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EFFECT OF INTEGRATED TEACHING OF MATHEMATICS AND PHYSICAL EDUCATION ON DURABILITY OF KNOWLEDGE OF GEOMETRY

Summary: *The aim of this research is to identify and explain the effectiveness of the integrated teaching of mathematics and physical education on the durability of knowledge of geometry of pupils in the 4th grade of elementary school. The sample consisted of an experimental (n=20) and a control (n=18) group of subjects. The sample of variables was made of a battery of geometry tests. This geometry test was done twice with a delay of 60 days. The experimental group of subjects was taught specified mathematics knowledge using only kinesiological operators. The control group of subjects was taught mathematics using traditional way of teaching. The experiment consisted of four integrated lessons of mathematics and physical education. Results obtained by univariate analysis show that long-lasting effects of integrated mathematics and physical education teaching are as good as teaching mathematics using curriculum guidelines.*

Keywords: *integration, memory, teaching*

INTRODUCTION

The teaching process which prepares students for living in their natural and social environment, characteristic for its diversity in form and content, as well as complexity, dynamism and variability of the process, cannot be rigid and static. Therefore, teaching should be flexible, interdisciplinary and related to real life (Jensen, 2003). However, people learn instinctively and therefore the learning program should relate to the whole system of body and mind. Games often stimulate a more efficient learning than early enrollment of children in various education courses. Motor growth and development as well as sensory integration are important for learning because movement activates specific brain regions important for learning. By synchronizing parts of the body and the mind, improved motor skills, coordination, memory, reading, speech, language and mathematical skills will be achieved with and improved balance, therefore reducing stress, anxiety and hyperactivity in children (Dennison, 2007).

A good teacher will probably make students love school and learning but the same applies in the opposite case, when we have a teacher who is not necessarily bad but less competent, which can also influence students' attitude towards school and in the end towards mathematics. We know that mathematics is a subject towards which students already have certain prejudices and stereotypes. That is why I think that a teacher is a person who can remove these and help create students' positive attitude if acting upon it from the beginning. Mathematics should be a subject in which children will learn through games, experience, application and observation. We lose precious time by asking students to sit for a long time. While we are standing, even if only for a few moments, the concentration is better. Students learn best through bodily-kinesthetic, spatial, verbal-linguistic, intrapersonal, musical-rhythmic, interpersonal and/or logical-mathematical activities. Bodily-kinesthetic activities are domains in which students can use self-expression. Such activities include: pantomime stories, puppet shows, dances, role-plays, stretching, demonstration, practical activities, exercises, sporting events etc. Teachers, as experts and pedagogues, should therefore include students in active interdisciplinary forms of learning in order to facilitate a thorough acquisition of teaching content, stimulate them to think and act critically and creatively and promote responsible and self-organized learning which will influence the development of self-consciousness, self-respect and the feeling of personal worth, and thereby set a higher level of aspirations of each individual. Since interdisciplinary learning is a process close to the manner in which the human brain function naturally, it is necessary to begin implementing integrated teaching already in early childhood. Teaching children is accompanied with particular responsibilities and high risk. Otherwise, the absence of innovation and new approaches and methods doesn't bring to improvement of either students or teachers.

The integration of content of multiple disciplines creates links between social, humanistic and natural sciences and it enables children to create 'real' experiences, natural and logical connections, as well as acquisition, transfer and implementation of knowledge in a meaningful way. Interdisciplinary approach reduces needless repetition and a pile-up of same content across various disciplines, reduces one-sided point of view and enables a comprehensive development of each individual. Therefore, it is necessary to implement integrated teaching content from the beginning of schooling because it ensures authentic interdisciplinary experiences, recognition of new relations, creation of new models and implementation of knowledge in more than one area. I believe that by using this approach and this method of teaching we will ultimately facilitate the students' acquisition of teaching content. The final product will be a strong foundation for the future development and the application of student's acquired knowledge.

The integrated approach implies that a certain problem is observed from various perspectives and the information on it is collected from various domains. This form of learning is called integrated teaching. It is defined as the planning and organization of teaching, which combines various disciplines, fields and courses, with the aim of attaining deeper understanding of certain content and, at the same time, acquiring the skills of reading, mathematical, scientific, computer and artistic literacy, as well as the skills of critical and creative thinking (Čudina-Obradović and Brajković, 2009).

