Augmented Reality as a Tool for the Development of Mathematical Skills

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Abstract

Presently the incorporation of Information Technology and Communications to improve the process of teaching and learning is an issue of global interest. This paper shows how the augmented reality can used as a tool to support the development of student skills in the mathematics area. In this sense, students' learning problems is showed, as well as the state of the art in augmented reality and the development of an activity in order to implement the augmented reality in the topic of sets. Such activity was developed in a mathematics course with some students of information systems at the Nayarit University. Finally, results and conclusions are shown.

Keywords: Augmented Reality, Mathematics, Basic Skills, Learning Styles

1. Introduction

Given the rapid changes in the contemporary world, training professionals with specific skills has emerged as a new challenge for the educational institutions. These skills need to enable professionals to not only address the current environment, but also transform it. Likewise, the type of skills used in the educational environment is closely linked to the "know-how-to-do" competence. It is the power to develop actions in a broad sense [1].

Although there is no single definition of the term "competence", in this document we will adopt the reference of the project on competences in the context of the Organization for Economic Cooperation and Development (OECD) called DeSeCo which classifies competences into three categories: use tools interactively (language, information technology, etc.); interact in heterogeneous groups; and act autonomously. All these categories are interrelated to form the basis for identifying and mapping

key or basic competences that an individual must have for professional growth and employment throughout life [2].

There has been great interest on the part of companies and world economy on the competitiveness of individuals and this has contributed to implement various types of assessment programs in order to measure the competences. One of these programs has been implemented by the OECD for the Evaluation International Student Assessment (PISA). The main objective of this program is to monitor the development of these competences at the end of the compulsory schooling.

Regarding math competences, PISA considers as mathematical literacy: the ability to analyze, reason and communicate effectively as well as to solve and interpret mathematical problems in a variety of situations involving quantitative, spatial, mathematical concepts of probability, or other [2].

According to the results in the implementation of PISA 2009, the development of these competences in Mexico is not very encouraging. This country was in level 1 in that year with regard to math competence. In the period between the implementation of PISA 2003 and PISA 2012, mathematics achievement in enrollment of 15 year-old students in formal education, improved by 28 points (385 points in 2003 to 413 points in 2012). However, the percentage of students with low performance remains greater than 50% and it showed an increase from 2009 to 2013 by nearly 5% (50.8% in 2009, 55% in 2013) [3].

1.1. Characterization of the problem

According to these data, teaching and learning in this area of knowledge, has become a priority for researchers who participate. Therefore, it is important to find the strategies and/or educational resources that lead to the production of mathematical competence. This is especially true because of the importance it holds for the development of analysis, reasoning and problem solving skills that impact on the development and application of this reasoning in several problems in the individual's ordinary life and consequently in the society.

Higher education in Nayarit is not exempt from this problem, thus, the Autonomous University of Nayarit (Universidad Autonoma de Nayarit, UAN) as part Institutions of Higher Education of the State, has taken through different actions and instances, responsibility for solution. Some of these have been implemented by the Academy of Interdisciplinary Quantitative Methods (QMA) of Computer Science (CSP), and Economics Programs (EP), members of the collegial body have conducted research to identify the triggering factors of poor performance, as this provides, from their perspective, elements that result in improved student-teacher relationship. And at the same time, these results verify the conditions of the problem of learning mathematics that students have from previous educational levels [4].

Under this premise the Academy has developed some strategies in order to find solutions. However, such efforts have been isolated and unplanned, which somehow have assisted, but they have not had a significant impact on the academic performance of students in this area. This is evident as there is a high level of students' academic disapproval in mathematics. According to data obtained from the Student Administration System at the UAN, in 2013 a cumulative total of 15 courses in the area of learning quantitative methods, with an average of 46 students per course were offered. From this amount, 44% students failed the subject at the end of the term.

Given the above, the QMA has reassessed a comprehensive strategy to ensure that students achieve mathematical competence, being one of the core considerations related to OECD as stem competences to be developed by students. These need to be well-equipped with the tools and skills (language, information technology, etc.) which can be used in the application of integrated methodologies.

