A SURVEY WITH FUTURE PRIMARY SCHOOL TEACHERS ON USING GEOGEBRA FOR 2D AND 3D SHAPES

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ABSTRACT

This article presents a quantitative and qualitative analysis conducted in Italy, regarding the planning of didactic units on the part of 23 university students. The degree course is in Primary Education Sciences, for future elementary school teachers, in the field of geometry and in particular of 2D and 3D shapes, integrating traditional teaching with the use of GeoGebra software. The data collected through a questionnaire administered to prospective primary school teachers present the many positive aspects of using the GeoGebra software for teaching and learning 2D and 3D geometric shapes and some negative aspects perceived by the sample considered.

KEYWORDS

Geogebra, Primary School, 2D And 3D Shapes, University Education

1. INTRODUCTION

The Ministry of Education and Research in Italy has promoted the creation of "Innovative Learning Environments", i.e. learning environments and spaces equipped with innovative technological resources, capable of integrating the use of technologies into teaching. An innovative learning environment is characterized by the centrality of students with their active engagement, by cooperative learning, with teachers who are open to acknowledging students' motivations and sensitive to individual differences, and who emphasize formative feedback. Such an environment is flexible, adaptable, and allows people and information to connect. Moreover, it strengthens the interaction between students and teachers, between contents and resources. Many studies have been conducted on teaching and learning processes in various disciplines (Adair, 2009), (Bruner1, 1957), (Bruner2, 1961), (Bruner3, 1973) (Bruner4, 1996), (Dewey1, 1933), (Dewey2, 1938), (Feiman1, 1990), (Feiman2, 2001), (Munna and Kalam, 2021). Literature on the teaching and learning of geometry in primary school is very broad, and different aspects can be considered, from learning difficulties to assessment, (Jirotková et al. 2019), (Bonanzinga et al. 2022). We focus our attention on Geometry and 2 and 3 dimensional (3D) shapes and on its teaching and learning in primary school. Geometry is often considered a difficult subject to understand and several software programs have been developed to aid teaching and learning processes, such as Cabri-Geometry, Geometer's Sketchpad and GeoGebra. The latter is used worldwide from elementary school to university, (Tatar and Zengin, 2016), (Velichova, 2011), (Zulnaidi et al., 2020), (Putra, et al. 2021) (Kokol-Voljc, 2007), (Bonanzinga, 2023). Numerous studies conducted in the United Kingdom, Luxembourg, Portugal, Lithuania, Hungary, the Czech Republic, Slovakia, Malaysia, Indonesia, Vietnam, Nepal, Africa and many other countries show the effectiveness of its use in learning geometry, (Bulut et al., 2015), (Žilinskienė, and Demirbilek, 2015), (Gunčaga and Žilková 2019), (Tay and Wonkyi, 2018) et al. GeoGebra software originated from a master's thesis project of Markus Hohenwarter at the University of Salzburg in 2002. It was designed to combine features of interactive geometry software (e.g. Cabri Geometry, Geometer's Sketchpad) and computer algebra systems (e.g. Derive, Maple) in a single, integrated and easy-to use system for teaching and learning mathematics (Hohenwarter and Preiner, 2007). Geometry and algebra are central to mathematics and have been called its "two formal pillars" (Atiyah, 2001). Over 20 years, GeoGebra has developed into an open-source project with a group of 15 developers and over 100 translators all over the world. GeoGebra has been translated into 52 languages and used in 190 countries. It has grown from a small student project to an international organization. At the end of 2007, the International GeoGebra Institute (IGI) was established to offer teacher training and support, to develop teaching materials and software, to conduct research, to outreach to less well-off communities. The GeoGebra Mobile application also allows its use on mobile devices, such as smartphones and tablets and therefore greater use by teachers and students who do not necessarily need to have a computer or a classroom equipped to use the dynamic geometry software GeoGebra, (Alkhateeb, et al. 2019), (Bonanzinga, V. et al. 2020). The Italian National Guidelines (MIUR 2012) for primary school suggest a conscious and motivated use of calculators and computers which must be appropriately encouraged from the first years of primary school, for example to verify the correctness of mental and written calculations and to explore the world of numbers and shapes. In this article, we present a survey conducted in Italy on the planning of lessons on flat and solid geometric figures by a sample of 23 students of a Primary Education Sciences degree course, future elementary school teachers, integrating traditional teaching with the use of GeoGebra software. The objective of this research is twofold; to evaluate future teachers in the fruitful use of technology, in particular dynamic geometry software (DGS), for (i) their training and (ii) teaching. Students were asked to assess their knowledge of software used for learning/teaching. Only 3 had any knowledge so we wanted to assess the skill of acquisition and time of acquisition. Numerous studies have demonstrated the effectiveness of using DGS in mathematics teaching and learning. This study investigates the time needed to acquire the basic knowledge of GeoGebra software for calculating the perimeter and area of plane figures and the volume of solid figures and the perception of future elementary school teachers regarding the obstacles and difficulties in their usage. Our aim was to ask if future teachers are ready for the use of specific technology in teaching. In detail, we asked if tutorials, prepared by expert primary school teachers, help train future teachers to better understand geometric concepts and help in teaching using new technology.

