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PICTURES WITH NARRATION VERSUS PICTURES WITH ON-SCREEN TEXT DURING TEACHING MATHEMATICS

Abstract: The purpose of the present study was to compare the effects of two different teaching methods on students' comprehension in Mathematics: pictures with concurrent narration versus pictures with on-screen text, during teaching triangles, a lesson in Mathematics. Forty primary school children (boys and girls) selected to participate in this study. Students splitted into two experimental groups with the technique of simple random sampling. The first group consisted of students who viewed and listened (pictures with narration group), while the second group consisted of students who viewed (pictures with on-screen text) a presentation of triangles. A recall test was used to evaluate students' comprehension. The results showed that students' comprehension was better when triangles' presentation (pictures) was accompanied with spoken words, than with printed words. The pictures with narration group performed better than the pictures with on-screen text group, in recall test ($M = 4.97$, $SD = 1.32$) $p<0.01$. Results are consistent with the modality principle in which learners are more likely to build connections between corresponding words and pictures when words are presented in a spoken form (narration) simultaneously with pictures.

Key words: dual-coding theory, modality principle, pictures, spoken words, printed words.

Introduction

One of the most important and basic principles of educationalists and those involved in the educational research, is the use of techniques which improve students' curiosity, motivation and learning process (Grimshaw, et al., 2007). During the last decades, one of those techniques is the application and use of Multimodality. According to Cope and Kalantzis (2009), Multimodality actually refers to a system of learning with multiple didactic teaching stimuli or tools: visual ones, such as letters, graphs and pictures (static or animated) and body posture, audible such as voices and sounds and kinetic such as hand making or hand solving. Those teaching stimuli are often referred to as modes, as organized sets of semiotic resources for meaning making (Jewitt, 2008).

In the school environment learning and generation of meaning can be achieved through the use of Multimodality, which is often used in the pre-school age in a variety of lessons such as Language, Mathematics and Painting (Matthews, 2003; Mellgren & Gustafsson, 2011;

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Papadopoulou, 2011). Information is presented to children through a variety of systems, such as linguistic (sounds), visual (images) and shapes (colors). In the pre-school age for example, teaching shapes to students is an important precursory skill in the lesson of Mathematics (Ojose, 2011). Due to the use of this teaching technique and principle, students' curiosity, motivation and generation of meaning is positively enhanced and learning is achieved by students through different ways (Picciano, 2009; Shah & Freedman, 2003).

The learning environment, in which the information or knowledge is presented in multiple modes or sensors (visual, aural and written) is called Multimodal (Crafton, Brennan, & Slivers, 2007; Clark & Mayer, 2003). Thus, in such an environment, material is presented in different ways with the increasing use of technology and multimedia (video, audio, images, animated images, static images, sounds and interactive elements), rendering to transferred knowledge and information a dynamic character (Narayanan & Hegarty, 2002). According to Mayer and Moreno (2002), in a Multimedia learning environment information is presented in two or more perceptual modalities, visual (pictures, images, graphs) and auditory (sounds, words). Therefore, Multimedia learning occurs when students build mental presentations from words and pictures that are presented to them. According to Jewitt (2005), print based reading and writing have always been multimodal.

A cognitive theory of Multimedia learning known as Dual-coding theory, advanced by Paivio (1986) is based on the main assumption that there are two separate channels (auditory and visual) processing information. In agreement with this theory, words and pictures activate independent visual and verbal codes. According to Dual-code theory, narration (verbal) is proceeded in the auditory-verbal channel, while animation (visual) is proceeded in the visual channel.

Students receive information and knowledge through a variety of stimuli (visual, audial) and tools (images, text, sounds and words). When an instructional message in words or pictures is presented to them, students are engaged in active learning by making connections between visual and verbal representations. The current combination of words and pictures, known as the contiguity principle, increases the effectiveness of a multimedia instruction message (Mayer & Anderson, 1992). According to Mayer (2003), students learn more deeply from a combination of words and pictures than from words alone, known as the multimedia effect. Furthermore, animation with concurrent narration enhances performance in addition to a method which includes animation with on-screen text or written words, known as the modality principle (Mayer & Moreno, 1998; Moreno & Mayer, 1999).

