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THE CONTRIBUTION OF USING GEOMETRY LEARNING STRATEGIES PROGRAM IN THE LEARNING-TEACHING PROCESS

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Abstract

Action research in the field of education has become very popular in the past twenty years. As a result, it has a real potential to improve schools, retold the role of teachers and advance teacher training.
There are difficulties that accompany teaching geometry, in addition to teachers having to master the formal part of geometry and add explanations, and as such need to know the concepts of the subject. To overcome these difficulties, teachers must have good expressive abilities, so as to mediate the subject to their students in heterogeneous classes. They need to develop mediation tools that will help their students cope with solving geometry problems (Kivkovich, 2015).
This article deals with the innovation and contribution of action research that examined the effect of use of a Learning Strategies Program (LSP) that combines teaching strategies - 'Thinking Person' in solving geometry problems on 10th Grade students in a high school in central Israel.
The research sought to investigate the contribution of LSP to student's achievement in geometry, and to examine the effects of using the LSP on student's problem solving skills as well as to evaluate the contribution of LSP to students' beliefs about mathematics in general and attitudes towards geometry in particular and to their perceptions of self-efficacy.

Keywords: Geometry, Strategies, students' attitudes, Learning Strategies Program (LSP**).**

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1. Introduction

Geometric shapes, especially polygons accompany students through their schooling years (Junior High School Curriculum, 2012), and cause difficulties in teaching geometry, as teachers need to explain mathematical and geometry concepts, and integrate them with students' previous knowledge while contributing to students' mental development.

A special program that integrates a variety of teaching strategies was constructed to help students deal with their difficulties in geometry. The program is based on the communicative approach and emphasizes identifying changes in students' mathematical communication and is congruent with present day approach of learning through participation. This requires mediated learning (Feuerstein, 1998), the approach whereby students are stimulated directly by and interact with the environment and that is how they learn. This interaction provides knowledge, skills, ways of looking at things and making connections that help them solve problems.

Furthermore, Vygotsky's (1978) theories were based on the belief that problem solving, drawing conclusions and other high mental functions that develop through language as a mediation tool that shapes one's consciousness in the social environment, underpin the communicative approach (Sfard, 2007), which pertains to thinking and language as communication that is based on similar patterns: thinking is the individualized aspect of interpersonal communication.

The heart of teaching and learning is in the conceptualization of mental processes and capabilities stemming from shared activities, and therefore, it is important to introduce such activities and cognitive tools that will lead to students' development. Thus, teaching in stages establishes a guiding line for teachers, and helps develop a framework of mutual teaching, learning and development influences (Galperin, 1992a, 1992b).

This approach suggests that geometry teachers must be capable, competent, need to develop expertise and have good discourse abilities so as to be able to mediate the subject to students in heterogeneous groups, while consturcting a meaningful mediation strategy by employing a variety of tools and skills and creating problem solving strategies and provide clear verbal explanations while using the language of geometry.

According to Schroeder et al. (2007), teaching strategies are methods, techniques and processes used by teachers to help students learn and reach the goals set for a lesson. The intervention progrram seeks to guide students towards experiencing the strategies, interact with adults, emphasize their uniqueness and reach a state of informed understanding.

2. Problem Statement

A strategic model can give teachers an effective teaching tool that will serve them in teaching geometry and implement mathematical-geometric dialogue between them and students. The tool will include expertise in teaching strategy and learning combined with a mathematical dialogue suitable for geometric problems. Teachers should integrate LSP including the ‘Thinking Person’ strategy from the earliest stages of teaching deductive geometry for the tool to be a significant component in the thinking process when solving geometry problems.

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3. Research Questions

3.1. In what way has the Learning Strategies Program (LSP) influence the students' achievements in geometry?

3.2. What is the contribution of the Learning Strategies Program (LSP) to the students' ability to solve problems in geometry?

3.3. What is the contribution of the Learning Strategies Program (LSP) to students' beliefs about mathematics in general and attitudes towards geometry in particular and to self-efficacy perceptions**?**

4. Purpose of the Study

The current research is an action research in the field of education. For the purpose of this research, an intervention program - Learning Strategies Program (LSP) was developed, which includes the strategic mediation tool 'Thinking Person'. The aim of the current research was to examine and evaluate the effect of using the strategy on students' achievements in solving geometric problems, the contribution of the program to students' abilities to solve problems as well as evaluate their beliefs about mathematics in general and attitudes towards geometry in particular, as well as their perceptions of self-efficacy.

