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Comparative Analysis Between Training Tools in Spatial Skills for Engineering Graphics Students Based in Virtual Reality, Augmented Reality and PDF3D Technologies

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Abstract

One of the skills that all engineering professional must develop very extensively during their formation is the mental management of the three dimensional reality in which they develop their professional actions. This competence is called spatial skill, a cognitive skill which can be improved with proper training. We have developed a series of learning activities for students in order to acquire, develop and improve their levels of spatial skill and, for this purpose; we have structured training with Virtual Reality (VR), Augmented Reality (AR) and PDF3D technologies. In this paper we collect the experience carried out to compare these three technologies together with the intention of finding out which one(s) of them provides best results as a training tool and improved the academic performance of students in the Engineering Graphics subjects. The experience was carried out at the School of Industrial and Civil Engineering of the Las Palmas de Gran Canaria University, during the academic course 2012/2013 on the Graphic Design subject during the first year of these degrees: Industrial Technologies Engineering, Industrial Design and Product Development Engineering, Naval Technology Engineering, Chemical Engineering and Industrial Management Engineering.

Selection and peer-review under responsibility of the programme committee of the 2013 International Conference on Virtual and Augmented Reality in Education

Keywords: Virtual Reality; Augmented Reality; PDF3D; Spatial Skills; Rate of Return; Success Rate

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1. Introduction

Engineering is the set of scientific techniques and knowledge applied to the creation, improvement and implementation of both physical and theoretical structures for solving problems affecting the society's daily routine. Therefore, it professionally applies the study, knowledge and command of mathematics, physics and other sciences for development of technologies and efficient management of natural resources aiming for society's benefit. Engineering is the activity which transforms knowledge into something practical.

This inventiveness needed by the engineer is supported by knowledge, dexterity and abilities which become essential for the development of their careers as they will allow them to make the correct choice while aiming for their objectives.

One of those essential abilities is the skilful handling of the 3D space where his procedures are taking place. That spatial ability is one of the dimensions of the intellectual activity's dimensions belonging to the intellectual abilities linked to the subject's cognitive abilities.

2. Context

In the academic environment, the Graphic Design teachers commonly find students with issues to solve those tasks requiring spatial reasoning and visualization. Augmented reality (AR), virtual reality (VR) and PDF3D have been successfully applied in the learning processes of the university degrees trying to get their students to realize their lack of spatial abilities.

The experience was carried out at the Civil and Industrial engineering faculty at Las Palmas de Gran Canaria University during the 2012-2013 academic course in the Graphic Design subject belonging to first course of the following degrees: Industrial technologies, Industrial design and development of products, Naval technology engineering, Chemical Engineering and Industrial Organization engineering.

3. Aim

The main aim stated in this work can be divided according to the following aspects:

- Developing and comparing tools and didactic material inside the graphic design environment, built through AR, VR and PDF3D following the principle of improving the spatial vision abilities and learning the graphic design's contents.
- Studying the scale of the improvement which might be achieved over the academic results of the students on the graphic design subjects.

4. Results

The conclusions of this work are based on the analysis of all data obtained in the experimental stage- We start from the basis that all students involved should be freshmen so they had no previous experience in any kind of spatial abilities training. Therefore, they will only have knowledge about this subject in the high school study prior to accessing university. For performing this experience, three training technologies were applied: (AR, VR and PDF3D) over 164 participants. There were also two 'control groups' including 38 students who didn't receive any spatial abilities training. Their results will be compared to those obtained by groups who undertook training. So, there were a total of 202 students involved in this experience.

The first part of this experience is based on results obtained while applying the spatial ability measure tools. The second is based on the correlation between data obtained in the first stage and the final results.

The following tools were used at the study:

- Mental rotation test (MRT), for measuring the spatial relations factor.
- Spatial relations test (DAT_SR) for measuring the spatial vision factor.

Both tests were applied following the methodology determined by the authors before and after training for obtaining the matching pre and post data. Besides, the final results of each student were taken according to their performance.

The following figures show some samples from these exercises.