Words can be used in a written (printed text) or spoken form (narration). Using words in a spoken form a teacher or student, known as Narration is a common teaching method in a variety of lessons in the Elementary education. Usually, in lessons such as Language, History, Essay, Religion and stories (Bell, 2002; Butcher, 2006; Colby, 2008), knowledge and information is presented to students in this technique. One main disadvantage of narration, is that students are usually pathetic recipients of knowledge and information is presented to them (Levstik & Barton, 2001). Narration is usually proceeded in the auditory-verbal channel.

Pictures on the other hand are used in a variety of forms such as illustrations, images, photos, maps, in a static or dynamic form. There is a variety of lessons where the visual stimuli and pictures are necessary for better understanding of the presented meaning such as Physics, Mathematics, Geometry, Mechanics and Physical Education (Barwise & Etchemendy, 1991;

Clements, 2001; Hegarty, Kriz, & Cate, 2003; Ioannou & Bakirtzoglou, 2016). The use of pictures use is proceeded in the visual channel. According to Rieber (1990), pictures and animation may reduce the cognitive load. Pictures (static or animated) are widely used in a Multimedia school learning environment. One of the main reasons of the growing popularity of animated graphics seems to be the belief that animation is more interesting, aesthetically appealing and therefore more motivating when it is used by a pedagogical agent (Young & Pass, 2015).

Mathematics is one of the most important lessons in the Elementary education, which uses visual stimuli such as pictures (static and animated), geometric shapes, patterns and constructions (Ojose, 2011; Steen, 2001). Teaching geometric elements is based on providing such visual stimuli which can be supplemented by word usage in a written (text) or oral form (narration). Students need not only to calculate correctly, but also to know how to create and use pictures, shapes or patterns to represent mathematical concepts (Hill, Rowan, & Ball, 2005). Mathematics appeals to the visual and aesthetic sense of the students (Clements, 2001).

According to the Modality principle, knowledge is constructed when a teaching presentation combines images (animation) with words in spoken form (narration) than words in printed form (Mayer & Moreno, 2002). Few studies compared the effectiveness of pictures with words in spoken form (narration) versus pictures with words in written form or on-text screen (text). The results showed that when information is presented to students in a model, which combines pictures with words in a spoken form it is more effective than a method, which includes pictures with words in a printed form (Atkinson, 2002; Gambari, Ezenwa, & Anyanwu, 2014; Mayer & Moreno, 1998; Moreno & Mayer, 1999; Moreno, Mayer, & Lester, 2000). Of these surveys, few of them examined the modality principle during teaching Mathematics (Atkinson, 2002).

Thus, the purpose of the present study is to compare the effectiveness of pictureswith narration (spoken words) versus pictures with on-text screen (written words) on students' comprehension during teaching triangles in Mathematics.

Methodology

Participants

Forty (n=40) school children in the 4^{th} and 5^{th} grade from 4 primary public schools from the prefecture of Rhodes (Greece), were selected for the purposes of this study with the design of random sampling. Children reported low levels of prior experience viewing and performing triangles, when they completed a participant questionnaire. Half of the subjects served in the pictures with narration group and half of the subjects served in the pictures with on-text group. Groups were designed by the method of random selection.

Materials and Apparatus

The paper-and-pencil material consisted of a participant questionnaire, one test sheet containing six questions and possible explanations-answers (recall test). The participant

questionnaire solicited information concerning students' age and asked students to rate their knowledge in triangles. It contained a triangles' knowledge scale in which students were asked to rate on a 5-point scale (1=very little, 3=average, 5=very much) their level of knowledge of triangles and to place check marks next to each of triangles that were presented to them (e.g., "I know the types of triangles by length of sides", "I know the types of triangles by angles", "I can design an isosceles and scalene triangle", "I know what are the differences between a right-angled and obtuse-angled triangle", "I can calculate the area of a triangle").

The recall test contained the six (6) following questions: "What is the difference between a right-angle and an acute-angle triangle?", "What are the characteristics of an obtuse and an acute angle?", "What are the characteristics of an isosceles angle?", "What are the differences between an equilateral and scalene angle?", "What is triangle's height and base?", "How do I calculate the area of a triangle?".

