SIMULATIONS AND VISUALIZATIONS OF SPATIAL CHANGES AS A TEACHING TOOL FOR THE COMPREHENSION OF GEOMORPHOLOGIC PHENOMENA. THE CASE OF EVOLUTION OF THE BASIN OF IOANNINA

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ABSTRACT

The present work discusses the effect of extraneous factors in the formation of the geomorphology of a place, the disadvantages concerning its teaching approach (perception difficulties of the size of the changes and of the geologic time), as well as the didactic intervention using Information and Communication Technologies.

The proposed didactic intervention includes the design, development and evaluation of a piece of software based on geomorphology modeling, simulations and visualizations. The software represents the temporal phases for the creation of the basin of Ioannina.

A case study with 95 undergraduate students studying the proposed visualization showed positive results concerning the understanding of geographic features and phenomena, indicating the power of natural semantics of virtual dynamic landscapes for the support of teaching and learning physical geography.

KEYWORDS: Teaching physical geography, simulations, visualizations, virtual landscapes, case study

INTRODUCTION

School Geography is a discipline that requires the use of proper visual aids to support information acquisition, skill development, knowledge construction, and conclusions' inference (Koeck, 1986). The visual aids that have been used up to now have been maps, atlases, pictures and diagrams presenting dense information about the characteristics of the area that is represented (Katsikis, 1999).

Information and Communication Technologies (ICT) offer new capabilities for the teaching of physical geography. Various technologies have been proposed, such as hypermedia applications (Gerhard and Wiktorin, 2000), INTERNET (Mikropoulos, 2000), GIS (Strobl, Heywood & Cornelius, 1995), providing visual aids in an educational context. Although these kinds of approaches exploit the power for information representation and processing, they rarely overcome the restrictions of traditional media. The main restriction of analog or digital representations of geographic information comes from the transformation of its information from a sphere to a flat two-dimensional (2D) sheet accomplished with projections, distortion being an important aspect of context. Concerning information, people understand the world differently, have different modes of expressing this in maps, and gain different understanding from maps. Moreover, the selection of symbols for a map (patterns and colors) affects the utility, legibility, and aesthetics of the map. In order to avoid the problems of the 2D map, geographers try to map the third dimension using stereoscopes that allow two photographs to be viewed simultaneously to create a three-dimensional (3D) view. This is static, and a huge series of photographs is needed for the 3D representation of a place in various degrees of detail.

Virtual reality technologies have been proposed in order problems of this kind to overcome, with the design of dynamic virtual landscapes (Mikropoulos, 1996). Moreover, there is very limited published research on physical geography learning using ICT, none of the above references being as such including empirical studies for the assessment of the proposed approaches.

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The present work proposes the use of models, simulations and visualizations for the support of physical geography teaching and learning, followed by the evaluation of specific visualizations exploited in the educational process.

A model is a physical or ideal system that represents and replaces a physical or ideal system at certain levels and with respect to certain viewpoints that are determined by the goal of the modeler's cognitive activity (Futo and Gergrly, 1990). When the model is realized in a computer it is called a simulation model, and the experimentation with it is called simulation. The simulation process and its results may be represented in many different ways. Concerning geography learning, we propose surface and volume visualization as the most suitable way for the representation of both data and concepts. Visualization is the construction of a visual image in the mind and a graphical representation of data or concepts. With the help of ICT, visualization from being an internal construct of the mind, has become an external artifact supporting learning. Using visualizations, one can form or understand ideas or abstractions, which may lead to new scientific discoveries and knowledge creation. By visualization we mean the realization of information and processes through visual explanatory experimentation, which is different from arbitrary animation. We propose virtual realities for the realization of visualizations, exploiting their main features. Three-dimensional interactive virtual environments using natural semantics and enhancing users' experiences, exploit the advantages of visualization and offer a lot to the learning process, befitting the guidelines for geographic education (Fromboluti, 1990).

The use of virtual realities offers new possibilities for geography teaching and learning, such as (Mikropoulos, 1996):

- Exploring existing places and things that students would not otherwise have access to
- Exploring real things that, without alterations of scale in size and time, could not otherwise be effectively examined
- Interacting with real people in imaginary spaces to support interactive design
- Interacting with a model is as motivating or more motivating than interacting with a real thing
- The experience of creating a simulated environment or model is important to the learning objective
- Visualization, manipulation and rearrangement of information is needed, so as to become more easily understood, using graphic symbols
- Developing participatory environments and activities that can only exist as computer generated worlds.