The integrated teaching allows students to connect various forms of knowledge into a whole, to memorize and acquire permanent knowledge more easily as well as to implement it. (Čudina-Obradović and Brajković, 2009)

In order to improve integrated teaching some preconditions are necessary: achieving a safe environment in classroom, achieving a cheerful emotional environment, achieving a meaningfulness of learning, asking questions and seeking explanations, emphasizing the comprehension, frequent feedback on the results of activities.

Most of information received through integrated teaching remains in long-term memory of students. It is important to stress that the long-term memory needs to be well-organized because it provides the opportunity to view information similarly to short-term memory. During the retrieval from long-term memory a special importance is given to the 'retrieval cues' which are used to recall the desired item i.e. information. There are certain differences between encoding in the short-term and the long-term memory. While the coding of verbal material in the short-term memory is based primarily on the phonological characteristics of words, for the coding in the long-term memory more emphasis is put on a meaningful organization of received information (Zarevski, 2007).

The scholars cannot agree whether there is a single long-term memory or if it is divided according to the incoming sensory information, the so-called memory according to sensory modality. The existence of sensorimotor memory as the initial one according to the time continuum is nowadays not disputed by any theory of memory. Some authors believe that there is no need for the separation on the short-term and the long-term memory because the only difference is to which degree the information is processed. The information that is better (deeper) processed will remain longer in memory (Zarevski, 2007).

There are various classifications of long-term memory. The difference in information being used distinguishes the motor and the verbal memory (Zarevski, 2007).

The more times certain distinct items or groups of data are repeated, the higher the possibility for them to be transferred into the long-term memory. The repetition is not regarded as an efficient method for storing information permanently if it is not connected with previously acquired knowledge (Craik, 1973). A more effective method is to make information more meaningful - to purposefully relate new information to things that are already well known (Woloshyn, 1994). Connecting new content with already well-known content is known as elaborated rehearsal (Rathus, 2000).

The analysis of sensory memory in children aged 7-11 showed the ability of faster processing of the incoming information, and in this way children become more successful at many memory tasks (Grgin, 1997). Nowadays, the changes in efficacy of memory are being attributed to the changes in procedures of information processing and not to the changes in the capacity of particular type of memory. It is important to notice it because we may influence particular information processing more than the mere capacity of received information.

Children learn more and easier through games. Hence, through games a child explores spontaneously without the fear of consequences and at the same time gains insight into consequences of various behaviors. Games occur most frequently in a safe and a familiar environment to the child which means that the possibility of stress is minimal (Zarevski, 2007). Some students have difficulties solely in learning mathematics. The nature of such problems is most often diverse. In order to help students to overcome difficulties we need to offer them diverse methods of learning and find the method whose results will be most efficient. In mathematics, children learn most often through specific games and the knowledge acquired in this manner can be used for an easier comprehension of abstract mathematical ideas. The easiest way for a child to find something helpful for learning is through game (Sharma, 2001). The teachers are expected to maintain children's' positive attitude to mathematics and stimulate their curiosity and motivation in solving new mathematical assignments (Liebeck, 1984).

The students in lower grades of elementary school most frequently acquire geometrical content through recognition of geometrical shapes and bodies in standard position. However, students should recognize and use the knowledge which they acquired through geometry lessons. This acquired teaching content will enable the students' development of spatial intelligence and logical reasoning as well as dealing with various life situations and the application of acquired knowledge.

People use the two brain hemispheres in various ways. The left hemisphere controls handwriting, the capacity to interpret symbols, numbers, letters, language domains, verbalization, phonetics and reading. The left hemisphere is responsible for noticing details and facts, following instructions, listening and listening association (Vitale, 1982) Teaching relies mostly on the left side of the brain. The right hemisphere contains a completely different set of skills. Although motor cortex encompasses both hemispheres, the ability to form conclusions on the basis of the relation between a figure in space and the recognition and processing of non-verbal stimuli is mostly concentrated in the right hemisphere. The ability to draw, differentiate colors and shades, the capability of color visualization, singing and playing instruments, manipulation of shapes and patterns as well as geometrical shapes is in the right hemisphere (Vitale, 1982). Both are necessary for genuine learning to occur. According to Vitale (1982) it is believed that there is an imbalance in teaching methods in which learning by the left hemisphere is predominant. It deprives those that have more aptitude for the holistic method of learning, i.e. learning by the right hemisphere.

