpose, a series of *t* tests for independent samples were conducted. In six of the seven indices, the grades of the teachers using self-regulated learning were significantly higher as compared with the grades of teachers using the traditional method. Nonetheless, contradictory to what was expected, in the index "teaching goals",—developing norms of mutual support and decreasing competitiveness, a reverse

pattern appeared where the grades of teachers using the traditional approach were significantly higher compared to the teachers using self-regulated learning.

The pattern in the findings indicates that teachers classified in the self-regulated learning group received high grades when using stimuli, varied and diverse material during the lesson, activating team work together with parents and advancing inter-cultural tolerance and mutual conversation.

10.3. Differences in the ability to solve challenge questions in math based on teaching method

The research question intended to examine differences in the ability to solve challenge questions in math among pupils with learning disabilities using teaching methods: self-regulated and traditional. In order to examine this query, a *t* test was conducted on independent samples. Table 1 shows the averages, standard deviation, and *t* test values of the math competency test based on teaching method.

The *t* test values in Table 1 demonstrate a significant difference in math competency test grades per teaching method. According to the averages observed, among the pupils using self-regulated learning, the level of math competency was significantly higher as compared with pupils learning the traditional way.

10.4. Gender differences in math competency

The second research question intended to examine whether there will be differences in the ability to solve Complex Math Problems based on gender affiliation. For that purpose, a *t* test for independent samples was conducted. In Table 2, the averages, standard deviations, and *t* test values of the math competency test according to participants' gender.

In looking at the *t* test values in Table 2, there is a significant difference in the math competency tests per participants' gender.

10.5. Differences in math competency per gender and teaching method

The third research question was designed to examine whether there will be an interaction between the teaching method and the gender in its propensity to solve challenge questions in math. In order

Table 1. Averages, standard deviations, and *t* test values of math competency test based on teaching method (*N* = 40)

	Teaching method				
	Traditional (*n* = 20)		Self direction (*n* = 20)		
	M	SD	*M*	SD	*t*(38)
Math competency test	84.25	3.78	93.00	5.03	6.22***

Notes: Asterisk indicates the degree of difference between the average. More asterisk means, the differences between the averages more bigger.

***Level of significant at $p < .001$.

Table 2. Averages, standard deviations, and *t* test values of math competency tests by gender (*N* = 40)

	Gender				
	Girls (*n* = 17)		Boys (*n* = 23)		
	M	SD	*M*	SD	*t*(38)
Math competency tests	88.65	6	88.61	6.01	−.02

Table 3. Averages, standard deviations, *F* values, and ηp^2 of the math competency tests by gender and teaching method (*N* = 40)

	Gender								Gender		Teaching Method		Gender* Teaching Method	
	Boys				Girls				*F*(1, 36)	ηp^2	*F*(1, 36)	ηp^2	*F*(1, 36)	ηp^2
	Self-regulation (*n* = 11)		Traditional method (*n* = 12)		Self-regulation (*n* = 9)		Traditional method (*n* = 8)							
	M	SD	*M*	SD	*M*	SD	*M*	SD						
Math competency test	93.55	3.73	84.08	3.61	92.33	6.46	84.50	4.28	.08	.002	35.29***	495	.31	.009

Notes: Asterisk indicates the degree of difference between the average. More asterisk means, the differences between the averages more bigger.
***Level of significant at $p < .001$.

to examine this query, a two-way ANOVA analysis was conducted in setting 2 structure (gender) 2 * (teaching method). In Table 3 are the averages, standard deviation, values of the two-way ANOVA analysis and the size of the math competency test effect per participants' gender and the method of teaching.

The values of the two-way ANOVA test did not find a significant interaction by gender* research group. In other words, differences in the level of math competency according to method of teaching did not change in their affinity to the gender of the participants.

11. Discussion and summary

The goal of the research was to examine the differences in the ability to solve complex math problems using two different teaching methods: self-regulated learning and traditional; the pedagogical ramifications of these differences as far as elementary pupils with learning disabilities were also examined. Additionally, the impact of gender on the ability to solve unusual math problems was tested.

