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A teaching approach of geometric shapes' properties with the use of online educational tools in Greek primary school

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Abstract

A number of researchers have shown concern at the difficulties that primary school pupils cope with in learning geometry, and have tried to explain why this happens and what can be done to make the subject more understandable to young learners. Van Hiele's theoretical model postulates five levels of geometric thinking as visualisation, analysis, abstraction, formal deduction and rigour. Each level uses its own language and symbols. Pupils pass through the levels 'step by step'. This hierarchical order helps them to achieve better understanding and results. In this research the teacher taught geometry in the 2nd class in a primary Greek school with the use of information and communication technologies. The aim is to find out the level of geometrical thought of the pupils and how geometrical activities – based on online tools – concerning the geometrical shapes and their properties, help students improve their mathematical knowledge in the class.

Keywords: Geometric thinking, online tools, shapes, geometrical activities.

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1. Introduction

The way in which geometry is taught is an issue that has been at times a concern for many researchers. It has been found that in the first stage, school aged children have an incomplete or even erroneous perception of geometric shapes. In recent years, teaching with the help of new technologies promises to contribute to the easier and more efficient learning of the objects of geometry. Their contribution to a better understanding of geometric concepts during the first school age was the motivation for the elaboration of this paper. Although children are familiar with geometric concepts before they even go to school, they encounter significant difficulties in learning geometry as primary and secondary school pupils. Teachers also experience problems during the lesson. This issue has been addressed by researchers, who have tried to answer why many pupils find it difficult to learn geometry and how teachers can intervene in order to make students more comprehensible.

1.1. Research questions

This paper is supposed to answer the following research questions:

a) How can a teaching scenario based on the use of ICT help students learn geometry easily in the Greek primary school?
b) Whether students are able to evaluate their level of mathematical thinking by themselves by participating in the teaching of geometry through use of ICT.

2. Educational use of ICT through appropriate software

The computer provides a presentation of multiple concepts. Because there is a great distance between the personal perception of a conceptual image – formed by students – and the concept definition, the appropriate educational software can help to reduce this distance, representing a concept in multiple ways. Another principle on which the pedagogical use of ICT is based is that of collaborative learning. The classroom that works with educational software typically involves students organised into groups to integrate them into the cooperative learning process: the teaching strategy in which students try to work in small groups to achieve a common learning goal. This practice aims at exploring the concepts and discovery of knowledge through discussion. It is also based on use of the best pupils' skills for the benefit of the most disadvantaged. Thus, the pupil gains both in learning and socially (Tearle, 2003).

Collaborative learning fosters the development of communication skills, building collaboration skills, exploring expressions, exchanging views and ideas. It encourages the development of an interactive relationship between participants with an increasing degree of individual and collective responsibility. It is also worth noting the possibility offered by the computer for the interdisciplinary approach of a cognitive object. Tackling and studying a concept in light of many different cognitive subjects or sciences effectively contributes to a deeper understanding of this concept and its context, while reinforcing the development of critical, analytical and synthetic thinking.

The teacher, in accordance with modern views of knowledge and learning, has the role of creating suitable learning environments in which the student is energetic, expressing his or her own ideas about mathematics and constructs knowledge according to his/her peculiarities. Also, the teacher has the role of researcher and model designer (Tawalbeh, 2001). More specifically, during the learning process, the teacher consciously separates the mathematics he knows from the mathematics his students construct, and is flexible so that at any moment he creates an appropriate model for the cognitive point in which each student is located so that, with appropriate interventions, it can lead him to advance his own knowledge. To this end, the teacher provides his/her students with a set of appropriate tools and designs appropriate learning activities. Activities are the ones that create the motivation for a student to carry them out and therefore play a central role in learning (Smeets, 2005).

For this reason, activities should, on the one hand, be of importance to the learner. They should be in the world of his interests and, on the other hand, they should activate him to explore in order to construct his knowledge. Among the types of activities, activities that can be resolved in multiple ways are important because they allow the student to express different kinds of knowledge such as intuitive, virtual and formal knowledge. In educational software environments, multiple solutions can be accomplished using different tools (Kordaki, 2004).

According to Koleza (2000), an activity should:

- Have short instructions that can be understood by all students.
- Have an unimaginable answer. In order to answer the questions raised by the activity, the learner must discover the knowledge that is sought through it, mobilising and reorganising his previously known concepts.
- The problem underlying an activity must be rich, containing many approaches, and enabling students to formulate questions and process them on their own or within the group. Any attempts from the teacher to cut the problem into smaller parts are excluded.

