EVIE-M (EDUCATIONAL VIRTUAL ENVIRONMENT MATHEMATICS) AN ALTERNATIVE APPROACH FOR AN EDUCATIONAL STRATEGY GAME FOR MATHEMATICS

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ABSTRACT
Mathematics is "a world of variables" of nature that lies between philosophy and reality. New technologies are nowadays added as an innovative variable that targets on taking the role of a more sufficient, meaningful and entertaining way for students to interfere in mathematical concepts, than those that are usually preferred in classrooms. Has there been enough effort to develop more attractive and tempting approaches in math's education through graphical environments and virtual reality, few have only achieved to "tickle" students willingness to learn mathematics. But, is it really the aesthetics and the graphical environment of educational software the only factors on which researchers should be based for the development of such technologies, or is there a more underlying aspect they should detect the issue from? Is it possible to develop a mathematical educational platform that finds application of mathematical concepts in real life? In order to address this issue, we are presenting an educational platform that introduces application of math concepts in real life through a motivating and interactive three dimensional environment.

KEYWORDS
Virtual Reality, Mathematics, Educational Applications/Games

INTRODUCTION

The use of computer assisted learning technologies in education seems to be widely accepted in recent years and has therefore become a top issue among the research communities, which are trying to comprehend mathematical concepts, such as spatial behaviour of objects, through more meaningful approaches than the traditional ones. Hillary McLellan (McLellan H., 1996) pointed out that the magical quality of virtual environments is that they help with visualization and spatial memory, both proven keys to learning, as also they provide students with an environment where they can build on knowledge they discover by manipulating objects in virtual worlds by reflecting on concepts and building their on worlds. The mutual pedagogical aim of these technologies is to visualize recondite concepts as mathematics and provide software and applications that facilitate learning and promote students education through graphical environments. 3D graphical user interfaces for mathematics have been developed that find application in geometry issues. According to Newby (Newby G. B., 1993), "…Education is perhaps the area of VR which has some of the greatest potential for improvement through the application of advanced technology…". Gittler and Gluck verify the positive effects of geometry education on the improvement of spatial intelligence (Gittler G., Gluck J., 1998). Geometry is a scientific field that deals with more sufficient mathematical concepts that are easily cognized. However, implementation of computer assisted learning in mathematical fields such as calculus, statistics and econometrics, that depict lower visualization capability still remains an area relatively unexplored. From the applications presented in the literature, it appears to be easy for students to interact with software and enhance their knowledge through this experience, though it is difficult to

affiliate teachers with such ways of teaching to be used in the classroom. Therefore, platforms and applications could participate in education as an assisting tool used by the side of students and supported by the teacher through the conventional classroom course. In this paper, we present EVIE-m (Educational VIrtual Environment-mathematics). Its main aim is to engage students with complex mathematical concepts through a 3D graphical environment that provides students with a more creative, meaningful and attractive view of mathematics. The rest of this paper is structured as follows: In section 2 we present background work already introduced in the area of utilizing Virtual Reality in the education of Mathematics. In section 3, we provide a general description of our platform with regards to its utilization as an educational means, while in section 4 we get into more details regarding the parameters that affect the creation of the virtual world introduced. In section 5, outline the technical characteristics of the platform, while the last chapter of our paper concludes with general remarks about the usability of our approach.

BACKGROUND

Jackson and Fagan (Jackson and Fagan, 2000) who have studied collaboration and learning within immersive virtual reality (IVR) use a head mounted display technology by the support of the College of Education and Human Interface Technology Laboratory at the University of Washington and they came to the conclusion that: "… VLEs can provide beneficial educational experiences unobtainable by any other means if they focus strongly on the affordances that are specific to the technology…" and due to students reports this kind of "experience" provided them with an enriched learning experience. Lunce (Lunce, 2004) administered a pre-test and post-test to students in a computer graphics course to gauge the effectiveness of a VR-enhanced simulation. According to the test results students who used the VR-enhanced computer simulation scored higher on practical examinations (post-test). Lunce has also reported that students' response to the VR-enhanced computer simulation was positive as demonstrated by willingness to devote more time working in the simulation than to more traditional study methods. Moreover, he reported that "…computer simulations provide important benefits to the learning experience in distance education…" Naeve and Nilsson (Naeve and Nilsson, 2004) developed a 3D program named CyberMath in the form of a 3D graphical environment were people from different physical locations can exchange information and take part in lectures, demonstrations etc. The virtual reality environment is provided with sound and the visitors are represented as avatars that enter the virtual space, which gives them the chance to observe and experience other users' actions. Yeh and Nason (Yeh and Nason, 2004) whose aim is to design and evaluate a VRLE(Virtual Reality Learning Environment) to facilitate the construction of knowledge about 3D geometry concepts, developed VRMath which is a 3D space as well as a mathematical micro-world where users can move by using the mouse and the navigation keys. This application consists of three components:

