A Pilot Project to Teach Road Safety Using Desktop Virtual Reality

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EXECUTIVE SUMMARY

In this work, the issue of road safety education is presented. Virtual Reality can be used for this purpose with very good results. An application was developed based on a 3D video game. This application was simulating the environment of a town with traffic and contained not only all of its elements (cars, traffic lights, pedestrian crossings) but also special conditions such as night and rain. It was developed to simulate the walk of a pedestrian and could accommodate many users simultaneously. It was tested by the students of the last three grades of a primary school in Athens. The acquired capabilities of the students/users were compared with the equivalent capabilities of students that had training in the class using printed material only and with the knowledge of another group that had no training at all.

Key words: 3D game, Constructivism, First/third person view, Game editor, Road safety education, Trigger, Virtual Reality

ORGANIZATION BACKGROUND

The Aegean University is a university network with departments in five islands and offices in Athens. It is a state university with 14, 000 students in all its 16 departments. It is a fast growing university with many postgraduate courses. The department of Education sensitive to the challenges of the area it operates, is developing know how that is not only to the benefit of education but also to the benefit of society. Therefore, all forms of distance education (synchronous, asynchronous, satellite, etc) are examined and researched, while applied extensively. Also nearly all forms of Virtual Reality are studied and applied not only in education in general but also to the remote schools of Greece, Europe and beyond.

SETTING THE STAGE

Road safety education can play an important role in the overall reduction of traffic related accidents, especially if it is introduced in early childhood (Thomson, Tolmie, Foot, & McLaren, 1996). This fact is identified by policy makers and relevant actions are introduced either in the school curricula and/or in the wider frame of a national policy for road safety. While the above holds true for many industrialized as well as developing countries (UK's Department for transport [DfT], 2003; New Zealand's Ministry of Transport, 2002; Road Safety Cambodia, 2008), in Greece, a country with a severe problem regarding road safety, very little is done. Whilst the government pledged that road safety education is going to be systematically taught in primary and secondary schools, the resent educational reform disproved all expectations.

Evidently, the lack of a specific teaching framework and didactic material is a fertile ground for any research group interested in developing and testing innovative techniques for teaching road safety to young students. We decided to address the subject using a 3D simulation, a Virtual Reality (VR) application, rather than a typical 2D application. The main reasons for this decision were the unique characteristics of VR applications, as they: i) allow training in a manner very close to real traffic conditions ii) permit the simulation of traffic situations that are very complicated to be presented in reality or extremely dangerous for students to be exposed to, iii) have a playful character similar to modern computer games and iv) provide the possibility to implement different teaching techniques (Fokides & Tsolakidis, 2008).

CASE DESCRIPTION

In our case, the task of creating a certain type of computer application was not that of converting the existing educational material in another form, since such material is non-existent. Consequently, we set the teaching objectives, determined the teaching methodology and we wrote, collected and modulated the teaching material. Furthermore, we considered the following conditions of great importance:

Effectiveness: Students should be able to learn a practical piece of knowledge and apply it in their everyday life;
Accessibility: A large number of students should be able to access and work with it. Since schools are not equipped with high-end computers, the application should be lightweight enough in order to run smoothly in mid-range or even low-end computers:
Compliance: The school life should not be disrupted with time consuming activities that will affect an already congested timetable and curriculum; and
Cost: Not to have significant cost regarding its development.

To form the instructive framework, the necessary knowledge, dexterities and behaviors which would enable children to a safer conduct in the street environment were determined. These are: i) orientation in space and the detection of traffic, ii) detection and the evaluation of dangerous situations, iii) evaluation of the vehicles' distance and speed and iv) synchronization of perception and movement as well as the co-ordination of information from various directions (Fokides & Tsolakidis, 2008).