The computer-based material consisted of two video presentations of the types of triangles, lasting approximately 2 min each. Multimedia programs were constructed using Adobe Reader 12 Version (for Windows). The first pictures with concurrent narration video, portrayed the types of triangles by angles (right angle, acute-angle, obtuse), length of sides (isosceles, equilateral and scalene) and also advices of how to calculate the area of a triangle along with concurrent narration. Each of the segments in the first video was followed by a corresponding narration segment which consisted of an approximately 112-words description about the types of triangles by angles and sides and how to calculate the area of a triangle, in digitized speech spoken in a male voice. Thefirst video was broken into 7 segments (Figure 1). The second pictures with on-screen text video portrayed the same segments as the first one, with the only difference that the 112-words description was given in written form close to each picture (Figure 2). To reduce cognitive load, words were presented close to each segment. During the two videos, all children received brief instructions keeping quiet and staying focused on the researcher's voice.

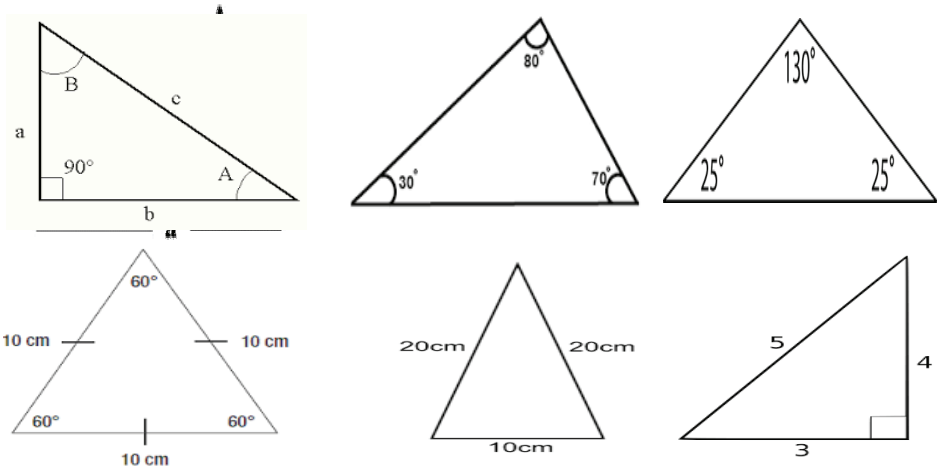
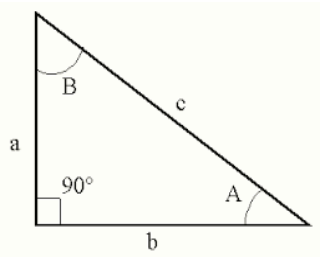
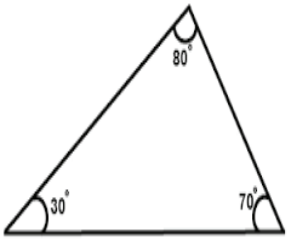


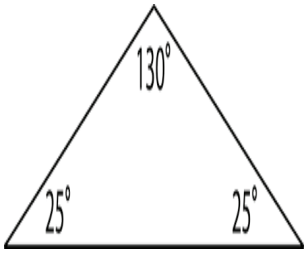
Figure 1. Selected animation frames and corresponding narration of triangle's types by angles and sides, and a way to calculate triangle's area.



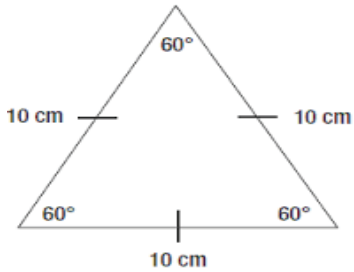
"Right Triangle: Has a right angle (90°) in its interior".



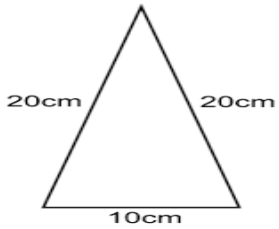
"Acute Triangle: Has all its angles acute (less than 90°) in its interior".



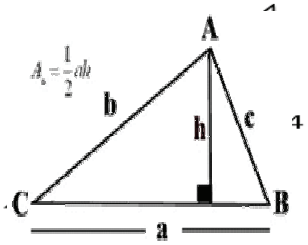
"Obtuse Triangle: Has an obtuse angle (greater than 90° but less than 180°) in its interior".



"Equilateral Triangle: Has all three sides of equal length and three equal angles (600)".



"Isosceles Triangle: Has two sides of equal length and two equal angles".



"Scalene Triangle: Has no equal sides and no equal angles".

"Calculation of Triangle's area: Base (a) is a side of the triangle. Height (h) is a line segment through a vertex and perpendicular to base. Multiply the base by the height and then divide by 2".