- topological: is the virtual reality interface that allows real-time navigation within the 3d virtual space.
- typological: is the Logo-like programming interface that links to the topological component when students are programming to manipulate and build objects within the 3D microworld and refers to any meaning by kind discrete representations of geometry such as language, texts, numbers, icons and buttons.
- social action component: which includes the hypermedia and forum interface that aggregates information and scaffolds discourse.

Another graphical environment named AquaMOOSE (Elliot et al, 2002), (Elliot J and Bruckman A., 2002) was designed to support free exploration of 3d mathematical concepts using primarily parametric equations and trigonometric functions. Motion in AquaMOOSE can be specified mathematically, by using parametric equations. An example they present is "Swimming in a sine wave in x and a cosine in y creates a spiral. At this application both Cartesian and polar coordinate systems are supported. According to their notes at the end of the school year indicated that very few of the students remembered anything about the unit on polar coordinates. "after the test, I will forget, because it's not interesting to me." Some of the answers of the students when asked if they enjoyed their experience with AquaMOOSE were: "I mean, I really didn't understand it overall. It was ok but like just to do, I wouldn't do it. Not just to have fun. I didn't think it was fun, if anything, it confused even more.

Another, student responded: “AquaMOOSE was awful [sic]. I didn’t learn a thing, my mind just got confused and un-oriented”. As it occurred from the experiments of the AquaMOOSE platform, students appear to request a more challenging, competitive and larger environment with more potential for exploration. Furthermore, they are requesting more structured goals to win, more community involvement. They also refer that it would more interesting if they had the chance to collaborate and play with their friends. Furthermore, an approach for web-based mathematics education (WME) was considered by Wang, Kajler, Zhou and Zou. (Wang et al., 2002) The WME framework designs a distributed system to enable web-based mathematics education. WME empowers the teacher and eliminates many technical difficulties of on-Web mathematics education. Kaufmann, Schmalstieg and Wagner (Kaufmann et al., 2000), (Kaufmann and Schmalstieg, 2002) presented a three dimensional geometric construction tool called Construct3D designed for high school and university education. This setup consists of a menu system with large, textured 3D buttons with meaningful 3D icons floating above the buttons to allow easy and fast selection of the menu elements. A stereoscopic head mounted display (HMD) is also used and students can see three dimensional objects in order to administer in a better way complex three-dimensional spatial problems and relationships. According to the authors “…The use of Construct3d is easy to learn and encourages experimentation with geometric constructions…” Alice (Conway et al., 2000), a 3d graphics programming environment designed for undergraduates with no 3D graphics or programming experience. It’s a Windows 95/NT tool for describing the time-based and interactive behaviour which occurs by manipulating 3D objects.