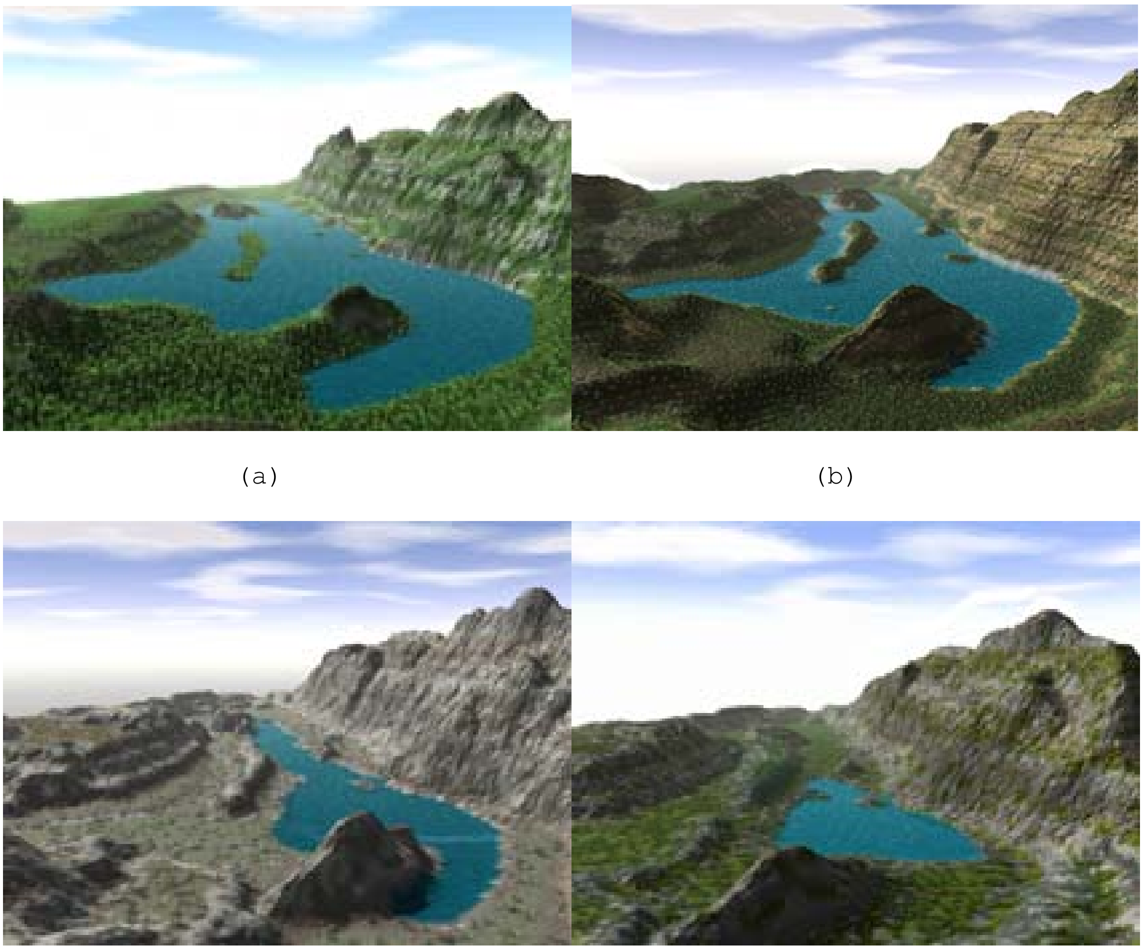
THE VISUALIZATION

The visualization used in the present work includes all the aspects concerning physical geography education, that is:

- Location, that is the determination of the position of a place on the earth's surface
- Place, that is the physical and human characteristics of a place
- Relationships with places, that is the adjustment of people to their environment
- Movement, that is people interaction on earth
- Regions, how they form and change.

Moreover, with virtual landscapes using natural semantics there is no need for metaphors, and learners do not need to transfer after reflection what they see and feel in the real world. The world and geomorphologic phenomena are there in a virtual mode enhancing their experiences, experiences learners might have neither using a conventional map, nor in the real world. This kind of visualizations, avoid the restrictions coming from traditional maps and atlases, such as projection problems, distortions, static data, symbols, patterns and colors.

The visualization used in the present study concern the representation of geographic features and the formation of the geomorphology of Ioannina basin. We have used surface and volume visualization in order to put data from digital elevation models (DEM) in a three-dimensional landscape simulation program (VistaPro 4.0). Thus, we have recreated four real world landscapes in vivid detail. The landscapes represent Ioannina basin as it was before 7000000 years, 2000000 years, 25000 years, as well as it is today. The DEM files used were based on real palaeogeographic data. The created virtual landscapes were the inputs to morphing software, the final result being a digital video movie visualizing the evolution of the landscape from 7000000 years ago, up to now. Figure 1 shows snapshots from the final morphing landform with its geographic features and flora in the four time periods.



(a) (b)

(c) (d)

Figure 1. Visualizations of Ioannina basin. (a) 7 million years ago, (b) 2 million years ago, (c) 25000 years ago, (d) today.

METHODOLOGY

The simulation we have created was a part of educational software with specific didactic goals for the support of teaching and learning physical geography. The simulation was used for an empirical study with 95 students from the Department of Primary Education, University of Ioannina (82 women, 13 men, ages 19-22). The axes of the research were to study the students' perception of geomorphologic features and dynamic phenomena visualized by the digital video, as well as to evaluate the learning outcomes resulting from the study of the visualization. In order to work towards these aims the students repeatedly viewed the simulation projected on a video wall, and answered to a questionnaire consisted of four closed and seven open type questions. Three questions required descriptive answers, coming directly from the observation of the visualization. The rest ones were knowledge or interpretative questions requiring the combination of the observation of the simulation with existing knowledge. The students did not know the place the simulation represented.