Among the technological tools needed is the use of technological devices to use virtual information to add to the physical information, called Augmented Reality (AR). Thus the reason why it is being developed the project called "Augmented Reality Strategy to Improve Performance Students in the Area of Mathematics", which aims at improving students' academic performance by taking subjects as Mathematics through the development of learning objects with AR.

2. Augmented Reality in an Alternative Education

Nowadays augmented reality is one of the most dynamic fields in the technology area, and general computing research. But what is Augmented Reality (AR)? Ronald Azuma [5], defines it as an environment that includes elements of virtual reality and real world elements. An AR system is one that combines real world and virtual world as interacting with real time and recorded in three dimensions. As opposed to Virtual Reality, AR allows the user to view the real world with overlapping or compounds with the real world virtual objects. Therefore reality complements RA rather than completely replacing it.

In order to work an AR system intervention, it is necessary some elements such as: display devices; devices

for the acquisition and processing of data, interface and user interaction. The latter defines the type of augmented reality. There are also different programs and applications that create AR [6].

Given the enormous potential of applications, AR becomes an alternative in education. This overcomes the difficulty of simulating situations and experiences that are not possible in real life situations, which leads to a more intuitive and interactive learning. However, in order to realize the potential of this learning tool, the implementation has to accompany other pedagogical issues, students' learning styles, and curriculum adaptation, to name some.

2.1. Augmented Reality as a Tool for the Development of Mathematical Competences

In many fields of training, it is necessary for students to visualize objects in different orientations, spaces and contexts, working with models of two or three dimensions and interactive images. Such is the study of Mathematics. Thus, researchers from different institutions at national and international level [7], [8], [9], [10], [11], [12], have been working with the use of this tool.

According to such literature review, research shows that AR can nurture the educational process by using items more creative, dynamic, interactive and three-dimensional learning, which allow strengthening intrinsic elements to educational practice, as the understanding of learning and motivation learning. Research shows that AR is a tool that allows the student grasps significant learning.

This research group has conducted the study presented as inquiry line developed by other research groups in other contexts. The main objective is to measure the learning opportunity offered by the AR as a support tool in the teaching and learning of Mathematics for Undergraduate students at the School of Economics at the Autonomous University of Nayarit.

Under the premise that the objective of this research is to improve academic performance in the area of mathematics, and based on the students' academic disapproval (44%), research was conducted as a longitudinal study. This was in order to examine specific cohorts. Thus, the first approach of using the tool in AR will consider the subject called "Logic and Sets". This subject is part of the quantitative methods at the Academic Computing Program, Curriculum 2012 for the cohorts 2013. The topic chosen for the development of models to use in AR was "Set Operations".

Once defined the class cohort, the subject, and the educational program, the initial selection of typology, software, and applications of AR were carried out. This was in order to use such tools based on an analysis of the programs and applications that allow the development of AR. Similarly, some benefits and requirements in its use were identified, some of which were as follows: ARToolKit, Buildar PRO, ATOMIC, Sketchup, Artag, Plug-in for SketchUp Ar-media, ArSpot, OSGART, FLARToolKit and Aumentaty Author.

Once the analysis was performed, and given the purpose of this stage of the project, it was decided to work with the type of AR by using markers to utilize the software called Aumentaty Author, as a tool that has a friendly interface for those who are not developers.

This is because augmented reality models were designed with the software Blender 2.66a in its free version, also because such models offer a more friendly-use program that allows conceptualizing and modeling pictures of an intuitive and flexible way. In this case models were designed to represent the basic operations on sets and markers associated with pre-designed Aumentaty Author. Moreover, mockups were designed and printed in order to represent the scenario of joint operations and thus give the explanation of a practical case (as seen in Figure 1).