GENERAL DESCRIPTION OF THE PLATFORM AND SCOPES

As described above, students seem to understand concepts that are easily cognized and visualized; on the other side of the coin, they appear to have problems when coming to the issue of applying things from theory to practice and vice versa. EVIE-m (Educational VIrtual Environment – mathematics) is a platform that engages students with critical thinking and mathematical concepts through a three-dimensional graphical interactive environment that is based on the virtual reality environment of commercial adventure video games, which provides students with a different and more attractive aspect of mathematics. In addition, it provides students with the opportunity to apply their mathematical concepts in a world that they develop themselves, due to the scenario they are given at the beginning of the game, they have the ability to create as commodious space as they wish, providing students with a sense of exploration. Thus, the direct target of the platform EVIE-m is to increase the engagement of students with complex mathematical concepts that are difficult to conceive, through an attractive aspect- 3D graphical environment. EVIE-m supports various levels of students’ knowledge depending on their level of knowledge at school. The level of each world occurs in accordance with the level of knowledge of the players and therefore EVIE-m consists of 3 levels of difficulty. Namely, Level A is designed according to the needs of lower education, level B is designed according to the mathematical knowledge of middle education and level C is designed for higher and advanced mathematical education. To become specific, the knowledge that is used at each level corresponds to the lessons taught in the classrooms, so that the students keep in touch with their school lessons and have substantial progress. The philosophy of beneficial acting to EVIE-m is: “even reckoning, makes good…players”. Therefore, the assessment of the students will occur according to the accuracy of their calculations and estimations. Furthermore, EVIE-m is a highly motivating platform since it keeps a worldwide database with all the present ranking of each player’s world that is updated rarely during the game progress. In especial, the goal of the game is to “dominate” in a world, not fighting against ones’ opponents, but through achieving to develop technology, science, civilization only if capable of developing mathematics. The immediate objective of EVIE-m, is to get the highest score and be as good as possible at the worldwide ranking and years during but also at the end of the game too. The covetable “The End” shall appear on the computers screen when the most accurate and correct answers will be given and therefore a perfect, safe and last but not least, immune world is created. In order to build the best world-and therefore increase their score and personal ranking- they have to continuously improve their mathematical knowledge, otherwise it is impossible to move successfully to the next movement that will upgrade their world. In that way, students gain the advantage to apply complex mathematical concepts, such as applied mathematics, algebra, calculus, economics, statistics, and

geometry and to find out the importance of mathematics in the real world. Concluding, EVIE-m, evokes a sense of personal victory through self-progress, collaboration, creativity and critical thinking.

SCENARIO AND PARAMETERS OF THE PLATFORMS

Students start with an initial map shared and common among users, an initial investment capital (initial budget) and an inchoate form of civilization, such us citizens, primitive infrastructure and law. Objective of the players is to create a "healthy" infrastructure, which will embody their world with durability against all difficulties that will appear during the progress of the game. In addition, forecasts about natural phenomena and other kinds of disasters are represented to the map according to the level of knowledge; for example, in middle knowledge such a factor is represented statistically and the students have to calculate the possibility of the accession of a disease, natural phenomenon or other kind of disaster. Moreover, students have the advantage of using a search engine and help files that provide them all mathematical concepts when necessary, as also they can collaborate with other students so that they reach their goal. The game is progressed over a virtual time space with one-year duration unit. The students' assessment is based on points that earn for their achievements and virtual-years they have utilize to develop them. Apart from the obvious competitors, which are co-players all over the world, the actual competitor is each ones self as they have to become better and better as soon as possible in order to retain the best ranking. Although there are some more underlying factors that will capriciously take place, these will cause problems which will bring about destructions that will affect each ones world analogical to the advancement of the technology, humanism and civilization students have achieved to develop.

PARAMETERS OF EVIE-M

EVIE-m consists of two types of parameters that affect to the game progress. The first type are the system parameters (Points, Time, Catastrophic events, Quality of Life) which are controlled, measured and imposed by the system and the second type are the user controlled parameters which are actions that the user gets in order to improve his civilization (Constructions, Economy, Environment, Education, Technology, Health, Culture, Civil Protection and Transportation).

Points

Points are the credits that students earn as revenue for their accurate mathematical calculations as well as for their overall performance during the game. While students interact with the game they are requested to perform mathematical calculations for every action they take. Calculations vary according to action from geometrical and calculus while constructing buildings to statistical while they are designing a Health care system or an educational infrastructure. The more accurate the calculations the more points they gather. A complementary way that students gather points is by the overall performance of the civilization they build. Performance is measured in a manner similar to the United Nations ranking reports indexes. Thus, civilization is evaluated according to Quality of Life (considering population per unit area, education, culture, health, civil protection) and Economy (budget growth, technology, transportations).

Time

Time is fundamental for the game. It reflects the progress of the student's world and is related to the accuracy of their mathematical calculations. Time also affects to the score of the students into the world ranking. Time is measured in virtual units (one virtual year unit).