RESULTS

The first of the descriptive questions concerned the description of the landscape using geographic terminology, as it was represented by the simulation (table 1).

GEOGRAPHIC TERM	NUMBER	FREQUENCY (%)
Lake	72	75.60
Mountains	65	68.25
Basin	5	5.25
Flora	22	23.1
Islands	9	9.45
Plain	12	12.6
Valley	23	24.15
Bays	4	4.20
Peninsula	1	1.05
Fen	1	1.05
River	1	1.05
Other	1	1.05
No answer	9	9.45

Table 1. Students' answers for the description of the geographic terms (N=95).

A considerable percentage of the students answered giving more than one terms, describing in detail the landscape. Dominant answers concerned the lake, the mountains, the valley and the flora. Even the nine students that gave no answer recognized the geographic features, since they referred to them in the other questions. The answer stating the river as a feature of the landscape was a misconception, probably coming from the initial state of the lake having an oblong shape, and not from lack of knowledge. The same may be held for the bays, coming from the lake configurations during the centuries. Although this question concerned the landform description, 17 students ascribed the dynamic features represented by the visualization, referring to the time factor.

The second descriptive question concerned the identification of the virtual with a real landscape. More than half of the students (59 students) referred to real landscapes. Fifty-one of them referred to the Ioannina basin, five to other Hellenic lakes without giving names, and three referred to American lakes without names. We believe that the success of the identification with Ioannina came from the natural semantics of the visualization and not from native students who were quite a few.

The third question concerned the changes the students see, being direct connected with the dynamic form of the visualization. The subjects' answers were consisted of more than one change and can be categorized in three classes. The majority (80 students) referred to the obvious lake diminution during the centuries. The second class included changes in flora because of the climatic conditions (62 students), and the third refered to the phenomenon of erosion (31 students). Concerning flora, 16 students described the total changes according the climatic conditions of each era, and 21 students referred only one of the stages, that of the flora decrease.

The next closed type interpretative question was asking for the factors that affect the changes in the landscape with the capability of multiple answers (table 2).

FACTORS	NUMBER	FREQUENCY (%)
Climatic	92	96.6
Erosion	64	67.2
Human	49	51.45
Earthquakes	43	45.15
Tectonic	33	34.65

Table 2. Students' answers concerning the factors of the geomorphologic changes (N=95).

Although all the factors of table 2 might affect the changes in the landscape, the students had to answer based on the visualization. The majority of the students (92) referred to the principal one that is the climatic. Forty-nine students referred to human factors, though the simulation did not represent these. Forty-three students referred to earthquakes probably because of the large differences between the initial and final states of the landscape, and not because of violent changes that were not represented by the simulation.

The next question requiring a unique answer was asking the students to state the most important of the above factors. More of the half students (48) referred to the climatic factor, 14 to tectonic and 10 to erosion. Other answers were varied among human, earthquakes, and all of the factors.

Concerning the time duration of the changes, the answers are presented in table 3. Most of the students (34), without being the majority, gave the right time duration. Seventeen students gave general answers such as "in too many years" or " in a large time duration". It is worth stating that the geological time is out of the human perception and it is a matter of prior knowledge.

TIME DURATION	NUMBER	FREQUENCY (%)
Years	10	10.50
Centuries	18	18.90
Millenniums	14	14.70
Million years	34	35.70
Billion years	4	4.20
Trillion years	2	2.10
General answers	17	17.85
No answer	2	2.10

Table 3. Students' answers for the time duration of the changes (N=95).

The final interpretative question was on the reversibility of the observable phenomenon. Twenty-three students answered that the phenomenon is reversible referring to human factors, 19 to climatic, eight to erosion, eight to tectonic, five to earthquakes, four students referred in general to the natural phenomena, one to the flora, and one to virtual reality technologies. It seems that there are misconceptions concerning the geomorphologic phenomena, since more than the half students believe that these are reversible. As the only reasonable answer can be considered this referring to virtual reality, meaning that reversible geomorphologic phenomena can be happen only in synthetic environments.

CONCLUSIONS

The results of the present study show that the visualization that comes as a result of simulation processes and is a tool for explanatory experimentation and not an arbitrary animation, gives positive learning outcomes in earth sciences, where there are big problems on reading and understanding of traditional maps with their typology (Kaminske, 1997; Livni and Bar, 1998). We believe that the visualization approach presented in this article contributes to Kaminske's questions on how can complexity be reduced to those elements and relations, which are necessary for the students in order to understand geographical structures without loosing their functional and causal correctness and proposes a consistent and logical representation with natural semantics. Our results are similar with those resulted by pupils' interactions with geomorphologic visualizations integrated in an educational software (Bellou, Stavridou and Katsikis, 2001).

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