Various studies investigated the differences in effects of the integrated teaching of mathematics and PE in relation to the traditional method of teaching mathematics. One study (DeFrancesco and Casas, 2002) showed that the effects of a two-week integrated teaching of mathematics and PE are equally good as the traditional method of teaching mathematics. Studies (Fahiminezhad, Mozafari, Sabaghiyanrad and Esmaeili, 2012; Hraste, De Giorgio, Mandić Jelaska, Padulo, and Granić, 2018) have proved that the integrated teaching of mathematics and PE has better effects than the traditional method of teaching mathematics. The study of a group of authors (Hraste, Rajčić, and Andabaka, 2018) determined that the long-term effects of integrated teaching are equally good as teaching mathematics according to the curriculum guidelines while the indirect effects of the integrated teaching showed that its effects are greater (Hraste, Mišurac, and Borović, 2016).

The external evaluation of students of the fourth and the eighth grade in elementary schools in Croatia was conducted in the 2007/08 school year in mathematics as well as in some other subjects. The average results of the fourth graders in mathematics on the national level was 52.9% although the exercises were appropriate and representative (NCVVO, 2004).

METHODOLOGY

The aim of this research is to identify and explain the effectiveness of the integrated teaching of mathematics and physical education on the durability of knowledge of geometry of pupils in the 4th grade of elementary school.

According to the defined aim it is possible to define two basic hypotheses:

H1- the peers in the control and the experimental group of subjects will differ significantly in the geometry results after the two-month time delay since the experiment.

H0- the peers in the control and the experimental group of subjects will not differ significantly in the geometry results after the two-month time delay since the experiment.

THE SAMPLE OF SUBJECTS

The sample consisted of the experimental group (n=20) and the control group (n=18) of subjects. The research was conducted in the fourth grades of Spinut elementary school.

THE SAMPLE OF VARIABLES

The sample of variables was made of a battery of geometry tests. The geometry test was administered twice with the time delay of 60 days between them. The two time points were defined as initial and final testing. The initial test consisted of eight tasks which were used to determine mathematical knowledge from previous education period. The initial testing was administered three days before the start of the experiment. The final testing consisted of eight tasks which covered the topics of the rectangle, the square and their perimeters. The experimental testing was administered two months after the experimental procedure. The experimental group of subjects was taught envisaged mathematical knowledge using only kinesiology operators. The control group of subjects was taught mathematics using the traditional teaching methods for mathematics in classroom. The experiment consisted of four integrated lessons of mathematics through kinesiology operators.

METHODS FOR THE RESULT ANALYSIS

Descriptive statistics gave insights into basic statistical parameters (arithmetic mean -AS, standard deviation - SD, median, minimum score - Min, maximum score - Max, skewness, kurtosis) for each group specifically.

Univariate analysis of independent variables variance (ANOVA) determined the level of significance of quantitative differences between the groups of subjects of the analyzed variable. Univariate analysis of independent variables variance (ANOVA) determined the level of significance of quantitative differences between the initial and final measurement of the analyzed variable. The numerical values given by these methods are analyzed through the level of statistical significance (p).

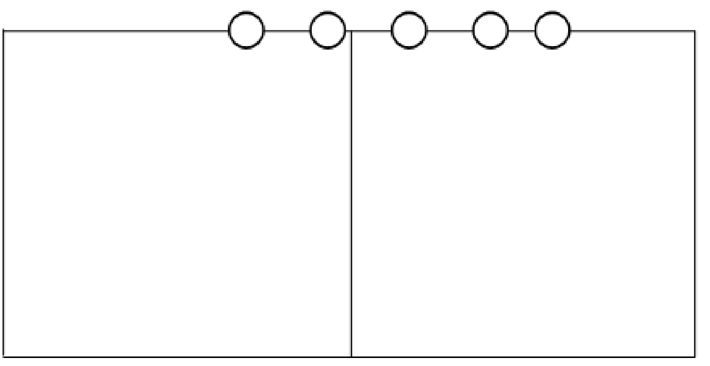
The processing of these results was done by the 'Statistica for Windows', 11.0. program at the Faculty of Philosophy of the University in Split.