The decisive factors for the success of any road safety education program are the active participation of students in the educational process and the extensive practice of what they learned. The active attendance during the training process is very well documented by the learning theories that stress the importance of social interaction and interactive learning (Piaget, 1985; Vygotsky, 1978). Documentation on the value of practice in pedestrian skills is rich, since it provides children with a concrete and tangible frame in which they can apply concepts that orally or written are difficult to comprehend and follow (DfT, 2002; Sandels, 1975). The resulting teaching methodology that is appropriate for road safety education is a combination of adult guidance and students' collaboration, a "guided collaboration". The "guidance" part of this methodology is, in essence, the practice in the traffic environment and the "collaboration" part is teaching in the classroom using teaching practices and principles that derive from the learning theory of constructivism. For the specific project, and since use of computers by students was involved, the guidance part was constituted by having students work in a simulated traffic environment, each on his/her own computer, but also forming groups of three. The collaboration part was constituted by the activities that followed in the classroom.

In order to examine the feasibility of the application to be implemented without causing significant agitations in the school's timetable, it was decided to address it to students of the last three grades of the primary school, where the timetable is already full of lessons and activities. A realistic duration of the application was considered to be two months, with a frequency of a two consecutive didactic hours once a week, which meant that it could include 7-8 instructive units for each grade.

The analysis of the dexterities and behaviors that enable children to safely walk in the streets resulted in the following general instructive objectives:

<u>Cognitive</u>: i) to know how to protect oneself in traffic environment, ii) to comprehend the role of the traffic signs, iii) to be aware of the problems that street users face (detachment of attention, weather conditions etc), iv) to understand when and how road accidents happen, and v) what to do in the event of an accident and how to ask for help.

<u>Dexterities</u>: i) to orientate, ii) to detect the traffic, iii) to become aware of and evaluate dangerous situations, iv) to evaluate the distance and speed of the vehicles, v) to synchronize perception and movement, and vi) to coordinate information from different sources and directions.

<u>Behaviors</u>: i) to be able to give and follow directions to a destination, ii) to use the traffic lights and understand the basic traffic signs, iii) to apply the safety rules that administer the actions of pedestrians and drivers on various situations, iv) to comprehend the consequences of their actions to themselves and to others, and v) to resist acting impulsively and without prior thinking.

The above objectives were grouped and allocated in instructive units, the general content of which was:

- Introductory unit. Learning the handling of the application, acquaintance with the traffic environment of a city.
- Unit 1. Orientation, giving and taking directions to a destination.
- Units 2 & 3. Road and highway crossing, time that is required for the safe passing of a road, finding secure places for crossing a street.

- Unit 4. Traffic signs for pedestrians and drivers, complicated situations that a pedestrian might face (e.g. roads without pavement).
- Unit 5. Weather conditions, precautions, streets at night.
- Unit 6. Traffic accidents, actions in the event of an accident.
- Unit 7. Using the streets in a complex urban environment.

Technology Concerns

Selecting the Software for the Development of the Application

There are a number of different types of VR applications (desktop, immersed, augmented, etc), each having its advantages and disadvantages. Desktop VR, though considered by experts as the humble relative of the other types, causes none (or very low) additional hardware costs to users, in this case schools' computer labs. Hence, desktop VR applications can be accessible by almost all students, satisfying two of the above stated prerequisites (cost and accessibility) and -self-evidently- was the type chosen.

The software to be used had to comply with the same requirements as described earlier. VR development software packages offer the most satisfactory solution, since they provide an ergonomic and windowed environment. The main drawback is the acquisition cost which can -in some cases- be considerable. An unforeseen category of computer applications, capable of providing relatively easy-to-use and cost effective tools for the development of VR applications is the 3D computer games and specifically "first person shoot them up’s". In these games, the user/player is placed in a 3D environment, eliminating "enemies", avoiding traps and solving puzzles. The characteristics that VR applications and 3D games share are so noteworthy, that the boundaries between the two are very difficult to discern.