Catastrophic events

There are four types of catastrophic events that are considered in EVIE-m. These are earthquakes, extreme weather conditions, diseases and fire. In EVIE-m, we provide the students with statistic estimations that represent the possibility and the frequency of occurrence of such events. Therefore, the student is prompted to calculate all the necessary parameters that will protect their world. For example, A level knowledge students should build their world far from places known as dangerous areas in order

to both minimize the risk of destruction of their constructions, but also to prevent a negative flow in their budgets, stemming from their reconstruction. Thus, a correct decision will result in a raise in the user's acquired points. For B level students, some statistics knowledge is important to seek all the possibilities of such an event at all the areas of the map. This implies the use of statistical analysis in order to decide the best appropriate area for the construction of their buildings. For advanced level students, probabilistic or statistic calculations for the safety of the constructions and the potential location of the constructions are utilized to analyze the situational factors for each area. In each case, the selection of the best possible area provides the user with the maximum of the points, while there is indirect penalty when the selection is the worst possible one.

Quality of life
Quality of Life parameter is used by EVIE-m to indicate the well-being of the civilization. It is automatically measured by the system and it affects the student's score. The Quality of Life parameter is influenced by the actions of the user on every parameter of the game. Dealing successfully, for example with a catastrophic event increases the Quality of Life parameter in order to indicate the satisfaction of the
civilians for this action.

Constructions
Students are asked to construct all means that contribute to the existence and the development of a community. In specific, they have to build a variety of buildings that provide basic or special services that we meet in our everyday lives such as roads, houses, hospitals, fire stations, churches, schools etc. These ust be build in best possible way. For example, a possible scenario request would be: Build a block of flats using the one of the following architectural designs. The student selects an appropriate design according to their civilization' needs and budget and calculates the materials that are necessary for the construction. In the case of A level, the architectural designs would be consisted of simple cubes and rectangular or circular surfaces. In the case of B level of education the same problem will include slopes and well as trigonometric calculations. Finally, in level C, designs are given in analytical function formulas that require 2D and 3D integrations. Points are gathered by the student according to the accuracy of his calculations as well as by the virtual time duration required to build the virtual construction. Virtual time duration depends on the resources (economical, human and materials) that the student assigns to a certain construction.

Economy
An important issue that we meet everyday in our lives and EVIE-m deals with is Economy. At the beginning of the game, students are given an initial budget as mentioned above. Budget allows students to achieve best evolution of their worlds, because according to their economical administration for example they can build constructions in order to improve their civilization. In addition to that, the evaluation of the user's results and actions regarding the administration of the budget and the investments made, provide the user with the corresponding points. For example, creating trading routes between fellow users for acquiring technology and know-how, which may be otherwise difficult to explore, results in an immediate gain of points through technology. The students' budget will be increased through merchandise and through points gathered by the accuracy of the required calculations for any action accomplished during the game.

Environment
Environment plays a dual role in EVIE-m platform. It is utilized as a sudden factor that causes catastrophic events, but also as an indicator on the level of well-being of the citizens of the virtual world. The student that achieves in creating the most beautiful world with parks, trees and a clean environment on the given time acquires the most points.

Education
In order for a civilization to be built the presence of a school is vital. A school affects both the technology and know-how of a civilization as well as the well-being of its citizens. Building an initial

school requires some fundamental mathematical knowledge, while high school and university require a minimum of technological advances in order to be created. The educational institutes promote technology. If for example the student builds a primary school then he gains access in performing certain primary tasks, as well as exploring fundamental technologies that would enable the creation of a high school. In turn, building a high school provides the user with the possibility of exploring new technologies that enable the construction of a university. Constructing a university enables the user to gain access to all the available technology. The points are amassed directly through the construction of the building, while the novel technologies explored indirectly provide the user with both points and budget. An educational structure is therefore required for the educational institutes to operate. At that point, the user should specify the income of the teachers of these institutes, while maintenance and infrastructure costs should also be considered.

Technology

Technology gives a great advantage to those who have made the best calculations and therefore increased their budget. Such an advantage leads to life in a better or even an advanced world, which of course increases budget, points and score. Technology affects every parameter of the world. Advances in the mechanical area, for example, enable the development of a car, and therefore minimizes the time required for a fireman to be transported to the area of a fire incident, and therefore reduces fire risk. In that way, the platform dynamically updates the statistical factors of the catastrophic events parameter.