EXPERIMENT DESCRIPTION

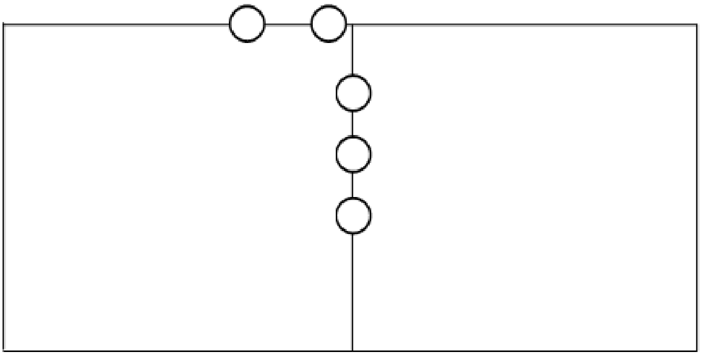
The experiment lasted for four lessons of 45 minutes. All four lessons were held during one week, Monday to Thursday, in March of 2014. The initial measurement of the mathematical knowledge in geometry was conducted on Monday before the start of the experiment. The initial measurement test in geometry consisted of previously acquired knowledge in the first three grades of elementary school. The final measurement was conducted 60 days after the conclusion of experiment, i.e. in May of 2014. The final test tested newly acquired knowledge from teaching topics of the rectangle, the square and their perimeters.

Some parts of the lessons of the experimental group of subjects in Elementary school 'Spinut' in Split can be found below.

Pictures 1 and 2 show the introductory part of the lesson in which running while performing certain assignment was carried out. The assignment was to move by combining walking and running in different tempo on the sides of the rectangle and the square.

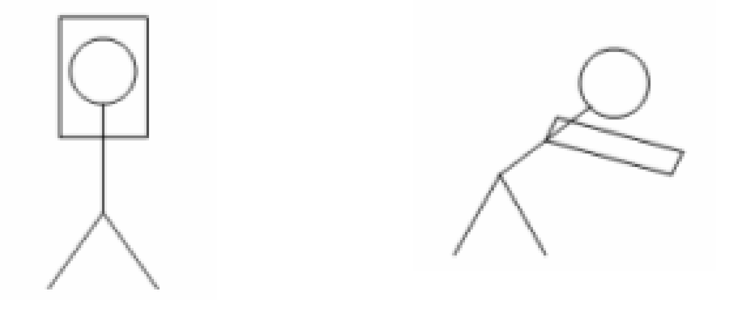


Picture 1. Students running on the sides of the rectangle.

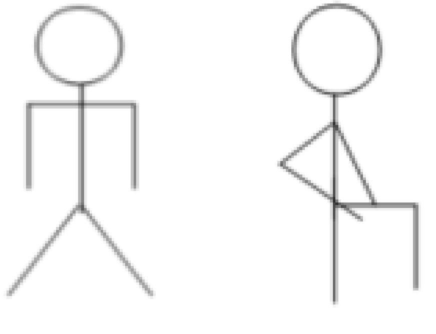


Picture 2. Students running on the sides of the square.

Pictures 3 and 4 show assignments carried out in the preparatory part of the lesson. The picture 3 shows students forming a rectangle above their heads while moving into forward bend. The picture 4 shows students forming the right corner with their leg while applauding with their palms under the raised leg.

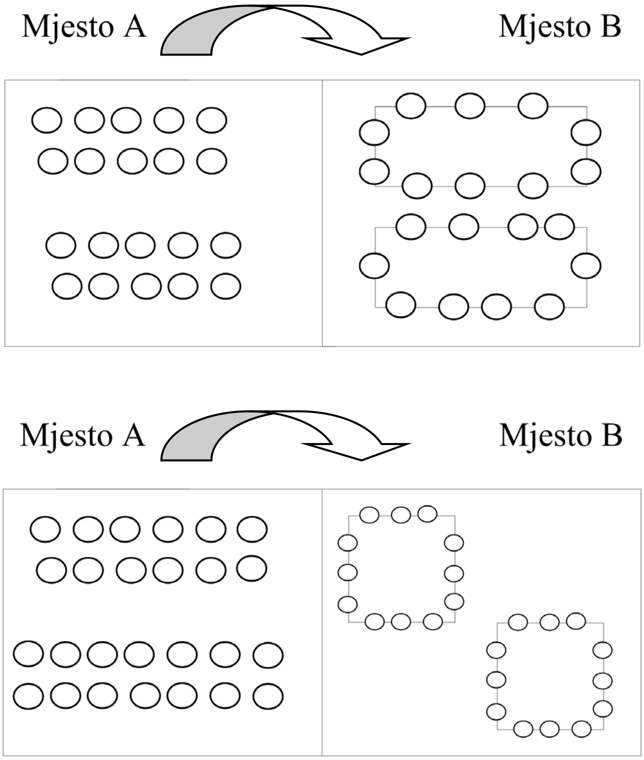


Picture 3. Forming a rectangle with hands.