In order to accomplish this experiment, a group of 18 students (10 men and 8 women aged 18 to 22 years) participated. They were from first year Computer AP, enrolled in the subject "Logic and Sets". Before starting the experimental phase, and with the purpose of evaluating its feasibility, participants completed a diagnostic tool which main objective was to gather information from students of the following variables: 1. Possible causes of the weaknesses in learning the topics covered in the subject; Two. Teaching resources that provide students with a better understanding and 3. Learning styles. The questionnaire to validate the variable 1 and 2 was built in accordance with the proposed research, obtaining the following result:

Variable 1. According to the students' perception, it was found that the three main causes of the weaknesses of learning the topics covered in the class are: poor teacher's performance in the subject, lack of clarity in the explanations and unrealistic cases used in class.

Variable 2. A conclusive assessment of the group of students through a Likert scale as can be seen in Table 1 and 2. According to what is shown in Table 1, it can be observed that the student considers that exercises done on the white board allows you to have a better understanding of the subject. In addition, the students considers important for the teacher to provide a thematic guide, as well as the use of clear and practical examples. This latter aspect was found as the most common factor

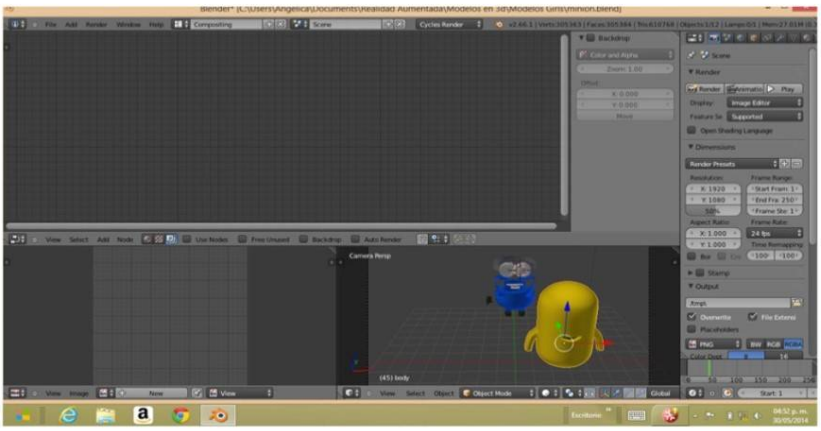

Figure 1a. 3D model design, by modifying a clip in Blender.

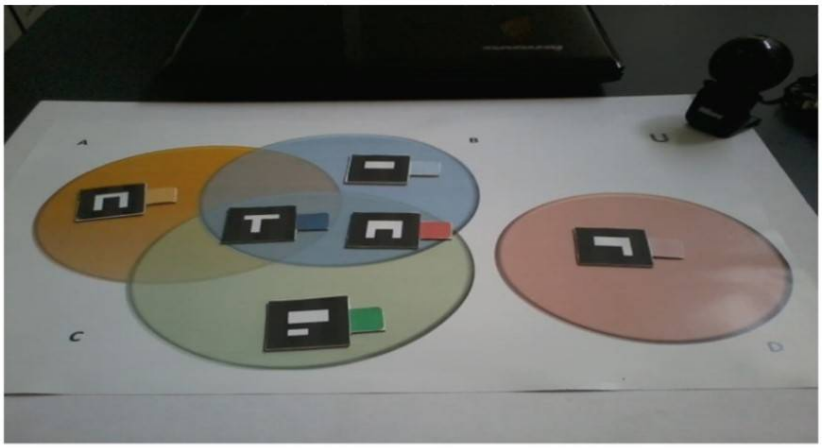

Figure 1b. Designing the scenary to show the Augmented Reality.

Figure 1. Development of Models RA, Stage and Markers using Blender 2.66 and Aumentaty Author.

in the order of utility values. For the case presented in Table 2, according to the results, respondents focus their priority on the first scale values in importance to the fact that the teacher should be creative and innovative in the classroom. For students it is important to use graphics and images in order to better understand examples.

Variable 3. According to Pulgar Burgos [13], learning is largely determined by perceptual means by which it receives information; assimilate information efficiency increases as the perception of some senses dominates over the other. Thus, it is assumed that if the teacher is able to know what the predominant channel of the student is, you can then assess whether the teaching is effective or not and, therefore, establish effective teaching-learning strategies. Starting from this assumption, a quick test was applied according to the VAK model which was applied in person with a brief explanation and a period of approximately 15 minutes to submit it.