5. Research Methods

Mixed methods research. Research tools:

Before LSP, Testing previous knowledge and understanding in geometry, polygons, triangles, parallelisms (Patkin, 1990) and Raven Test (Raven, 2000) for examining general nonverbal cognitive levels and evaluate intellectual ability and abstract thinking.

Before and after LSP, Van Hiele Questionnaire (as developed by Patkin, 1990), achievement tests, Questionnaire with regard to beliefs about mathematics (Pinchevsky, 2001) and attitudes regarding geometry (Patkin, 1990), Motivated Strategies for Learning Questionnaire (MSLQ) (Pintrich & De Groot, 1990).

After LSP, In-depth interviews with students. Interviews held with a sample of 8 students from each research group that chosen randomly from each group.

The research included 77 participants, 15-16 years old, 10 grade students from three classes, in a high school in central Israel, studying mathematics 4 points level (Israeli high school subjects are taught on the basis of points, or credits – the highest level is 5 points; 4 points is the second highest level etc).

Thus, the experimental design included two groups: Experimental group – one class that studied the subject according to the integration of Learning Strategies Program (LSP). Control group - two classes, the same age group that studied the issue in accordance with the regular curriculum without the integration of Learning Strategies Program.

The data was collected in a method that integrates qualitative and quantitative research methods. This combination allows effective research with high reliability, which combines human and scientific aspects by employing different research methods at various stages of research (Tashakkori & Teddie, 2003).

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Furthermore, this research is action research, in which the researcher examines his/her own practice and actions so as to lead to changes and improvements in the context under study, the professional development of research participants and systemic changes. (Carr and Kemmis, 1983 in Kinney, 2006). A teaching program was constructed especially for this research, consisting of 8-10 geometry lessons, focusing mainly on polygons and solving problems, by using such strategies as deductive reasoning, informed reading, deducting data from givens and more, while employing memory supports drawing data, concepts in mathematical language, so as to elicit previous knowledge.

The lessons are based on the geometry curriculum and a 'Thinking Person' mediating strategy, which was applied to the experimental group to examine the effectiveness teaching strategies in geometry.

The strategy integrates a mediating tool between teacher and student for the improvement of teaching geometry for teachers and the learning process for students.

The LSP intervention program includes two aspects: **Theoretical pedagogical** - a basis for the program's activity channels by integrating geometric content. **Mediating strategic** - includes the mediating strategic tool - 'Thinking Person'.

The LSP consists six sessions of approximately four hours. Each session includes: Outline of the **'Thinking Person'** tool and employing it while teaching the deductive language of geometry and teaching the tool and instructions of how to use it, **collaborative peer learning**, **brain storming** and **meta- cognitive thinking**.

6. Findings

6.1. Quantitative Findings:

According to data analysis, it was found that all three groups had improved their results in the second compared to the first geometrt test. In addition, it was found that the experimental group received the highest average score in the final test. Moreover, the experimental group's average score improved the most between the intermediate geometry test and final test. Furthermore, improvements were seen in the mean scores in the experimental group in the seconed van Hiele test in all levels. It can be concluded that the experimental group, compared to the other groups, improved its achievements the most.

Analysis of the two tests yielded the quantitative data based on the 'Thinking person' strategy criteria. The results revealed the same level of comprehension, and improved results were identified in the categories of Reading, Application, Score, Analysis and Synthesis.

6.2. Qualititative Findings:

After implementation of the intervention program, which included geometry teaching combined with the 'Thinking Person' strategy, interviews were carried out with a sample of students from each of the groups. Qualitative findings based on the interviews, were collated and categories chosen traced in the interviews according to the criteria examined using the other research tools.