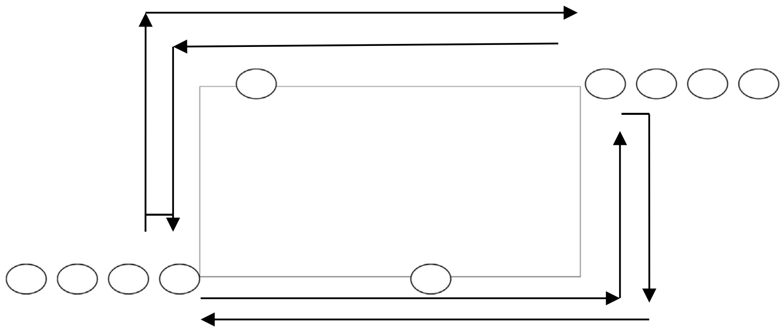
Picture 4. Forming the right corner with legs.

Picture 5 shows two games carried out in the main part of the lesson in the experimental group. One of the games is *'Who will form a rectangle faster?'*. The aim of the game is for the students to form and to notice rectangle as a geometrical figure with two pairs of parallel sides, 4 right corners and four vertices. Students were divided into two groups. The students' task was to form a rectangle as soon as possible. Students are in the area A and need to form a rectangle in the B area. The winner is the team which is the first to form a regular rectangle. Similar was done in the second game in which students had the task to form a square. The game was named: *'Who will form a square with their bodies faster?'*. The aim of the game is for the students to form and notice the square as a geometrical figure which has four sides of equal length. The winner is the first team to shape a regular square in area B.



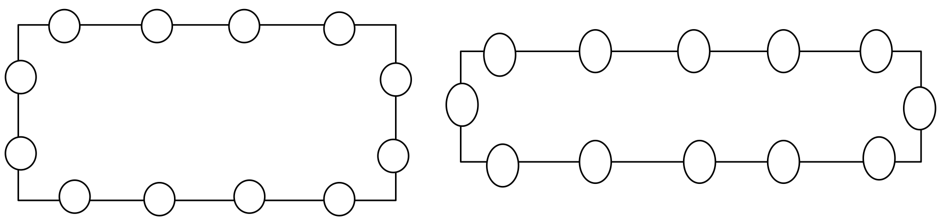
Picture 5. Game: *'Who will form a rectangle and square with their bodies faster?'*.

In picture 6 we can see one of the examples of a relay race game which was carried out in the experiment. It is titled 'A relay race on a longer and a shorter side of the rectangle'. The students are divided into two lines. The two lines are on the diagonals of the vertices of the rectangle. The assignment for the students is to run across the longer side and the shorter side of the rectangle and then return the same way to their line. At the end of their running they touch the next runner in the line and go to the back of the line. The winner is the first line to complete the task.



Picture 6. Relay game: *'A relay race on a longer and a shorter side of the rectangle'*.

Picture 7 shows the final part of the lesson. In the final part of the lesson a game of very low intensity was carried out in which students have the task to use their bodies to form the maximum number of rectangles from the group of 12 pupils.



Picture 7. Game: *'How many different rectangles can be formed by 12 students?'*.

RESULTS AND DISCUSSION

Table 1. Descriptive statistics for the experimental and control group of subjects (AS-arithmetic mean, % - percentage of successful test completion, Median, Min – minimum score, Max – maximum score, SD – standard deviation, Skewness, Kurtosis).

Geometry knowledge	AS±SD	%	Median	Min/Max	Skewness	Kurtosis
EGIM	15,00±3,58	62,50	15,00	6,75/20,25	-0,80	0,08
EGFM	17,21±5,01	71,71	17,00	8,00/24,00	-0,20	-1,11
KGIM	18,38±3,15	76,58	19,13	11,25/23,25	-0,54	-0,08
KGFM	20,17±3,01	84,04	20,50	13,00/24,00	-0,61	0,05

EGIM = experimental group initial testing, EGFM = experimental group final testing,
KGIM = control group initial testing, KGFM = control group final testing.