Figure 2. Selected pictures and on-text screen of triangle's types by angles and sides and a way to calculate triangle's area.

Apparatus consisted of one Toshiba Satellite C55-A-1F5 laptop with 15.6-in., connected with a projector EPSON EB-S31 3LCD. Headphones FRISBY FS-75NU were plugged into the audio output of Toshiba laptop.

Procedure

Five days before the measures children and teachers were informed both in writing and orally about the objectives and scopes of the study. An informed sheet was given to teachers. This form clearly stated that participation is voluntary and the child may be withdrawn at any time. Consent was obtained in accordance with the policies of the Ethics Committee of University of the Aegean.

Measurements started early in the morning after 09.00am. Students were randomly assigned to treatment groups (pictures with concurrent narration group and pictures with text group). They were instructed that they would receive a presentation of brief pictures with concurrent narration (pictures with narration group) and a brief presentation with concurrent on-screen text (pictures with on-screen text group) about the types of triangles that they should pay attention to and after the presentation that they would have to answer some questions about the material. First, students completed the subject questionnaire at their own rhythm. Second, after receiving brief instructions, students (pictures with concurrent narration group)

viewed and listened the types of triangles three times, while half of the other students (pictures and on-screen text) viewed the presentation with on-screen text three times as well. Pictures with narration and pictures with on-screen text lasted approximately 2 min each. Third, students wrote answers to recall test in a period of 5 minutes.Students were given 5 minutes to write as many solutions as possible to each question. During this time, students could not return to previous questions or continue to the subsequent question.

On the questionnaire students rated their knowledge in triangles as average and indicated that they had few experiences in this lesson of Mathematics. The recall test was scored by tallying the number of acceptable answers to each of the six questions. Students were given one (1) point for each acceptable answer. Example of acceptable answers for the six questions included respectively, the following: (a) A right triangle has 90^{o} in its interior, while an acute triangle has all angles less than 90^{o}, (b) An obtuse triangle has an obtuse angle (greater than 90^{o} but less than 180^{o}) in its interior, while an acute triangle has all its angles acute (less than 90^{o}) (c), An isosceles triangle has two sides of equal length and two equal angles (d), An equilateral triangle has all three sides of equal length and three equal angles (60^{o}), while a scalene triangle has no equal sides and angles (e), Height (h) is a line segment through a vertex and perpendicular to base, base is a side of the triangle (f), Multiply the base by the height and then divide by 2. Students received no more than 6 points overall.

Results

Table 1 shows the number of participants examined according to treatment condition and age. As shown, the two experimental groups (conditions) had equal number of participants.

Table 1.*Descriptive characteristics of participants examined as treatment condition and age.*

Group	Age	Total
Pictures with Narration	9.7±0.47	20
Pictures with on-screen text	9.8±0.41	20

Statistical analysis included the use of T-test. Statistical significant differences were found between the two treatment groups. Table 2 presents the mean scores and standard deviations for the two groups on recall test.

Table 2. *Mean scores and standard deviations on recall test for the treatment groups.*

Group	Recall test
Pictures with Narration	5.30±0.80**
Pictures with on-screen text	4.35±0.74

**p<0.01

Students in the pictures with concurrent narration group performed better and remembered more ideas in the recall test (M = 5.30, SD = 0.80) than they did in the pictures with on-screen text (M = 4.35, SD = 0.74) t(29,57) = 5.30 p<0.01.

Discussion

Multimedia instructional environments are widely recognized to improve the way and process of learning and comprehension (Mayer, 2009). Based on the principle of Multimodality in a Multimedia learning environment, knowledge may be presented in multiple ways (text, video, audio, image, interactive elements) making learning environment interesting curious and attractive (Johnson, Rickel, & Lester, 2000; Luke, 2003). Thus, Multimedia learning occurs when learners build mental representations from words (narration, spoken or printed form) and pictures (animation) that are presented to them (Mayer, 2003; Moore, Burton, & Myers, 1996).

Dual-coding theory of Paivio (1986) gives emphasis on a mixed model of knowledge, where both visual (pictures) and verbal (words, sounds) information is used to represent knowledge. According to this theory, animation is usually proceeded in the visual-pictorial channel and on the other hand narration is proceeded in the auditory-verbal channel or spoken words (Mayer, 2003). There is growing research base showing that students learn more deeply from well-designed multimedia presentations (pictures with words and sounds) than from traditional verbal-only messages (Mandl & Levin, 1989; Mayer, 2009; Sweller, 1999).

