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Procedia - Social and Behavioral Sciences 182 (2015) 136 – 142

Procedia
Social and Behavioral Sciences

4th WORLD CONFERENCE ON EDUCATIONAL TECHNOLOGY RESEARCHES, WCETR-2014

Mapping free educational software used to develop geometric reasoning

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Abstract

The use of educational software as a teaching resource is becoming more common. However, teachers still need to choose which software best meets needs of their students. The goal of this study was to map free educational software regarding space and shape content for mathematics education. The study was conducted with public elementary teachers (grades 6-9). Of the thirty-three software titles, 55% could contribute to space and shape content. Thirty percent of the software simultaneously developed geometric, numeric and algebraic reasoning as well as metric and proportional reasoning.

Peer-review under responsibility of Academic World Research and Education Center.

*Keywords:*Free software; grades 6-9; mathematics; geometry;educational software

1. Introduction

Geometry is the study of the properties of and relationships between geometric shapes. Understanding the concepts of space and shape provides a basis for learning mathematics and other subjects (Clements, 1998; Jones, 2002). These concepts are linked to thinking geometrically and developing logical thought. In other words, learning to use geometry is learning to think logically (Surynkova, 2011). By learning geometric concepts, students develop

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Peer-review under responsibility of Academic World Research and Education Center.
doi:10.1016/j.sbspro.2015.04.748

special thought processes that allow them to geometrically and systematically understand, describe and represent the world in which they live (Brasil, 1998; National Council of Teachers of Mathematics, 2000). These skills are essential for problem solving.

In order to use geometry to solve problems in mathematics and other fields, students must be able to express problems geometrically (Surynkova,2011). Three registers are possible in geometry: natural language, symbolic language and the figural register (Deliyianni et al.,2009). The figural register depicts relationships between concepts and properties.

There are many cognitive stages ranging from exploring physical objects such as works of art, paintings, drawings, sculptures and crafts (Brazil, 1998), to geometric situations described by natural language and represented by geometric figures.

Several studies have focused on understanding the mental progression of students as they follow these steps (Duval, 1995, 1998, 1999; Fischbein, 1993; Van Hiele, 1986).Our study focuses on the transformation of a real object into a geometric object and the understanding of the object's properties.

In order for students to advance cognitively, teachers use concrete materials (Figueira-Sampaio et al., 2012) and educational software (Figueira-Sampaio et al., 2013).

However, the challenge of choosing and even finding appropriate software may discourage teachers from actually using this educational resource. Therefore, our objective was to present viable software options for developing geometric reasoning by mapping free educational software regarding space and shape content.

2. Methods

We selected 33 software packages from those proposed by Nogueira et al. (2013) and others mentioned in digital or print format. All software packages were free and intended for 6^{th} to 9^{th} grade mathematics education. All of the software packages were easy to install and freely available on the internet.

Thirty-four public middle school teachers (grades 6-9) determined the mathematical content targeted by each software package. To accomplish this, the features of each computer program were presented to the teachers, who then filled out forms identifying the specific mathematical content addressed by each package. The content was organized into thematic blocks based on Brazilian national curriculum parameters (PCNs – Parametros Curriculares Nacionais): Numbers and Operations, Space and Shape, Quantities and Measurements, and Information Processing.

3. Results and Discussion

According to the teachers and based on the thematic blocks (PCNs), 55% of the 33 software packages could be used to work with Space and Shape content. A further 48% of these could also be used for Numbers and Operations and/or Quantities and Measurements content.

The software packages *C.a.R.-Regua e Compasso, Dr Geo, GeoGebra, Geonext, MathGV, Poly* and *Wingeom* were the most frequently identified for the Space and Shape block. These programs address concepts needed to understand displacement and space content and to study geometric shapes (Fig. 1 and 2). Specifically, these programs can be used to work with planar geometric shapes, points, lines and planes; line segments, altitudes, collinear and consecutive line segments; non-planar geometric shapes, vertices, edges and faces; rotations and angles; polygons; points in a Cartesian plane; triangles and their elements; classification of triangles based on sides and angles; quadrangles and their elements; relative positions of two lines in a plane; perimeter and diagonals of polygons; angles of convex and regular polygons.

Of all the teachers who evaluated *Dr Geo, GeoGebra, Geonext, Polígonos, Teorema de Pitagoras, Triangulo, Trigonometria* and *Wingeom* (n=15, n=25, n=24, n=20, n=19, n=18, n=23, n=20, respectively), 100% identified the software as appropriate educational resources for the Space and Shape block. These teachers also indicated that all of these programs could be used to create activities to work with the elements, measurements and classification of angles. Forty-three percent of the professors (n=21) identified *MathGV* as a potential source for developing geometric knowledge. In general, the software could be used to demonstrate and visualize angles, which contributes to the understanding, but not the memorization of content. Understanding content allows students to use concepts to understand and reflect on mathematical problems or concrete cases instead of simply applying rules.