3. How children learn geometry

Geometry teaching is considered as an autonomous lesson but also as a means for the development of other mathematical concepts, e.g. the understanding of multiplication, fractional numbers, etc. (Koleza, 1997). Geometry provides the framework for the development of mathematical thinking, such as the recognition of the shapes as well as the discovery of the properties of the shapes and the solving of mathematical problems (Koleza, 2000). Children get in touch and get experience with geometric concepts before they even start school. In their everyday lives, through playing, they distinguish different geometric shapes according to their shape or size, discover their properties and recognise their names. These children's knowledge can be used as the basis of the curriculum of geometry (Klaudatos, 1999).

The study of geometry is also possible at a younger age, based on children's experiences of 'space', which is a part of their environment and their lives (Kontogiannis & Ntziahristos, 1997). The geometric thinking of the child is developed with its contact with the geometric environment. The development of the child's perception of space can be learned through children's plans at an early age. Piaget's researches concluded that Euclidian geometry, which has dominated schools throughout the world for centuries, is incompatible with the development of the child's thinking in the first grades of elementary school (Kordaki & Potari, 1999).

In primary school, where descriptive or informal geometry is taught, students seem to recognise geometries relatively easily, but they find it difficult to learn their properties and the mathematical terms used to describe them (Toumasis & Arvanitis, 2003). The peculiarities of certain shapes 'force' them to ignore the mathematical definition, although they know it: for example, the elevation of the height in an obtuse triangle, the recognition of the right angle in an 'unusual' position, the distinction between a square and a diamond (Koleza, 2000).

4. Van Hieles' levels of geometric thinking

Pierre van Hiele (1959/1984) formulated the theory of the five levels of geometric thinking, which constitute a proposal for the organisation of the teaching of geometry.

4.1. Level 0 (basic level) – visualisation or recognition

Students recognise and name shapes based on their overall form, seeing them as a whole (Figure 1). They can name them as triangles, squares or cubes, but cannot express their qualities. Properties and shapes are not recognised, nor are the relationships between the components of the shape and between shapes perceptible.

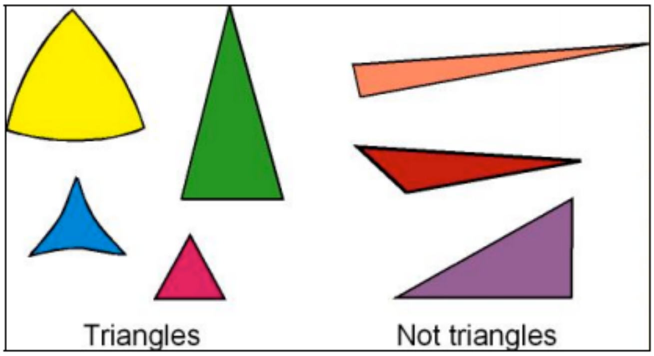

Figure 1. Level 0 (basic level)

Students classify shapes based on their form. They are able to see similarities and differences between the shapes they observe. They can create and begin to understand the shape classifications.

4.2. Level 1: analysis or description

Students can look at all shapes as a group rather than each figure alone. They recognise the shape they see as a representative of the category it belongs to (e.g., rectangles). If a shape belongs to a category, then it has the properties of that class. The properties of the figure are experimentally established, with measurements, drawings, layouts on other images or folds. Students can recognise a shape from their properties, for example, a shape is rectangular because it has four right angles.

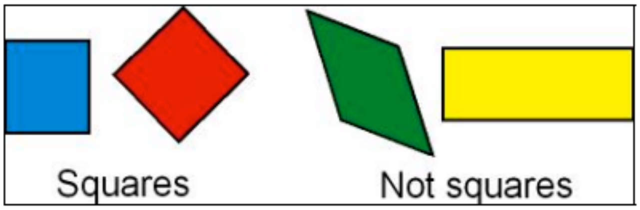

Figure 2. Level 1 (analysis or description)

4.3. Level 2: informal deduction or order

Students understand the relationship between the properties of the shapes and between the shapes. They associate shapes based on their properties and classify them into categories, e.g. 'Each square is rectangular'. They can categorise patterns using lesser features (Figure 3).

