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SPATIAL DATA INFRASTUCTURE: DEVELOPMENT OF SPATIAL ABILITIES IN THE FRAMEWORK OF EUROPEAN SPACE FOR HIGHER EDUCATION

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Appearance of information and communication technologies (IT) in geography and cartographic environments involve a change in professional's work environment format. These technologies had great impact both in Geography as science and Geographic Education (Durán, 2006).

At university, aims of new degrees in Geography and Engineering from the European Space for Higher Education seek development of specific abilities related to obtaining, analysis, treatment and sketching of geographic and cartographic information (R.D. 55/2005 de 21st January y R.D. 1393/2007 de 30th October).

However, there is no available data stating a direct relation between developments of these specific abilities with use of new interfaces of geographic information.

In this paper, components of spatial ability are analyzed as well as their development with use of new Geographic Information Technologies in collectivities where spatial vision abilities suppose a deciding factor in their future success options in the professional field as engineers and geographers. (McGee, 1979; Hsi, et al., 1997; Miller, 1996; Smith, 2002, Martín Dorta, et al., 2008).

Having this in mind, a short duration course is designed where fifty two volunteer students from Geography and Engineering degrees at La Laguna University are proposed several exercises performing a test battery measuring their spatial abilities using the IDE Canary Spatial Data Infrastructure as a platform.

1 Work developed inside the «Assessment and development of competences linked to spatial vision ability in new Engineering degrees» investigation project. Ref.: EA2009-0025, financed by the Science and Education Ministry. Main researcher: Dr. José Luis Saorín Pérez.

There are several classifications of spatial abilities. While analyzing in our test the development of spatial abilities inside a cartographic environment, Mafalda's (2000) classification is the one regarded as experimental part of this work as it contemplates spatial orientation as one of the components of spatial ability together with other two components: spatial orientation and spatial visualization:

— Spatial relations: Ability of rotating in our imagination two or three dimensions figures quickly and correctly (Linn y Petersen, 1985); these authors also prefer using the term spatial rotation instead of spatial relation.
— Spatial orientation: Ability of evaluating how a spatial movements sequence may be sketched from different orientations (Mafalda, 2000). Other authors choose definitions such as the skill consisting on imagining the objects' aspect from several observer orientations (McGee, 1979), or the ability of orientating relating to the environment and self-location awareness (Reber, 1985).
— Spatial visualization: This component measures a learning and linking process as well as a spatial shapes mental manipulation process (Mafalda, 2000). It's also defined as the ability to manipulate complex visual information when several stages are needed for producing the right answer (Linn & Petersen, 1986) linked to the spatial vision term.

Tests used for measuring these abilities are:

— Mental Rotation Test (MRT) (Vanderberg & Kuse, 1978), for measuring the spatial rotation component. It has been also used on previous experiences (Devon et al., 1994; Sorby & Baartmans, 2000; Gerson et al., 2001; Saorín, 2006, Martín-Dorta, 2009; Martín, 2010).
— Perspective Taking / Spatial Orientation Test (Hegarty et al., 2008), for measuring the spatial orientation component. Also used on previous experiences (Hegarty & Waller, 2003, Kozhevnikov & Hegarty, 2001, Hergarty, et al., 2008).
— Differential Aptitude Test – Spatial Relations Subset (DAT-SR5) (Bennet, et al., 2000), for measuring the spatial vision component. Used on previous experiences (Devon et al., 1994; Sorby & Baartmans, 2000; Gerson et al., 2001; Saorín, 2006, Martín-Dorta, 2009; Martín, 2010).

The work hypotheses set are the following:

— A short duration course using Spatial Data Infrastructure as a valid tool for the aim of improving spatial abilities and specifically Spatial Orientation.
— The student is answering positively to the use of this tool.

A null hypothesis is set so supposition may be validated or not through statistical inference methods. Satisfaction surveys data will also be provided helping to confirm the second hypothesis.

Work is divided in three sessions: six hours of classroom work in two sessions of three hours each and two hours of individual student homework.

1st phase: Introduction

— Level 1: Introductory session (3 hours): Description of Canary Islands SDI platform and its applications. Students learn operating commands and contents becoming familiar with the interface measuring distances, areas, obtaining profiles and visualizing the ground through different methods in two and three dimensions, while looking up the database.
— Level 2: Improvement session (2 hours): It's designed having in mind all practices which should be carried out at home by the student himself with tools that had been used at the classroom. Geographic evolution analysis is proposed to the participants focusing on a zone chosen by each student providing a 10 pages document including cartography and imagery exercising their spatial orientation abilities with them.

2nd Phase: Improvement

— Level 1: Work review (half hour): All work performed by students about question proposed on level two is revised projecting them on screen so every participant can check their fellow students' work.
— Level 2: Practical exercise (2 ½ hours). An exercise is proposed containing five blocks of questions where each one is designed for students to execute all commands as well as checking Canary Islands SDI platform:

Unit I: Measurement. Several questions are asked about operating commands for distances measurements, areas and slopes.

Unit II: Orientation. Two exercises are proposed and students should use their spatial orientation skill for solving them. On first exercise they should point out where the sun was at the time picture was taken using ortophotos for its visualization. Meanwhile, on second exercise routes should be covered across a certain area using a small scale denominator on visualization. During this route, student should recognize known places using cartographic format during the outward journey and ortophotos on their return. When covering the same route, Geographic North position should be activated and deactivated.