Health

There is nothing better than a healthy and well organized society. After checking all the parameters of the world, a clever estimation on the place where the hospital should be settled will definitely give extra points and budget, while it also changes the health factor (possibility of disease) as well as Quality of Life parameter. Installation of a health care system temporarily decrease the budget of the player, but in the long run, along with technological evolution, offers a means of identifying, curing and preventing diseases, while also improving the user's score and budget.

Cultural

Culture is a social factor that enhances the well-being of people. The higher the cultural factor the more intellectual and entertaining is real life. EVIE-m follows the same rules in replicating a cultural system in virtual reality world. In order to be able to envisage culture in a virtual world it is required to have education system that will offer the fundamental elements required to promote culture. This results in improving the Quality of Life parameter that will offer points and increase user budget.

Civil Protection

All societies need civil protection. For this reason fire stations are provided for the case of a fire. According to the scenario students must decide-making all calculations where the fire station should be settled in order to be closer to the places with most possibilities to get fire. For example, low level students should calculate the distance between the fire station and the places that get fire more often in order to be closer in the place and put the fire off within the limit of endurance of the building. In higher education other factors as probabilistic schemes representing obstacles imposed by transportation will intermingle, requiring an advanced level of mathematic calculations. As mentioned above there is variety of constructions; each construction has its own durability factor e.g. schools have higher durability factor than all others constructions, which should be taken under consideration. However, making the appropriate calculations minimizes the cost of reconstruction, thus preventing decrease in the overall budget. A proper construction of civil protection buildings as well as right calculations regarding the routes to each incident will also enhance the points gathered by the user.

Transportation

Transportations and traffic conditions are included into EVIE-m scenarios. Successful transportation infrastructure implies a higher score for that task. In the Transportation parameter, students have to calculate and adapt infrastructure into traffic requirements imposed by the population, city topologies

and roads. Transportations affect parameters like Catastrophic Events by reducing consequences, Civil Protection by increasing accessibility and Economy by improving merchandise capability.

TECHNOLOGICAL ASPECTS

EVIE-m is built on an educational platform already developed in Technological Educational Institute of Crete. The platform named VClass3D is an interactive Virtual workspace with chat, video, audio and file-sharing capabilities and is developed using Sun Java programming language and technologies as Java Media Framework. VClass3D already has a virtual 3D environment (Malamos et al., 2006) that supports a virtual 3D collaborative workspace. However, EVIE-m targets not only in extending the current infrastructure but also to work as an autonomous, interactive module to VClass3D. From a technological aspect EVIE-m uses XML technology for the representation of its objects. Each object is a series of vectors and attributes. The vectors are used to represent the objects while the attributes specify its behavior in EVIE-m. These attributes are also recognized as input to the formulas embedded in EVIE-m, specifying the interaction between the objects in the EVIE-m 3D environment.

PEDAGOGICAL VALUE

ICT-enhanced education subsequently follows the same rules that apply for traditional education. In order for the learning process to be successful, Jackson and Fagan (Jackson and Fagan, 2000) point out that it should be “active”, “cumulative”, “constructive”, “goal-oriented”, “diagnostic”, “reflective”, “discovery-oriented”, “contextual”, “problem-oriented”, “case-based”, “social and intrinsically motivated”.

EVIE-m was deliberately designed keeping these criteria in mind, and therefore several of these are inherent in the platform. First of all, activity in EVIE-m is one of the fundamental and obvious characteristics. The student constantly has to deal with and successfully solve a number of problems related to the educational nature of the game. The game scenario is guiding students to build their knowledge through the constructive “knowledge by experience” model. Cumulative knowledge is enhanced by the objectives of the game. As described above the students is always urged to construct a world, through not only his common perception of how a world should be but also by being presented with the outcome of their actions through their correct or wrong mathematical calculations. In addition to that, EVIE-m tries to enhance the knowledge of the students. This is accomplished by gradually increasing the difficulty level of object construction in the virtual environment, as the world is expanding. Thus, the game follows the school progress of the students and provides him new mathematical experiences by adjusting the games’ short term objectives. This progressive approach is not only important for understanding new information but also urges the students to discover new things (and therefore to acquire new knowledge) in order to accomplish the objectives of the game. The existence of objectives (either short-term objectives as solving a mathematical problem to construct a building or avoid a natural disaster, or long-term finishing the game with an efficient score in order to be registered in the global rankings) inevitably promotes goal-oriented and problem-oriented knowledge, while every objective is based either according to common sense or according to game interaction to a case which the students have to solve in order to extend their knowledge.