The Dual-Coding theory of Paivio (1986) and Multimedia learning theory (Mayer, 2003) provide theoretical support for the use of verbal (words) and nonverbal (images) influences on the memory. Students have the ability not only to build both verbal and non-verbal modes of representation, but also to establish meaningful connections between them. Furthermore, even verbal forms or teaching methods of presentation such as narration have long dominated education, the addition and use of pictoral forms of presentation in a teaching environment can enhance students' understating (Sweller, 1999).

According to Mayer & Moreno (2002), there are seven principles of Multimedia learning: Multimedia principle, Spatial contiguity principle, Temporal contiguity principle, Coherence principle, Modality principle, Redundancy principle and Personalization principle. The fifth principle is Modality, where students learn more deeply from animation and narration rather than animation and on-screen test (Mayer & Moreno, 2002). When animation or images are accompanied with spoken words (narration), rather than on-screen text, students will learn better. A theoretical rationale is that student's visual channel (animation or images) might become overloaded, when words and pictures are both presented visually, thus students must process the animation and the on-screen text through the eyes. As a result, thestudent or learner might not have much cognitive capacity left over to build connections between words and pictures. On the other hand, when words are presented in an oral form of presentation (narration) or through the auditory channel as such, then the visual channel is less likely to become overloaded and students or learners can make better connections between words and pictures (Mayer & Moreno, 1998; Moreno & Mayer, 1999; Moreno, Mayer, & Lester, 2000).

The aim of the present study was to compare the effectiveness of two different teaching methods: pictures with concurrent narration (pictures with words in spoken form) and pictures with on-text screen (pictures with words in written form) on students' comprehension and learning performance during teaching triangles in Mathematics. Results showed that the teaching method which combines pictures with concurrent narration improved students' comprehension better than method of pictures and on-screen text.

Students who received information and knowledge through pictures and words in spoken form, improved their comprehension and knowledge significantly in the recall test (M = 5.30, SD = 0.80) and they were able to transfer and apply what they had learned to solve a new problem.

This result is in agreement with surveys which indicate that learning performance is improved when information is presented in a model which combines pictures with narration rather than pictures with on-screen text. Those surveys showed that in seven experimental comparisons, involving explanations of how lightning forms, how brakes work, how plants grow and how electric motors work, students' knowledge was improved and transferred to new problems when animation was accompanied by spoken words (narration) than by printed words (Mayer, Dow, & Mayer, 2003; Mayer & Moreno, 1998; Moreno & Mayer, 1999; Moreno, Mayer, & Lester, 2000). However, surveys before used animated than static pictures as the present study.

Mathematics, as a lesson, uses both verbal and nonverbal forms of presentation. Some researchers investigated the thought of students learning better through animation and narration rather than through animation and on-text screen. Results showed that when Mathematics and solid Geometry lesson were presented through animation and narration, students' performance was better, than when adding on-screen text to animation (Atkinson, 2002; Gambari, Ezenwa, & Anyanwu, 2014). Therefore our result is in agreement with the results of the above surveys, with the only difference that the present study used static pictures instead of animated.

The result of this study also suggest that adding Multimedia instruction in classroom is a way to improve students' learning performance in Mathematics. Moreover, students who learn Mathematics with pictures and words in spoken form, improve their ability to recall and create solutions to a Mathematical problem. According to our results, combining pictures with spoken words, rather pictures with written form of words is an effective method of teaching as students learn more deeply.

Conclusion

The Multimedia learning environment is multi-sensory. It stimulates both the visual and auditory senses of the learner. Results of this study indicate that students learn better from pictures with words in a spoken form (narration), rather than from pictures with words in a written form (on-screen text). In the present study there is consistent empirical evidence in favor of the Modality principle: students learn better when pictures are presented contiguously with words in a spoken form (narration). It seems that combining pictures with words through the spoken form of communication or through the auditory channel, improves comprehension better, rather than adding words in a written form of communication (text) close to pictures during teaching Mathematics. Thus, in the presentation of instructional materials in the classroom, a combination of pictures and spoken form of words enhances and contributes most on students' learning performance in Mathematics. More studies should focus in the future about the effectiveness of animated pictures with narration against animated pictures with on-screen text

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