These common characteristics are (Fokides & Tsolakidis, 2003):

1. Both types of applications are simulations of complex 3D environments, highly interactive and explorable.
2. Interactions and behavior of objects in general, are controlled through scripts or by triggers (programmable entities that control the flow of events in the virtual world).
3. Multi-channel sound and "3D sound" is supported.
4. The user can look up or down, turn left or right, move forward or backwards, walk, run, fly and can have first or third person view of the virtual environment. All these are the result of an imaginary camera placed in front or behind the user's avatar (the 3D model that represents the user).
5. Both provide network support, allowing a number of users/players (from few up to thousands) to use the application simultaneously. Network traffic is minimal by transmitting only the coordinates of each user/player while the actual 3D environment runs locally. Interestingly enough, games use this feature in order to record the course of the game not as a disk consuming video file but as a set of sequential coordinates that uses far less disk space. This feature can be very helpful either for research or for educational purposes.
6. VR applications utilize specialized -and expensive- equipment in order to increase the user's immersion. Games do not use these devices, but a joystick or a D-pad can totally replace the mouse and the keyboard. These devices function quite similar to that of VR navigation devices. Finally, glasses that are used for stereoscopic viewing are the same in both cases.

For the above reasons, it was decided to investigate towards this direction. One way to create a 3D game is to use game development software packages, the majority of them having a low or reasonable cost. Also, open source game development software packages, totally free of charge, are available. The other way is to use an in-game editor (the software tool that the game company used for the creation of the game). What is of interest is that most editors are included in the game packages, allowing users to create their own levels. Some in-game editors of older games are even distributed under the open source license.

The selection of a game editor has to carefully balance its cost on one hand and the features it provides on the other. What was realized, by studying and evaluating games, was that they take good advantage of the user's hardware and that the quality of the virtual environment, and of the 3D graphics in general, was high. It was also noted that the provided in-game editors are not -at first glance- easy to use and that external programs have to be used for content creation (e.g. 3D models, sounds, textures). The final conclusion was that almost all game editors could satisfy the needs of this application. Thus, the choice of one editor over another is subjective, depending on ones' personal preferences.

Development of the Application

The general idea was to create an application that simulates an urban environment. This environment would act as a platform for placing the cognitive elements of each instructive unit as well as to provide students with an area to practice and test these elements. The developing process included the following phases:

1. Familiarization with the game editor.
2. Construction and/or editing of 3D models, sounds and graphics.
3. Construction of the application's urban outline (e.g. roads, pavements, buildings).
4. Placement of the static and moving objects (e.g. trees, traffic signs and cars).
5. Placement of the basic interaction points (e.g. traffic lights).
6. Placement of the cognitive activities.

In each phase extensive tests were conducted, evaluating the application's performance and the validity of the pedagogic ideas incorporated within it.

For the construction of an urban setting, various 3D models were needed, mainly that of cars. Models of people, traffic signs, traffic lights and various other decorative elements (e.g. trees, street lights, trash cans and fences) were also needed. It was decided to use models that are freely available over the Internet in order to reduce the application's work load and cost. 3D models are constructed with the use of polygons (mainly triangles). The number of the polygons of each model was a point of concern. High polygon count models are very detailed but drain the computer's resources. For the buildings, pavements and streets we used simple parallelepipeds accordingly textured and that did not put strain on the application's performance since the number of polygons was extremely low. All the other models were edited in order to balance quality and polygon count. Also, three copies of each model were created, each having roughly half the polygons of the previous one. This was done in order to utilize the technique of "level of detail, LOD", which allows the replacement of a model with another less detailed when the distance from the user increases (*image 1*). By doing so, the number of models present at any given time was ample while the application functioned smoothly because of the reduced total number of polygons.