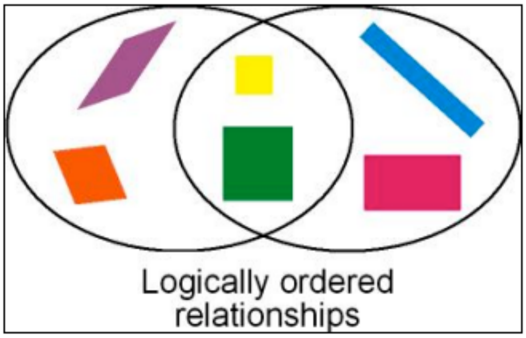

Figure 3. Level 2 (informal deduction or order)

4.4. Level 3: formal deduction or abstraction

Students are not only able to examine the properties of the shapes but also the relationships between the properties. They can distinguish an axiom from a theorem and conclude that a sentence is a logical consequence of another proposition. They develop reasoning to prove a proposal using data, e.g. how the axiom of parallelism implies that the sum of triangle angles is 180°.

4.5. Level 4: rigour

Students realise the importance of precision for the formulation of geometrical theories and are able to analyse various systems with great rigour. They are aware of the existence of axiom systems for Euclidean geometry. They understand qualities such as the consistency, independence and completeness of the axioms. At this level geometry acquires a general character and wider applications. A minority of pupils arrive at it during higher education. Most never arrive.

4.6. Levels 0–4

The levels are successive. Students, to reach any level above the baseline (level 0), must go through all previous levels. They cannot overtake levels, regardless of the training they will receive. Passing one level means that the student has acquired the appropriate experience in geometric thinking for the next level and is able to manage the relationships that are the focus of the next level. Levels do not depend on age, like Piaget's developmental stages. At level 0, it could be a pupil of the 3rd Grade of Primary School and one of the Gymnasium. Also, some adults never reach level 2. However, age is directly related to the totality and types of geometric experiences people have. For this reason, almost all pupils of the second grade and most of students of the third grade are expected to be at level 0. The transition from one level to another does not happen automatically, over time, but under the influence of a specific teaching–learning programme. The main factor that affects the progress of a student from one level to another is the geometric experience. Students who have the opportunity to explore, discuss and interact with the next level content, as they increase their experience at the level they are at, are more likely to improve their geometric thinking and reach higher levels faster. The level at which each person is, is not directly related to his/her age (Van Hiele, 1984, 1999).

5. Summary and main idea of a teaching scenario

This study was based on the mathematics taught in the Second Class of Primary school, and especially on the section titled 'I'm making geometric shapes'. The approach to this subject aims to systematise and enrich students' knowledge of geometric shapes (square, rectangle, rectangular triangle and circle) through a variety of activities. In particular, students are able to classify and designate geometric shapes based on their characteristics, to follow instructions in order to construct geometric shapes, to discover that in the square all sides are equal and the opposing parallel, whereas in the rectangle the opposing sides are equal and parallel, recognise polygons and learn their naming, learn the importance of geometric shapes over the years, and compose based on geometric shapes. All this is done by overcoming the traditional way of teaching with innovative pedagogical methods, where children freely express through discussion and dialogue, painting and music.

The educational scenario is implemented in the computer lab, where students use the appropriate educational software in which they seek, choose and discover new knowledge and new concepts. In this way, pupils conquer new knowledge effortlessly and develop a spirit of cooperation and teamwork, respect and appreciation. There will be classes of the Second Grade consisting of 40 students. That is why we need the right space and the appropriate number of computers. It is proposed to organise pupils in groups of 2 or 3, similar to the number of computers in the classroom. Also, the groups will be heterogeneous, (boys–girls) and their members will have different abilities and capabilities.

Students will not have a passive attitude but will communicate, exchange views and act by avoiding inactivity so that the lesson is interesting and new information is discovered and stored more easily. Activities will support the learning process with the pedagogical use of ICT in order to make children aware and explore geometric shapes through pleasant activities.

5.1. Educational software used

The teacher will use the following software that are pre-installed on the PC and students know how to use them: Kidspiration, Microsoft Office Word, Inspiration, the educational software of the Greek Pedagogical Institute (Mathematics of Primary School), Sketchpad, Hot Potatoes, Revelation Natural Art, PowerPoint presentation software, Jigsaw Puzzle Creator and the Internet.