It was found, that the following categories and themes were employed most by the experimental group:

Category: Self- Efficacy Perception

- Theme: **Motivation to Learn**

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"I compared myself to how I used to solve geometry problems and how I solve them now. Now it is more fun and easier. Now I am really enjoying geometry and want to succeed….I use what we learnt in class"

Category: Strategies to Solve Geometric Problems

- Theme: **Employing the 'Thinking Person' Strategy**

"Once, too I kind of did not like geometry, and then, when I sort of got used to it really …and this 'Thinking Person' helped gradually…now I am really love geometry"

Category: Diverse Feelings about Geometry and Mathematics

- Theme: **Positive feelings towards mathematics**

"You have made it (mathematics) more fun, sort of, more experiential, and not only numbers or grades"

Analysis of findings from "Attitudes toward Geometry" and "Beliefs about Mathematics" questionnaires: The two questionnaires yielded statements that were classified into categories that emerged from the qualitative research stage. The statements were placed in tables, thus allowing for a comparison between the three research groups. Significant statements that scored highest/lowest in the experimental group prior to and after the LSP intervention were collected, in the attempt to reach an understanding of the discrepancies between groups. Differences between the groups prior to and after the intervention were calculated by employing a two-way ANOVA

Table 01. Findings from "Attitudes toward Geometry" and "Beliefs about Mathematics" Questionnaires-before and after the LSP Intervention

Category	Statement	Before	After
Beliefs about Mathematics Questionnaire			
Collaborative learning	"I believe that independent learning contributes as much to the ability to solve math problems as teachers' instruction"	⬇ **3.292**	⬆ **4.000**
Attitudes toward Geometry Questionnaire			
Ways of learning	"I find it ***difficult*** to concentrate in geometry class lessons"	⬆ **2.833**	⬇ **2.591**
Attitudes to geometry	"I do **not** like geometry as a subject "	⬆ **2.708**	⬇ **2.545**

Verbal (Visual) Protocol from the Interviews. These findings are reinforced by the **visual protocols**, which describe the interviewees' verbal thinking during the process of solving geometric problems, as found, the greatest number of interviewees who chose the protocol, characterizing the 'thinking person' strategy, were interviewees from the experimental group. The protocol describes interviewees' complex thinking during the process of solving a geometric problem. In the first stage, the interviewees

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observed the sketch only, and tried to break the shape in it into its various components, thus getting to know the problem while understanding the shape and its different geometric aspects. Next, they observed the problem and drew conclusions from the givens, while integrating them with the givens in the sketch, and in parallel to observing the figure, reach the solution.

This Visual ***Protocol*** was used similarly by the control groups **but the most** by experimental group.

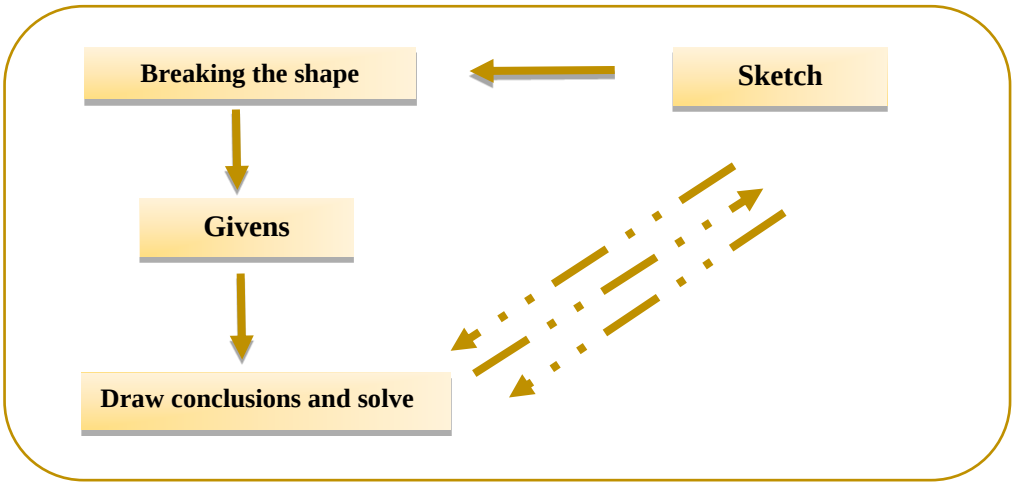

Figure 01. Visual description of Protocol

7. Conclusion

At the end of the program, the experimental group's results revealed improvement in the Van Hiele thinking levels, and they got higher grades in their geometry test. This lead to the conclusion that when the 'Thinking Person' strategy is applied to the teaching program, student's achievements in geometry improve significantly, and their thinking skills improve as well.

Students' achievements in geometry and thinking levels improved as a result of teachers' successful mediation of the strategy, using it correctly on both the part of teachers and that of students, and the environmental support they got.