Table 3 shows the results in terms of learning styles,

Table 1. Students' Deliberation of Utility Regarding the use of Teaching Resources to allow Deep Understanding Issues in the subject Logic and Sets.

Student's opinion/Resources	First Place	2nd Place	3rd Place	4th Place	5th Place
Using interactive images	0	2	2	1	1
Use technology tools for explanations	1	1	3	0	2
Topic Guide	2	2	3	2	1
Readings	1	1	1	2	3
Noting down exercises on the white board	7	4	2	2	0
Motivating presentations	0	2	2	2	7
Clear and practical examples	5	3	2	4	0
Audios with the explanation of e/o of the issues	1	1	0	1	1

Table 2. Important reasons that allow students' better understanding (students' perception).

Student/Resource	First Place	2nd Place	3rd Place	4th Place	5th Place
The teacher is creative and innovative in their classes	8	4	2	0	1
Students experience and manipulate	1	2	3	1	3
Student listen and share	1	2	4	8	1
Students sense and explore	0	0	0	1	2
Students reflect and think	0	6	1	2	4
Students make collaborative work	1	2	3	0	2
Students write dictations	1	0	0	2	1
Students puts into practice realistic examples	5	1	4	1	1

Table 3. Learning styles of students enrolled in the UA Logic and Sets, Generation 2013 semester January to June 2014.

Learning Style	Number of students	%With total relational
Visual	10	56%
Auditive	5	28%
Kinesthetic	0	0%
Visual-Auditive	1	5%
Visual-Kinesthetic	2	11%

it is observed that the visual style is the profile in which students represent more than 56% which indicates that more than half of the group recalls more information that is presented by using abstract and concrete images. It is also reported that 11% are visual-kinesthetic students who possess greater retention of information through images, thus, they have to interact with these and manipulate, and while the auditory students reached second place only 28% of students in the group are more reminiscent of spoken information.

Given these results, one possibility can be seen in the use of AR as a tool for learning. In order to carry out the experience with the use of the AR tool, an activity was implemented in the classroom in which students had to solve a practical case on which they were supposed to apply set operations. At this point, it is important to point out that the group of students had already taken the theory class with their professor, and had answered all exercises without the help of the AR.

At the beginning of the experiment students were given a sheet with the instructions of the practical case. They were also given ten minutes to solve the exercises by using prior knowledge but without the use of AR. It was found that students had difficulty solving the case study, the instructor (researcher) then proceeded to give advice by using the AR tool (See Figure 2). This experience allowed the researchers to assess the student's attitude when trying to find the solution of the case with the support of the AR tool.

3. Conclusions and Future Work

Given the objective of the research, data collection allowed us to accomplish those. In the same way, it was possible to build interest and satisfaction indicators through the students who took part in the piloting phase.

The collective opinion was focused on emphasizing the use AR tool as a dynamic, motivating and entertaining class. This is because such tool allowed them to understand better and they could have a visual perception of the problem to solve.

The survey showed that students see the AR as a tool that allows them to interact with the study matter. They also reported that that they would like the teachers to implement it in their classes, since it makes them more intuitive and easy to understand. 89% reported that the lesson taught with AR was better understood as compared to not utilizing AR in the classroom.

It is concluded that within the advantages of using AR in mathematics, which allows students to highlight possible solutions to identify problems and grasp knowledge, AR helps to interact with objects. This allows students to strengthen their capacity for abstraction.

On the other hand it is important to point out that the use of this technology in the classroom is not as easy as teachers cannot bring their ideas into something tangible. It is therefore necessary for the teachers to be able to design, simulate, animate, identify, and the like, elements of augmented reality. However, if the institution has the opportunity to rely on skillful teachers this can be of great support to improve teaching and learning.

As future work for this project it is necessary to plan and develop the curriculum at the QMA by working more extensively on anthologies that contain practical cases with markers by using AR.

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Figure 2. Scenarios with Experimental Phase Using Augmented Reality Tool.

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