- Geometer's sketchpad: is an open software where learning is managed through discovery, exploration and building. It belongs to dynamic geometry systems that help students build and explore mathematical concepts relevant to the subject. In this scenario, students will learn to construct geometric shapes. In the end, they will reach conclusions that will be announced to the classroom.
- Hot potatoes: Educational software that allows interactive quizzes, crossword puzzles, match assignment, grading and fill-in exercises. It belongs to general-purpose software based the theories of behaviour. It is a quite widespread software because it is a collection of small applications for creating exercises or evaluation exercises through PCs or the Internet. The teacher creates exercises he or she needs in order to share them with students or other teachers. This software was used as an open source software.
- Revelation natural art: is an open educational learning software (authenticity, versatility, support framework) that can become a valuable cognitive tool in the hands of the creative teacher. Children cultivate skills of composition, comparison, organisation and generalisation. Through the analysis and creation of pictures, static and animated, as well as the addition of text, creativity is awakened and maintained. As a result, the expression of children is cultivated in the form of complex representations.
- Jigsaw puzzle creator: is an open-source educational software based on socio-cultural and constructive learning theories. Children playfully create their own original designs with images and enjoy their masterpieces. Children build, create and become active during teaching, as there are many possibilities, such as adding sound, background, time and so on. The teacher has the role of mentor and animator and helps in solving any problems, while children are the creators and builders.

6. Methodological approach

We use collaborative learning that advocates the organisation of lessons that promote social interaction and collaborative, group learning. For this, it was necessary to organise pupils into small groups (2–3 pupils) who would work autonomously on the computer under the guidance of the teacher and use the appropriate worksheet. Groups are organised by students of different capacities and different characteristics in order to teach children to show tolerance and acceptance of a variety of learning styles. Also, the group helps those who need more help or encouragement, and through the collaboration and interaction of the group members the didactic approach will be achieved. Apart from the above, the cognitive conflict between the students of the group and among the other groups helps cognitive cultivation, all-round development and the emergence of a modern teaching. The teacher has the role of a mentor, animator and facilitator, who encourages all of the students' efforts. At the end of each activity (worksheet) he/she asks the students: 'How did you find it? How did you think about it?', in order for students to develop and cultivate their metacognition skills.

6.1. Teaching approach with the use of ICT

ICT learning makes the lesson attractive. It is in line with the humanistic learning theories that say that students learn better and faster when learning is 'personally important', that is, when students consider it relevant to their own needs. Using software, understanding and systematisation of knowledge is playful with activities that use ICT technology tools to a great extent, serving the cognitive goals set. ICT enables students to discover, explore their knowledge, organise and record their thoughts and conclusions. In this way, the added value of the script is that students through a playful process are free to explore the subject by making assumptions and experiments as often as necessary to reach generalisation and conclusion, free of fear of a possible error. The use of ICT in teaching makes learning interesting, allowing students to see flat geometric shapes in a snap look, discussing them, discovering concepts and giving different interpretations, having transformed the class into a learning community. Also, the integration of pupils into groups helps them to interact and feed back into the assumptions they make and the decisions they make. Finally, this scenario attracts students, wins their interest and makes them all involved as active members of the group (Raptis & Rapti, 2007).

6.2. Population and survey sample

The questionnaire was given to all pupils who participated in the teachings, i.e. a total of 40 pupils of the Second Grade of Primary School. These students had very general and basic knowledge of geometry before the teachings and in particular possessed the necessary mathematical knowledge of the first class of primary school, combined with the knowledge gained in the first months of study in the second class. The teachings were made during the school year 2015–2016 at the Private Elementary School 'Themistoklis' in Piraeus, Greece.

6.3. Measuring instruments

Observation: It is the process where a phenomenon or behaviour is observed in a planned, organised, systemic manner by people skilled or trained for this role.

Interview: It is one of the best-known methods of collecting material, where the researcher submits to the respondent a series of questions to answer. What interests the researcher is to discover what the respondent thinks about a subject and compares the opinions of respondents. Then the researcher is interested in comparing and grouping their views.

The questionnaire: This is a form that contains a series of structured questions that are presented in a specific order and to which the respondent is asked to respond. The questionnaire is the means of communication (interface) between the researcher and the respondents, directly or indirectly, depending on the method of data collection. Composing the questionnaire, due to its properties, is the most critical and delicate task, crucial to the success of a statistical survey.

7. Results

During the geometry lesson with the use of ICT, we realise how much more interesting the lesson is for the students and how much faster they fit into the meaning of the lesson. Their interest remains unchanged throughout the implementation of the teaching scenario, and the educational software, programs and webpages they use make geometry more understandable and the lesson deviates from traditional data. The question, however, is whether the use of technology offers learning results. Students of a class may not all be at the same level of geometric thinking (Van Hiele's levels) or may not have the same degree of acquisition.