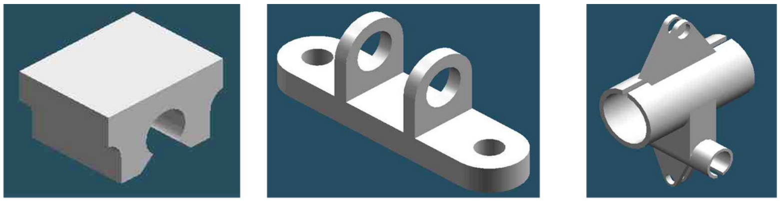

Fig. 1. Exercises

Table 1. Descriptive statistics.

		MRT			DAT		
		pre	post	Δ	pre	post	Δ
AR	Mean	15,52	24,69	10,31	18,80	31,15	12,35
	SD	8,31	9,78	5,21	8,03	9,45	5,51
VR	Mean	17,75	23,52	5,77	29,02	36,29	7,27
	SD	5,64	6,27	3,28	8,19	7,63	4,69
PDF3D	Mean	14,42	22,81	8,39	24,49	36,07	11,58
	SD	7,31	7,88	5,47	8,39	8,47	7,38
CONT	Mean	13,87	19,61	5,74	18,97	25,37	6,39
	SD	4,72	7,55	4,75	6,49	7,72	3,60

An unbiased way of measuring the student's success in certain subject is considering the number of pass grades. This work uses both performance and success rates, which are defined as the percentage of students who obtained a pass respecting the participants and the percentage of pass grades respecting the total of students enrolled.

We divide the student in two categories: with or without training for finding out the difference between performance and success rates. The results obtained are shown on table 2:

Table 2. Grades summary WITH and WITHOUT training

	With training			Without training		
	>5	<5	DA	>5	<5	DA
Industrial	33	21	2	7	10	3
Design	32	22	2			
Naval	10	7	-			
Chemical	11	4	1			
Organization	10	8	1	9	7	2

Where the following values where obtained as shown on table 3:

Table 3. Performance and success rates in groups WITH and WITHOUT training

	With training		Without training	
	Performance	Success	Performance	Success
Industrial	58,93	61,11	35,00	41,17
Design	57,14	59,26		
Naval	58,82	58,82		
Chemical	68,75	73,33		
Organization	52,63	55,55	50,00	56,25
Mean values	59,25	61,61	42,50	48,71

The obtained data are depicted on figure 2 and 3:

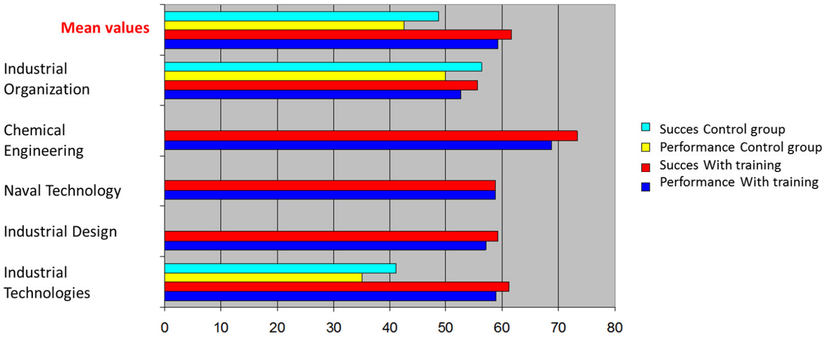

Fig 2. Performance and success rates in groups WITH and WITHOUT training

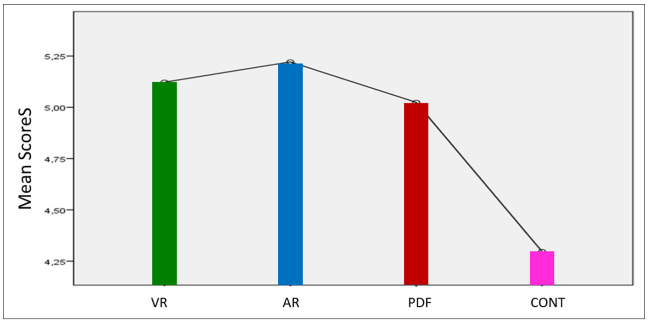

Fig 3. Mean scores of final exam by kind of training

5. Conclusions

Having in mind the results obtained, we may conclude that we indeed improved the academic performance of those students who undertook the spatial abilities training through any of the three studied technologies.

The augmented reality technology specifically shows even better results than virtual reality or PDF3D although differences are small but still quite relevant compared to those obtained from the students belonging to the control group.

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