Three research questions were designed and empirically tested. The first question examined the differences in the ability to solve challenge questions in math among pupils with LD per teaching methods: self-regulated and traditional. The pattern of the findings indicated that the differences in pupils' competency were congruent with the method of teaching; pupils using the self-regulated learning method demonstrated a significantly higher level of math competency compared with pupils using the traditional teaching method.

These findings are congruent with research literature that claims that using self-regulation in math instruction develops in pupils a mathematical thinking that allows them to reach a correct solution independently and in a shorter, more efficient way (Geary, 2004; Hakim & Gazit, 2011). These strategies are characterized by flexibility in thinking and makes it possible to deal with a variety of math problems in various ways (Eyni, 2008; Gazit & Patkin, 2009; Yee, 2005). Therefore, it seems that pupils that used the self-regulated learning method developed the thinking strategies and abilities necessary to solve Complex Math Problems, leading to higher math competency and achievement.

The second research question examined the differences in math competency among pupils with LD based on their gender. Professional literature contains conflicting findings on this issue. The pattern of findings indicated there were no significant differences in math competency test scores based on the participants' gender.

The characteristics of the self-regulated method include teaching pupils through research assignments, use of illustrations, and mathematical representations, and the understanding of the characteristics of and the connection between terms, all part of human nature, male and female alike, therefore using self-regulated learning is likely to assist and advance both genders' academic achievements (Giron, 2009).

The third research question related to the existence of in interaction between method and gender in its propensity toward pupils' achievements. This due to lack of published research on the subject. The pattern of the findings indicated that the difference in math competency based on teaching method did not change in the propensity for such competency in each gender (Giron, 2009). This further emphasized the importance of using self-regulation in teaching math to students with learning disabilities because the method enables thought flexibility and the development of thinking skills in general among this population.

12. Recommendation and pedagogical ramifications

To arrive at a solution for an ordinary problem, the pupil is usually required to represent the situation and data inside a known mathematical model. On the other hand, a challenge question allows examining the application of the material studied at levels that do not include recreating algorithm or a procedure practiced in class.

In the process of solving challenge questions in math, pupils with learning disabilities experience difficulties in understanding the question and in distinguishing between the given data and the necessary operations. Pupils are required to turn the text into a mathematical expression that includes operations and numbers. There is difficulty in beginning the process of solving and inability to find a way to solution. Another difficulty is in attaining full mathematical knowledge required to conjure all the possible ways to a solution per acceptable mathematical rules. In addition, challenge questions require high order thinking skills when the pupil faces a significant difficulty to find the appropriate solution. Sometimes the pupil chooses one way of solving to find out the solution is wrong, something that can cause frustration and loss of motivation to keep trying.

In order to overcome these difficulties, it is recommended to use the self-regulated learning method in the subject of math in elementary schools. It is important to incorporate engaging and thought provoking algebraic questions in the learning process using a variety of thinking strategies to arrive at a solution to the questions, while developing a proficiency in dealing with numbers, evaluation strategies and with a conversation style that develops awareness toward the creative thinking process. It is also recommended to check the answer after the solution in a methodical way and act to develop mathematical thinking that relies on handling mathematical problems from a logical and creative perspective.

One of the ways to encourage and develop self-regulation in solving complex math problems among pupils with learning disabilities is work in small groups. During group work time, the pupils will attempt the solution together and acquire creative and efficient math thinking skills.

One of the methodical ramifications arising from this research is that in researches that examine pedagogical aspects of teaching math, it is vital to examine the efficiency of different ways and methods to teach the subject, especially methods that involve developing self-regulation and creative thinking among elementary school pupils with learning disabilities.

This unique population is in need of teaching methods adjusted to advance each pupil, it is therefore important to develop flexible and varied curriculum that uses equally flexible and varied teaching aides.

In future research, it is recommended to add one observational tool in order to further clarify the distinction between self-regulation and traditional teaching in math lessons among teachers that use different teaching methods.

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