In table 1 are shown the central and the dispersive parameters of mathematical knowledge in the initial and the final measurement for the control and the experimental group of subjects. The review of the results of the control group of subjects shows a relatively small difference in arithmetic mean between the initial measurement (AS=18.38) and the final measurement (AS=20.17). The result of the percentage of successful test completion of the control group shows clearly the differences between two groups of subjects (approximately 7.5%). Both control groups show much better results than the national average (external evaluation, 2008). Namely, the national average is 52.9% and the control group in initial testing has the average of 76.58% and in the final measurement even 84.04%. The investigation of the results shows the difference in the arithmetic mean between the initial measurement (AS=15.00) and the final measurement (AS=17.21) for the experimental group. The results of the percentage of successful test completion of the experimental group show the differences between the initial and the final testing (approximately 8%). Both experimental groups show much better results than the national average (external evaluation, 2008). The standard deviation in the initial and the final measurement shows similarly different dispersion of results (SD INIC=3.58 and SD FIN=5.01).

Table 2. Descriptive statistics' parameters (AS – arithmetic mean, SD – standard deviation) for the variable mathematical knowledge, the differences between the initial and the final measurement (ANOVA – univariate analysis of variance) and the differences between the groups (ANOVA – univariate analysis of variance).

	Initial measurement	Final measurement
Geometry knowledge	AS±SD	AS±SD
Experimental group	15,00±3,58	17,21±5,01°
Control group	18,38±3,15*	20,17±3,01°

**statistically significant difference between groups in the initial measurement at p<0.05*
°absence of *statistically significant difference between groups in initial measurement at p<0.05 in both groups of subjects.*

In table 2 are the results of the univariate analysis of variance between the control and the experimental group of subjects in the initial and the final measurement. Table 2 also shows the results of univariate analysis of variance between the initial and the final measurement for the control and the experimental group of subjects. The review of the table shows that there is a statistically significant level of differences between the control and the experimental group of subjects with a degree of importance. A further look can show that there is no statistically significant level of differences between the control and the experimental group of subjects in the final measurement. The table shows that there is no statistically significant level of differences between the control group and the experimental group of subjects. The results of the univariate analysis of variance show the statistically significant level of differences only between the control and the experimental group of subjects in the initial measurement. Between the control and the experimental group of subjects in the final measurement and between the initial and the final measurement there are no statistically significant differences in either group of subjects. According to the results of the univariate analysis of variance it may be concluded that both programs of acquisition of mathematical knowledge in teaching topics of the rectangle, the square and their perimeters are of equal quality for the students of the fourth grade in elementary school. The results of this experiment are in concordance with previous studies of this type (DeFrancesco and Casas, 2002; Fahiminezhad et al., 2012; Hraste et al., 2016; Hraste et al., 2018).

In the future studies it would be better to divide students into a control and an experimental group following certain criteria ensuring the classification into two or more similar groups. There are studies in which students were divided into two equal groups by IQ (Fahiminezhad et al., 2012).

The following may be listed as a drawback of this study: (1) learning was carried out in an open playground where students could not fully concentrate on their tasks, (2) relationships between students in particular classes are strained so at certain moments they refused to cooperate with another group of students, (3) after learning mathematics through movement the students did not have the opportunity to repeat the content in the manner they acquired that knowledge.

According to the observations of experts carrying out this experiment there is an impression that the students of the experimental group were very interested in learning mathematics through kinesiological operators. Observation on the extremely good results of two students with special needs in the final measurement gives room as the basis for some future studies on the effects of the integrated teaching for the students with special needs.

CONCLUSION

The aim of this research is to identify and explain the effectiveness of the integrated teaching of mathematics and physical education on the durability of knowledge of mathematics of pupils in the 4th grade of elementary school. The experimental and the control group of subjects were administered tests of previously acquired knowledge and newly acquired knowledge in geometry. In an attempt to measure long-term effects of newly acquired knowledge the final testing was conducted two months after the execution of the experiment.

The results provided by analysis show that the long-term effects of integrated teaching of physical education and mathematics are equally good as teaching mathematics according to the curriculum guidelines. In future studies it would be preferable to explore the long-term effects with a greater time delay from the conclusion of experiment. In some future studies it would be recommended to carry out a student evaluation of their impressions on learning in this manner because the impression was that students accepted this method of learning and were very interested and motivated. This study proved that students can acquire mathematical content, and surely some other ones, through kinesiological activities. The integrated method of teaching mathematics and physical education can serve as a sample model to teachers, and they can recommend it to the Education and Teacher training Agency for evaluation and inclusion into the curriculum.

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