Unit III: Query. Consisting of a questions set where student may access contents of the georeferenced database. They are also asked about data around variables listed in the Canary Islands SDI database.

Unit IV: Positional Scenario. In this section it is required to choosing between several 2D and 3D formats around a specific location.

Unit V: Dynamic Scenario. Like previous case, student is required choosing between different 2D and 3D visualizing formats across a certain route that should be covered.

Before and after performing the course, spatial skills of students were evaluated.

In table 1 scores are shown as well as the average gains for the MRT test, Perspective Taking/Spatial Orientation Test y DAT-SR5. Perspective Taking/Spatial Orientation Test's score is deviation in sixtieth degrees respecting the correct answer; that's why a lower score belongs to a better choice (Table 1).

Table 1
SCORES OBTAINED AND AVERAGE GAINS

TEST	Mental Rotation Test			Persp. Tak/Spat. Orient. Test			Differential Aptitude Test		
	Pre	Post	Gain	Pre	Post	Gain	Pre	Post	Gain
	(s.d.)	(s.d.)	(s.d.)	(s.d.)	(s.d.)	(s.d.)	(s.d.)	(s.d.)	(s.d.)
Total n=52	13,1 (5,83)	17,46 (7,37)	4,37 (5,73)	50,36 (30,22)	35,29 (28,27)	15,06 (20,02)	24,88 (8,09)	32,96 (9,78)	8,08 (6,81)
Men n=31	13,45 (6,42)	17,87 (8,04)	4,42 (6,11)	51,29 (33,72)	33,73 (30,48)	17,56 (21,02)	23,65 (7,85)	31,58 (10,28)	7,94 (7,09)
Women n=21	12,57 (4,95)	16,86 (6,4)	4,29 (5,25)	48,99 (24,89)	37,60 (25,21)	11,38 (18,33)	26,71 (8,28)	35,00 (8,84)	8,29 (6,53)

s.d.: standard deviation.

Mean gains were 4.37 for the Mental Rotation Test (MRT), 15.06 for the Perspective Taking/Spatial Orientation Test and 8.08 for the Differential Aptitude Test (DAT-SR5).

For statistical analysis we use the t-student variable (Student`s *t*-test), starting from null hypothesis (H0): mean values of spatial abilities have not changed after training. *t*-Student test is applied for paired series getting the *p*-values representing probability that this hypothesis is true (*p-valor* MRT=0,00000124087, *p-valor* Persp. Taking/Spat. Orient. Test=0,00000160455, *p-valor* DAT-SR5=0,00000000001).

It is shown that significance level never reaches 1 °/°°, so null hypothesis is rejected in all cases and we can state, with a significance level above 99.9% that average variation of studied group has increased. There is indeed an effect of the course with the Canary Spatial Data over the mean gains of spatial abilities measured by the Spatial Rotation test (MRT), Spatial orientation (Perspective Taking/Spatial Orientation Test) y Spatial vision (DAT-SR5); this effect consists on the improvement of abilities from those who underwent this training.

It's also observed that gains obtained on tests have a similar increase according to gender excepting on the Perspective Taking/Spatial Orientation Test, where it's significantly higher on men compared to women. Several works state that gender difference has an effect on spatial orientation (Coluccia and Louse, 2004).

About user's satisfaction analysis, a survey in paper format is used stating the questions according to Likert's scale where every user will assign a numeric value to each question indicating agreement or disagreement level about it on a five points scale.

Opinions shown in the survey express a high degree of user's satisfaction about the course. Student thinks that course has helped him assimilating concepts such as scale and different coordinates systems used in cartography. At the same time, he perceives that it has helped him improving his spatial abilities understanding space and relief better using different visualization formats offered by the Spatial Data Infrastructure. He also regard that tool may also be very interesting for his development as a student.

Scores obtained about overall satisfaction level (4.48) and about recommending course to other fellow students (4.71) are indicators of the measure of user's general satisfaction.

Bevan (2006) mentions that for reliable estimations of satisfaction level's results at least eight to ten participants are needed although bigger population samples offer more significant result's values as in our case, where fifty two students took part.

Once finished the training for improvement of spatial abilities through use of spatial data infrastructure and according to results obtained in test, data files and satisfaction surveys, we may conclude that:

— Spatial abilities may be improved through specific training. As seen on obtained results and the performed analysis, the set of activities developed in the improvement course with the geoportal of Canary Spatial Data Infrastructure has being a good choice.

— This course model may suppose an increase in spatial skills level. Mean gain was 4 points for the spatial rotation component and 8 points for the spatial vision component.

— Spatial orientation skill is significantly improved after completing the course with an average increase of 15,06 points.

— Increase of spatial skill occurs in a similar way in either women or men for the spatial rotation and spatial vision components. However, increase in spatial orientation component happens to be higher in men compared to women with an 11.38 increase for women and a 17.56 for men.

— Student's satisfaction respecting the course has been quite good, which encourages preparing teaching innovation strategies around new geographic information technologies (TIG).

Geographic information is changing its format. In this investigation's context it's been considered analyzing Virtual Globes as well as Google Earth and the Google SketchUp software. Given its use's simplicity and accessibility we think it may become a good tool for teaching at university.

About hardware, it would be interesting studying how user interacts with 3D land modeling through augmented reality as well as analyzing the possibilities offered by tactile screen devices of new generation such as Ipads for looking up, visualizing and updating geographic information.