Also constituting a progress tool in geometry teaching and scaffolding students' progress, it is important to integrate this practical, strategic mediated discourse tool that uses the language of geometry in lesson plans and curricula as early as possible in the stages of teaching deductive geometry, for students to assimilate it as part of their thinking process.

LSP intervention program provides students with tools to cope with solving geometric problems and contributes to enhancing their meta-cognitive capabilities. This is expressed in applying thinking protocols to the 'Thinking Person' strategy, which was extensively used in the experimental group. The strategy and the intervention program influenced thinking criteria when solving problems in geometry. Thinking criteria are part of the LSP and serve as grounds for the 'Thinking Person' strategy.

The conclusion arising from this is that the LSP together with 'Thinking Person' strategy improved students' skills of solving geometry problems: drawing skills, logic and visual and verbal skills. This means that 'Thinking Person' strategy is a useful tool for collaborative learning activities that contribute to students' development.

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Another conclusion arising from the findings is the students' attitudes towards teachers as mediators and the importance of their role for their success in mathematics, and especially in solving problems in geometry. Furthermore, a possible conclusion is that students' perception of the learning process had changed owing to using the strategy, and hence they found meaning in their learning, after using memory supports, which enabled them to access immediate memory, engage in continuous thinking, which enhanced their ability to break shapes, process information and understand geometric shapes. This emphasizes the importance of teachers' role as mediators that pave the way to their students' independence as learners

It is possible to conclude that there are strategies that assist and advance students and it is teacher's responsibility to understand and implement them in lessons in order to carry out a mediated discourse that will advance students to more effective learning processes. As such, the tool that teachers can use to produce complete and quality mediated learning, is dialogic discourse. Mathematics includes verbal and non-verbal aspects, and as a result, geometry teachers must develop great skill in the formal parts of the subject and integrate them into verbal explanations that have specific wording in geometry, as well as non-verbal aspects. This obligates teachers to have high discourse capabilities, be suitably qualified, so that they can fulfill the role of mediators between contents and learners. Using innovative pedagogy, it will be possible to guarantee reaching required goals, as well as the quality of teaching-learning-evaluation processes.

Additionally, the process of finding a solution jointly by teachers and students, with correct use of geometric language through visual scoring and finding memory supports of previous knowledge and using them through asking questions, will advance students' authentic mathematical activity, make them face problems, many different methods and solutions, advance their creativity and may even provide them with a bridge from concrete to abstract thinking in geometry, to dealing with more abstract and broader situations in their lives. Furthermore, mediation characteristics included in the intervention program, were those that led to higher achievements, have a direct influence on positive attitudes to geometry and create a link between a sense of self-efficacy and students' level of involvement. The LSP contributes to students' in raising achievements, improving ways of problem solving in geometry, empowering sense of confidence and motivation and higher level of self-regulated learning.

The theoretical contribution of the research: is in the implemention of an innovative geometry teaching program (LSP), developed by the researcher, which includes learning strategies for solving geometry problems - the 'Thinking Person'.

The practical contribution of the research: Students acquire ocused learning strategies by learning geometry by using LSP. The program's strategies offer tools that help them cope with other problems as well. The strategy does not need to be memorized and thus suits all students. By using it, the students develop solving problem skills that will serve them at all levels. The strategy I taught together eith the contents and is a useful tool for meaningful collabioratibe learning activities that contribute to students' cognitive development.

The metodological contribution of the research: Is in constructing a semi-structured interview that included solving a geometry problem and providing a verbal explanation of the way to solution. This tool constitutes the ground for mapping the class, regarding thinking processes, that are involved in problem

solving. The semi-structured interview has the potential to be implemented and conducted with students of various ages, in the area of geometry.

Contribution to Academic Knowledge: The innovative program (LSP) that includes the 'Thinking Person' strategy contains aspects from psychology and educational pedagogy, as well as aspect from geometry, and combines them into an innovative theory.

A further contribution of the research is in increasing awareness of the importance of using teaching strategies in geometry. These strategies will be able to demonstrate thinking skills, which teachers will be able to instill in students though purposeful teaching. Teachers that pay attention to teaching behaviors integrating strategy, and their own teaching behaviors, will gain another tool to help improve their teaching. It is important that teachers carry out their work understanding and conscious of their own teaching behaviors.

This research may have a universal contribution in implementing the programs in other age groups and other countries, in the efforts to improve achievements and attitudes to mathematics in general and geometry in particular.

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