2. PARTICIPANTS

Twenty-three students of an Italian university (21 females and 2 males), aged between 21 and 46 years, participated in the study: 3 students had worked with the GeoGebra application before the proposed activity, while the other 20 had never used it before. Only two students knew about software other than GeoGebra, namely MATLAB and WeSchool. Twelve students were enrolled in the second year of the course, 6 in the third and 5 in the fourth year. They were asked on a scale of 1 (not at all) to 5 (very much) about their interest in mathematics.

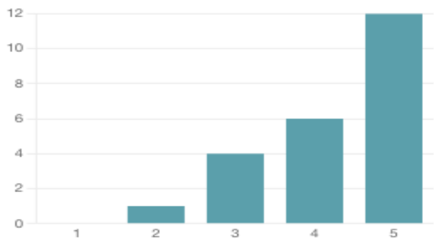

Figure 1. Interest in mathematics

Regarding the use of the computer, it was noted that most students had access to this resource at home. On assessing the students' entrance exam to the course, we ascertained that level of math skill was quite low and therefore this sample provided an opportunity to evaluate the use of GeoGebra with a relatively naïve population.

3. METHODOLOGY

This study can be considered in line with the above mentioned larger GeoGebra projects on developing a model to support teachers' mathematical, didactic, and technological knowledge by integrating DGS GeoGebra software. In this present paper, the researchers present a case study of prospective elementary teachers' experiences with GeoGebra for 2D and 3D geometric shapes. First, the students were given 5 links relevant to GeoGebra: 1 link was to download the program; 3 links were for tutorials prepared by expert teachers on the use of GeoGebra in primary schools; 1 was examples of activities created by teachers and students on volumes of diverse solids. The initial tutorial explained how to start to teach geometry with the program using the basic commands. For instance, the teachers are shown how to hide the algebraic part of the software and the Cartesian plane. They then learn how to insert the squared background. In this way, the children can recognize the squares of their squared copybook. Then they learn how to use the text function, to insert data, to change font size and color, to move geometric objects and also to use the function to insert points. The second tutorial shows the function of polygon: to insert a generic polygon and a regular polygon, to draw a polygon in an anti-clockwise way so as to be able to visualize the internal angles of the polygon. Regarding the regular polygon function, they are shown how to choose the length of the side and the number of sides. The third tutorial explains the area and perimeter considering the function of distance and length. Moreover, stretching the sides and reasoning on isoperimetries and equi-extensions were also included.

The link regarding the sample activities are open educational resources that can be modified and adapted depending on the needs of the teacher.

The student teachers were asked to prepare one or more lessons, on plane and space geometry, with particular reference to the area of plane figures and the volume of solids, integrating traditional methods with new methodologies, contextualizing problems, using software, in particular GeoGebra to check their results. The proposed didactic model suggests a synergistic use of pen-paper and software, (Farihah U., 2019), and combines the 5E instructional model and that of Revised Bloom's Taxonomy (RBT, Anderson et al. 2001). The 5E instructional model is a student-centered model for teaching, which consists of five stages: engagement, exploration, explanation, elaboration and evaluation (Bybee, 1997). Regarding the definition of learning outcomes, we follow Bloom's taxonomy, reviewed by Anderson et al., in 2001, which provides a list of six categories of skills, in ascending order from the simplest to the most complex,

1. Knowledge: ability to memorize information;
2. Comprehension: being able to translate and interpret the stored information;
3. Application: knowing how to extend the acquired concepts to unusual situations;
4. Analysis: ability to distinguish elements of information and qualitatively separate data;
5. Evaluation: critically examine a situation;
6. Creating: put elements together to form a new coherent or functional whole; reorganize elements into a new pattern or structure (design a new set for a theater production, write a thesis, develop an alternative hypothesis based on criteria, invent a product, compose a piece of music, write a play).