CONCLUSIONS

In this paper we presented an approach on utilizing virtual reality in creating a virtual 3D world as an educational platform for mathematics. The world comprises advanced social and economical factors in an attempt to simulate real world and promote the encapsulation and utilization of mathematics, as one would in real life. The novel features of our platform are the utilization of mathematical concepts depicting low comprehension factors in an entertaining way, while simultaneously offering the necessary background information in order to understand the structure of the society and the importance of mathematics in it. Nothing is what it seems to be! There are no one-dimensional behaviours, objects, relationships and concepts in life. What makes the difference is the point of view we observe them. We

hope that EVIE-m will give a pleasant "glimpse" to the way students look at mathematics and reveal the answer to the great question that dangles above their heads: "Why should I learn Math?"

REFERENCES

Conway M., Audia S., Burnette T., et. al.. (2000), Alice: Lessons learned from building a 3D System for Novices in CHI 2000, CHI Letters, 486-493 2(1)

Elliot J, Adams L. and Bruckman A. (2002), No magic bullet: 3D video games in Education, Proceedings of ICLS 2002

Elliot J and Bruckman A. (2002), Design of a 3D Interactive Math learning environment, Proceedings of DIS 2002 (ACM conference on Designing Interactive Systems). 64 – 74

Gittler G. and Gluck J. (1998), Differential Transfer of Learning: Effects of Instruction in Descriptive Geometry on Spatial Test Performance. Journal of Geometry and Graphics, 2(1), 71-84

Jackson R.L and Fagan E. (2000), Collaboration and Learning Within Immersive Virtual Reality, Proceedings of the 3rd International Conference on Collaborative Virtual Environments, 83 - 92

Kaufmann H., Schmalstieg D. and Wagner M. (2000), Construct3D: A Virtual Application for Mathematics and Geometry Education, Education and Information Technologies 5(4), 263-276, Kluwer Academic Publishers

Kaufmann H. and Schmalstieg D. (2002), Mathematics and Geometry Education with Collaborative Augmented Reality, in SIGGRAPH 2002 Educators Program. SIGGRAPH 2002 Conference Abstracts and Applications, pp. 37-41

Lunce L. M. (2004), Computer Simulations in Distance Education, International Journal of Instructional Technology and Distance Learning, 1(10), DonEl Learning Inc.

Malamos A.G., Mamakis G., Sympa P., Tsirakis M., Piperidis G., Karakechagias J, Mavraganis K., and Kaliakatsos Y. (2006), VClass-3d: A multimedia educational collaboration platform with 3D virtual workspace support, Proceedings of WBE 2006, 19-24

McLellan, H. (1996), Virtual Realities, in D. Jonassen (Ed.), Handbook of Research for Education, Communications and Technology (pp461-498), New York, NY.: Simon &Shuster MacMillan

Naeve A. and Nilsson M. (2004), ICT-enhanced Mathematics Education within the Framework of a Knowledge Manifold, Proceedings of the 10th International Congress of Mathematics Education (ICME)

Newby G. B. (1993), Virtual Reality: Tomorrow's Information System of just another pretty interface? Proceedings of One American Society for Information Science Annual Meeting, Medford, NJ: Learned Information. 30. 199-203.

Wang P. S., Kajler N., Zhou Y. and Zou X. (2002), Initial Design of a Web-based Mathematics Education Framework, Proceedings of IACM 2002

Yeh, A. and Nason, R. (2004), Knowledge Building of 3D Geometry Concepts and Processes within a Virtual Reality Learning Environment. Proceedings of World Conference on Educational Multimedia, Hypermedia and Telecommunications, 2175-2182.

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