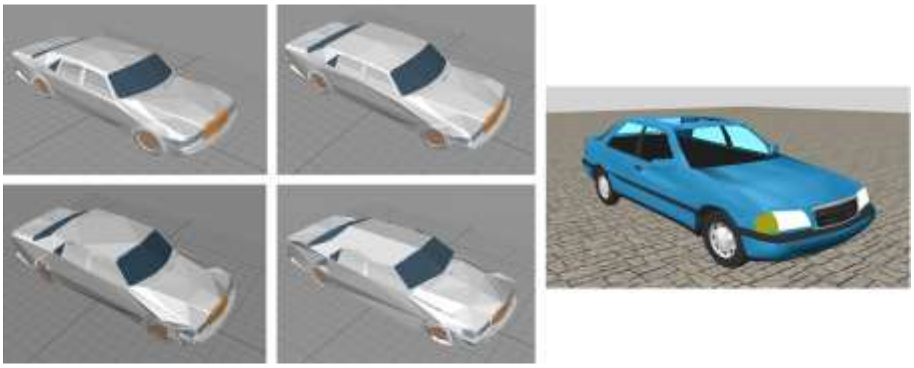

Image1. Level of detail and the final 3D model

The placement of the building blocks, squares and roads was not simply the positioning of parallelepipeds of various sizes. Vital questions had to be answered regarding the density of the buildings, the distance between them and which street arrangement would be convenient for the movement of cars. Also, the placement of buildings and streets would have to create multiple routes to and fro a destination, while ensuring that all cognitive elements would be visited by students. Obviously, the streets were the central point of the application. Their width, in conjunction with the number and frequency of cars traveling in them, would determine the traffic "gaps" which would or would not allow users to cross them. Highways were also placed. In a number of places, the crossing of roads and of highways would be controlled by traffic lights introduced in a following stage. Finally, pedestrian crossings were regularly positioned in easy to find places.

The speed of cars and their flow in the streets was a matter of concern. To simulate real traffic conditions and at the same time to have a minimal number of moving 3D models, two techniques were used. The first was to circle the cars around building blocks. The second, applied when the cars were moving at a straight line, was to "teleport" them back when they reached the end of their path. The speed of each car was varied according to a predefined scheme. We have to mention that one-way or two-way roads had two lanes in each direction (three in highways). Cars in each lane had different speeds and distances than that of the other. The above resulted in having streets constantly filled with cars, which "seemed" to vary in numbers and speed. Therefore, in any given road, varying traffic "gaps" were created challenging the students to decide if and when to cross. At the same time, the traffic pattern was complex enough and seemingly random, making it not easily recognizable by students, discouraging them to try to resolve when the next safe "gap" would appear.

The next task was to regulate the motion and the turning speed of the head of the user's avatar. We determined that throughout the application the user should walk at a quick pace, since this is the speed with which one crosses a street. For a road 6-8 meters wide, 1.5 to 2 seconds for crossing were needed. Far more important was to settle on the rotation speed of the avatar's head. The speed should allow the user to thoroughly check the traffic. Two research studies (Whitebread & Neilson, 1999; Tolmie, Thomson & Foot, 2002) suggest that 4.68 (11 year old children) up to 5.45 (7 year old children) seconds are needed for checking (but not crossing). The second study also concludes that children check traffic for 3 up to 5 times before crossing. In a third study (Simpson, Johnston, & Richardson, 2003), traffic gaps of 6, 8 and 10 seconds were used. The findings suggest that for a one-way road, 6 meters wide, 8 seconds are needed for checking and safe crossing and 5.4 seconds allow checking but a marginally safe crossing. This study, even though it had a small research sample, is the only one in our knowledge that used an immersive VR application for establishing the way children perceive traffic gaps. We concluded that gaps of 8 to 10 seconds (depending on the type of the street) can be considered as "safe" for crossing, approximately 6 seconds gaps are marginally safe and below the threshold of 6 seconds gaps are unsafe. The rotation speed of the avatar's head was accordingly adjusted.