In the first phase of the project, the objectives to be achieved according to the model were termed "S.M.A.R.T." conceived by G. T. Doran and published in the November 1981 issue of Management Review. With the acronym S.M.A.R.T., the characteristics of the objectives to be pursued are indicated:

• Specific: Results should not be too general
• Measurable: the results must be able to be measured, it is therefore necessary to devise methods to quantify progress
• Achievable: the results must be achievable
• Relevant: the desired outcomes must be relevant to the course
• Time-limited: It must be clear within how long the goals should be achieved.

Tutorials for installing and using the software for primary school students were indicated and some examples were provided.

Through a questionnaire, future primary school teachers were analyzed regarding the time taken to carry out the assigned activity, the positive aspects of using the GeoGebra software and any negative aspects.

4. RESULTS

The degree of acquisition of GeoGebra skills was divided into three levels: low, medium and high.

Level	GeoGebra skills	Percentage
High	Full mastery of the tools, functions and commands of the software relating to the 2D and 3D shapes	22%
Medium	Good mastery of the tools, functions and commands of the software relating to the 2D and 3D shapes	48%
Low	Limited mastery of the tools, functions and commands of the software relating to 2D and 3D shapes	30%

Figure 2. Degree of acquisition of GeoGebra skills

In the first level of skills acquired with the GeoGebra software, students describe, name and classify plane figures. For example, imagine asking students to count the number of squares and triangles present in a plane figure or to use different colors based on the different geometric shapes, as illustrated in the following figures.

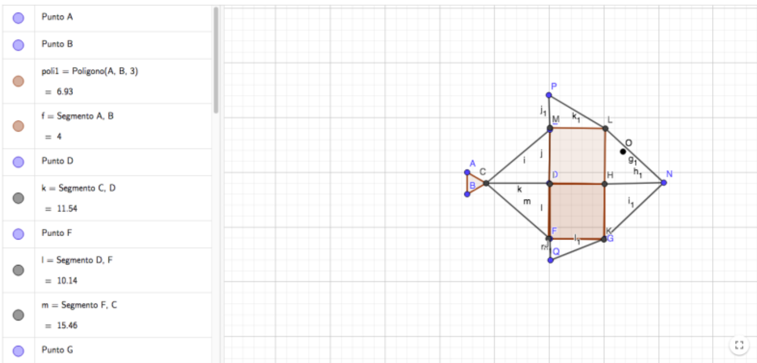

Figure 3. On counting squares and triangles

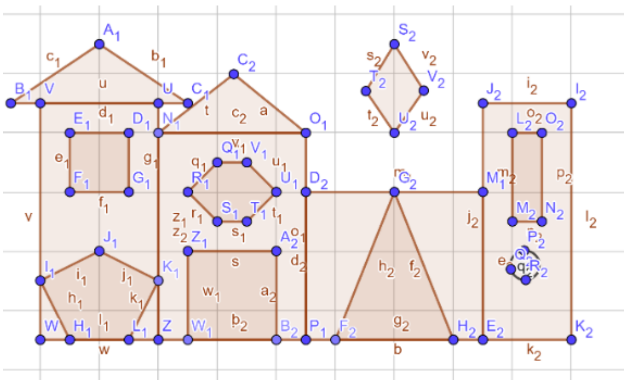

Figure 4. On coloring different 2D shapes

In the second level of skills, the student describes, recognizes, and classifies the 2D shapes and uses the functions for calculating area and perimeter, as illustrated in the following figures:

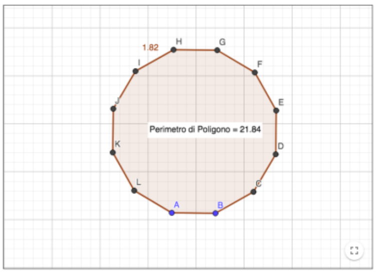

Figure 5. Perimeter of a dodecagon

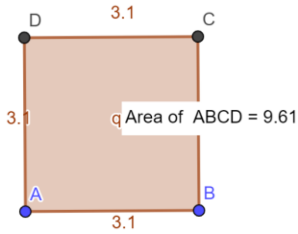

Figure 6. Area of a square

In the third level of skills, the student describes, recognizes, and classifies 2D and 3D shapes and uses the functions for calculating area, perimeter, volume and the slider to change the size of a side as illustrated in the following figures:

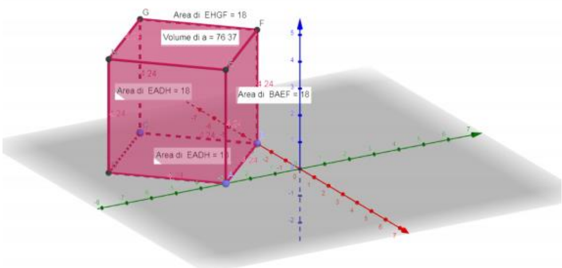

Figure 7. Area of the faces and volume of a cube

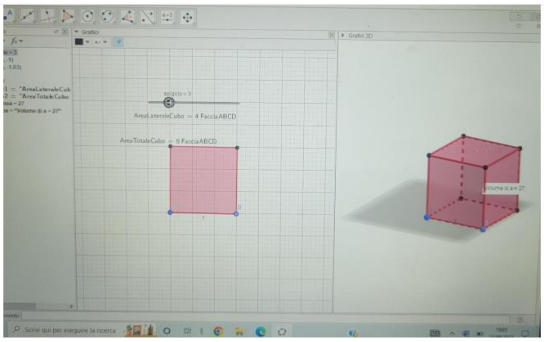

Figure 8. Slider to change the size of an edge

In the following tables, we summarize the positive and critical aspects perceived by the students on the proposed activity:

Table 1. Students' positive considerations on the proposed activity

Fast, simple and fun, it stimulates the pupil's interest, adapts to the educational needs of the pupil and to the very different levels of preparation.
It improves learning processes, helps keep pupils' attention high, helps pupils actively participate, is useful for consolidating pupils' knowledge, presents an alternative way of teaching, increasing pupils' skills.
Makes learning challenging; helps fill the gaps and achieve goals more easily and effectively.
The use of educational software in primary school stimulates pupils' reasoning and allows the teacher to create personalized educational paths.
The use of technology in education improves the quality of learning, facilitates access to resources and in some cases as group work; it also favors collaboration and the exchange of ideas.
The proposed methodologies help pupils' learning
The proposed methodologies help pupils develop skills.
The positive aspects are the simplicity of use for introducing topics. Pupils can use it to calculate perimeter and area of polygons and draw various geometric shapes.
GeoGebra is very intuitive, but with advanced features.

Table 2. Students' critical considerations on the proposed activity

Excessive use of GeoGebra software could become a source of distraction and not everyone has the possibility of accessing technological means outside the school walls.
Pupils may underestimate the lesson, cooperation with peers may be lacking, pupils may not be familiar with computers.
Limit creativity and dexterity in writing or drawing; can be distracting during the lesson.
Pupils may consider the lesson and/or explanation as if it were a game.
Educational software could lead to less interaction between pupils, since each child, having his own electronic device at his disposal, could isolate himself from the rest of the class.
Constraint on the use of digital resources.
A negative aspect may relate to the automatic calculation of the perimeter and of the area, which can push those who use it to rely completely on the automatic system without engaging individually in the calculation.
Time necessary to acquire knowledge of the commands, functions and potential of the software.

The different levels of acquisition of skills with GeoGebra also depend on the time spent in training and experimentation.

Hours/Days	Number of students	Percentage
1-2 hours	8	35%
3-5 hours	5	22%
1 day	3	13%
2-3 days	7	30%

Figure 10. Time taken to carry out the requested activity

The students were asked on a scale of 1 (not at all) to 5 (very much) about their interest in GeoGebra.

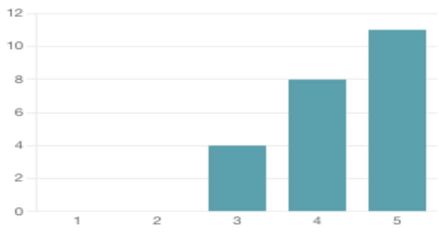

Figure 11. Interest in software GeoGebra

5. DISCUSSION

Feiman-Nemser, in 2001, explains specific principles and strategies on how to apply educational mentoring and some notions on how to carry them out. In Kokol-Voljc 2007, pedagogical advantages of the use of mathematical software in teaching are outlined. In Jirotková et al. 2019 the research focused on the issue of the relationship between perimeter and area and the presence of a misconception "same area, same perimeter". Our study is in line with the above mentioned works, whereby tutorials given by experts are seen as helpful, student teachers appreciate the software which helps them to understand the concepts, and finally the students' own misconceptions, often not trivial, are clarified, thus helping them teach better.

6. CONCLUSION

The case study highlights significant positive aspects of using the GeoGebra software, it is interesting, intuitive, useful, simple to use, fun, effective and stimulates curiosity. From analysis of the activities carried out by the future elementary school teachers, it emerges that only 22% of the students have acquired full mastery of the tool, 48% of the students have good knowledge of the software and 30% have limited knowledge. Therefore, a guided training course is certainly essential for its more effective and widespread use. Furthermore, the need for a complementary, but not exclusive, use was underlined. The risks of exclusive use of software would lead to a loss of dexterity in design and measurement, and in calculation ability.

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