Thus, when students of one class use the same word in geometry, they can interpret it quite differently. For example, if one student is at level 0, the word 'square' simply means a form that resembles a square. At level 1, the student thinks of the square as a set of properties, but cannot distinguish what is appropriate and necessary to define a square. On the other hand, the educator, who thinks at a higher level, knows not only the properties of a square but also the relationships between the different attributes and thus can prove on the basis of these that a shape is a square. The teacher should therefore know the Van Hiele's level at which a student is, so that he/she can effectively communicate with him/her and adapt the activities so that they suit the level of all pupils. It should, in other words, provide them with the appropriate experience, depending on their level, and direct them to the highest level.

8. Conclusion – discussion

Ultimately, the answer to the question at the beginning of this survey, namely whether the use of technology offers learning results, is definitely YES. To the point, however, that properly trained teachers will have an important role in the learning process and attain the goals and objectives of learning. Enlightened teachers, according to Vygotsky, will always be the key and the bridge to approach the upcoming development of their students. The computer, as a valuable means of teaching, as well as a powerful mediating tool will always work in an auxiliary way.

The ICT has a special role in teaching. Naturally, no one is neglecting its divisive implications and consequences on digital illiteracy. The teacher with his positive attitude towards ICT can make modern curricula and can offer many opportunities for developing collaborative education and knowledge-building as a dynamic three-fold component of class. Further research could include a larger sample of pupils of all primary school classes on a larger scale, provided that they would only have been taught in the new school textbooks of mathematics.

In addition, the degree of conquest of the second level (Informal Production or Disposition) of Geometric Thinking by van Hiele could be investigated by the elementary school pupils of Second grade. Finally, it could be investigated whether the five phases of van Hiele learning (Information, Guided Orientation, Expression – Analysis, Free Orientation, Integration) appear in the elementary school textbooks in the study of flat geometric shapes, and the transition from one van Hiele level to the next.

References

Klaudatos, N. (1999). What does Mathematical Education mean for 'Active Attitude to Mathematics?' *Inspection of Scientific and Educational Issues, A* (2), 62–77.

Koleza, E. (1997). The role of activities in teaching mathematics. In *Proceedings of the 14th Panhellenic Conference of the Greek Mathematical Society*, Mytilene, Greece.

Koleza, E. (2000). *Gnostic and teaching approach of elementary mathematical concepts*. Athens, Greece: Leader Books.

Kontogiannis, D. & Ntziahristos, B. (1997). *Basic concepts of Geometry* (3rd ed.). Athens, Greece.

Kordaki, M. (2004, January 9–10). *Supporting the role of technology in teaching and learning mathematics: the case of mathematics and technology centers*. Paper presented at Scientific Meeting on Education, Patra, Greece.

Kordaki, M. & Potari, D. (1999). Children's approaches to area measurement through different contexts. *Journal of Mathematical Behavior, 17*(3), 303–316.

Ntziahristos, B. & Zaranis, N. (2001). The use of van Hiele theory in the understanding of the geometric concepts of the 1st gymnasium with the help of educational software*.* *Mathematical Inspection, 56*, 55.

Raptis, A. & Rapti, A. (2007*). Learning and teaching in the age of information* (Vols A & B). Athens, Greece.

Smeets, E. (2005). Does ICT contribute to powerful learning environments in primary education? *Computers and Education, 44*, 343–355.

Tawalbeh, M. (2001). The policy and management of information technology in. Jordanian schools. *British Journal of Educational Technology, 32*, 133–140.

Tearle, P. (2003). ICT-implementation: what makes the difference? *British Journal of Educational Technology, 34*, 567–583.

Toumasis, M. & Arvanitis, T. (2003). *Teaching mathematics using PC*. Athens, Greece: Savvalas.

Van Hiele, P. M. (1984). *A chil's thought and geometry*. In D. Fuys, D. Geddes & R. Tischler (Eds.), *Dina van Hiele Geldof and P. M. van Hiele* (pp. 247–256). Brooklyn, NY: Brooklyn College, School of Education. (Original work published 1959)

Van Hiele, P. M. (1999). Developing geometric thinking through activities that begin with play. *Teaching Children Mathematics, 6*, 310–316. Retrieved April 8, 2016, from http://schools.nyc.gov/NR/rdonlyres/0EFD73D4-340A42E28EB4- 3BC2A6B05603/38319/30vanHielePlay.pdf