Programming the function of traffic lights was the most intricate interaction materialized in the application. Each crossroad has two pairs of traffic lights controlling the flow of cars and another two pairs for pedestrians. While one pair of car traffic lights is green, the other is red and vice-versa. While one pair is green, the pair of pedestrian traffic lights at this part of the crossroad has to be red and vice-versa. Car traffic lights in Greece change colors according to the following scheme: red-green-orange-red. When car traffic lights become red (or green), the corresponding pedestrian traffic lights do not become green (or red) spontaneously, but after a few seconds, for safety reasons. Cars have to reduce their speed (in order to stop) when the traffic light is orange. Cars stop when the light is red, but in rare cases (not so rare in Greece) drivers violate this rule, forcing pedestrians to be more alert. In order to accomplish all the above, more than forty triggers were used in each and every crossroad and about twenty were placed in order to control the traffic lights placed of simple roads (*image 2*). It was also arranged for some traffic lights to be out of order and that -randomly- a car would violate the red traffic light.

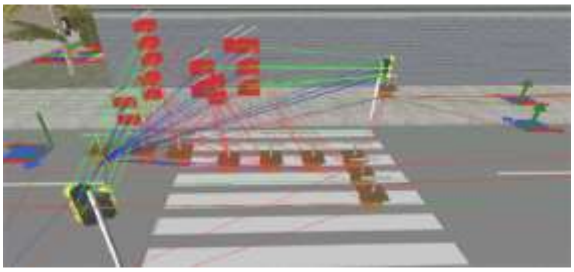

Image 2. Triggers of traffic lights in a simple road

While adding moving cars, trees, traffic sings and all the 3D models in general, the application became complex and its editing intricate. In addition, the large number of 3D models would cause the application to run with difficulty even in high-end computers. Therefore, the application was split in a number of levels equal to the number of the instructive units (*image 3*). Each level was also split in sub-levels. The user would be able to move from one to another sub-level using '"teleportation", a concept widely used in 3D games. In this case, it was decided that it would be better for the users not to perceive teleportation, because the application might be mistakenly taken for a game. Exit and entry points in sub-levels were constructed in a manner that created the illusion of a single level. For instance, the architectural structure at the exit point of a sub-level was the same as the entry point of the next.

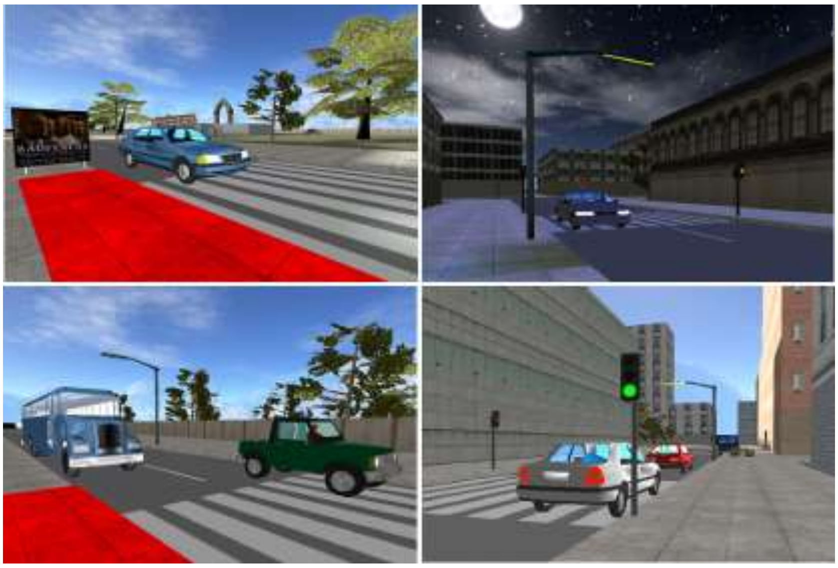

Image 3. Snapshots from the application

The cognitive elements were presented to the user when she/he pushed buttons or used levers. By doing so, the user could read or hear instructions on what to do in certain traffic situations, see an example using the 3D models present at the scene, or use these models to practice. For instance, on the instructive unit which dealt with weather conditions, students were able to push the brakes on cars that moved on dry or wet road surface (in low and high speeds) and measure the distance required for the cars to stop.

All levels were thoroughly tested, especially regarding the frame rate, which was constantly well above the threshold of 25fps (60 fps in average). Finally, to control the application's avatar, a PlayStation type of controller was used instead of the mouse and keyboard. The application was administered to a small number of students (with computer skills ranging from novice to good user) in order to have feedback concerning difficulties in using the application or difficulties in understanding certain cognitive parts.

As mentioned in a previous section, in-classroom activities followed the completion of each level. All these activities were printed and were given to students in the form of a booklet. The activities included but were not limited to presentations of the subjects of each level in theatrical sketches, in debates and drawings. Hence, the booklet acted as a quick reminder of what the students faced at a particular unit and as an area for taking notes or for doing their drawings. A booklet for the teacher was also written, which included the purpose and the general instructive objectives of road safety education, the specific instructive objectives of each unit and guidelines for the in-game and in-classroom activities. Finally, a manual for the installation and usage of the application was also written.

Implementation of the Application

To collect research data and evaluate the application, a public elementary school was selected, situated in central Athens. The selection criteria were: i) to be an urban school, ii) students of the last three grades never to have attended a road safety educational program of any kind, iii) teachers to be interested and available and iv) the availability of a computer lab. Students of a neighboring school participated at a conventional road safety program. For this program, all the cognitive material and activities included at the virtual world were "transformed" in text, pictures and images and formed a printed students' handbook. Also, the in-classroom activities were the same. Students from a third nearby school were the control group, no road safety education lessons were taught to them.

A series of administrative-organizational and technical interventions were needed, essential for the uncomplicated implementation of the application. The school's computer laboratory was upgraded with the installation of new middle-range graphics cards. Earphones and joysticks were also fitted. The next step was to schedule the lessons. In conventional teaching, this task did not raise any problems since a unit could easily be taught to all students of a grade in two successive hours. In total, 21 two-hour lessons were planned (3 grades by 7 units, once a week). Altogether, 7 days were needed because teaching could take place in each grade's classroom and be conducted by each grade's teacher, hence a unit could be taught simultaneously in all three grades. The situation in the VR courses was far more complicated. Schools in Greece have one computer lab with 8 or 9 computers (9 in our case). This meant that in two successive hours, only three groups of three students of one grade could use the lab. During this time, no one else could use it; therefore, simultaneous teaching was not possible. In total, 7 groups of 3 teams of 3 students were formed, 49 two-hour lessons were planned (7 groups multiplied by 7 units, once a week) in a period of 49 days. Both VR and conventional courses started and ended together.

In order to collect research data, a complex system was established, combining questionnaires, interviews, observations during teaching, evaluation of the in-classroom activities, analyses of students' actions in the VR world and post-courses evaluation with the use of photographs and video clips. Data for the project were collected from multiple sources in order to have a more accurate and objective aspect of the entire procedure.

Prior to the beginning of the courses, two questionnaires were issued to all groups of students (to the ones that were going to use the VR application, to the ones of conventional teaching and to the ones of the control group). The purpose of the first one was to establish the degree of "traffic autonomy" of each student, i.e. to what extent she/he is exposed to traffic environment and how autonomously she/he functions in it. The second questionnaire's purpose was to establish the degree of infiltration of game consoles (e.g. Playstation, Nintendo, Gameboy, etc) and of computers in the children's daily life. Also, in collaboration with the schoolteachers, the psychological-intellectual profile of each student was outlined, in order to detect factors that influence their street behavior that might play an important role in the effectiveness of both types of teaching.

During the VR courses, attendance, interest expressed for the activities, "presence" in the VR world or detachment were recorded. Students were interviewed every two units. The duration of each interview was 15 minutes at the maximum. Students were not pressed to give answers and only the first spontaneous reaction-answer was recorded. The aim of the interviews was to collect data regarding technical and cognitive aspects of the application.

The students of the VR courses kept notes on the activities they performed. The answers they gave to various questions were also transferred to their handbooks. The same applied for the students of the conventional courses. Since the in-classroom activities that followed were common in both types of teaching, the evaluation of the handbooks and of the activities was the first method used to compare the effectiveness of the two forms of teaching. A month after the completion of both courses, a video was presented to students, consisting of twenty scenes, each having 20 to 25 seconds duration. Also, an album of 40 photographs was given to each student. Both the video and the photo album presented groups of right and erroneous pedestrian actions-behaviors in no particular order. Students were asked to spot the right ones having limited time at their disposal (immediately after each video clip and ten minutes for all photographs). The same form of evaluation was also given to the control group.

The most comprehensive form of data collection was the build-in recording system of the virtual world. It was proven -by far- superior to a video camera recording each student. It allowed the exact timing of actions, repetition at will, simultaneous observations of the actions of the whole team and anybody could see what the student saw at the virtual world. For instance, it was possible -for each student- to monitor how many times she/he checked the road before crossing, how much time this action has taken and what types of mistakes were made.

Students in both forms of teaching were briefed that they will attend a series of courses regarding road safety, that they will work in a different way than usual and that they will not be examined or graded. During the introductory unit in the VR courses, instructions were given on the controls and the usage of the application. Students were informed that they were going to work in groups of three while inside the VR world as well as during the in-classroom activities. The majority of students, although used in playing computer games, proved to be unfamiliar with the first person view of the VR world (in contrast to the third person view of games, where the user sees his/her avatar). It took some time to come at ease with this way of viewing the VR world.

An interesting point was students' collaboration in VR world. It was observed that when a student crossed a road, she/he waited for the others to do the same. However, when a student had problems in crossing, the others told him when to do so. For this reason they were instructed that helping and collaboration holds for anything else but crossing. In general, the different way of working caused some difficulties to students, in both forms of teaching, because they are used (or even depended) to the traditional model where "the teacher teaches and the students attend". In the conventional courses, that were more close to the traditional model, fewer problems occurred. In the VR courses, especially at the beginning, the teacher was literally bombarded with questions such as: "what do I have to do now?", "where should I go next?". Even though there were very few students in the computer lab, the teacher had to address each student or each group separately, because: i) students were wearing earphones and ii) all groups were not -most of the times- at the same section of the VR world, thus they were engaged in different activities.

At the introductory unit of the VR courses, a small portion of the urban environment was included. Almost all students crossed the streets from random spots, without checking and many "deaths" occurred. During the discussion that followed, students justified their actions by saying that this is what they do in reality. This is an indication that: i) they transferred their perceptions in street crossing from the real world to the virtual one, ii) the virtual world was considered "valid" and not a game and iii) their traffic culture was very small if non-existent. Another clue that shows that students deemed the virtual world as "valid" was the way they walked on the pavement. Even though there were a lot of parks and open spaces with vegetation, students chose not to cross them diagonally in order to go from one point to the other. The explanation they gave was that "in parks it is not right to step on the grass".

Students welcomed both types of courses with joy and enthusiasm (*image 4*). In general, the positive attitude of students is a very powerful indication on how much and urgently a different philosophy in the way of teaching is needed.

Image 4. Snapshots from the VR courses

DISCUSSION

The analysis of the quantitative and qualitative data collected by the system, eventually provides evidence for the application's value. It must be noted that there was a wealth of data to be analyzed (indicatively, for each student that participated in the VR courses, more than 750 variables were recorded), therefore in the following paragraphs only the most important findings will be presented.

General Observations

In total, data were collected from 198 students (67 from the control group, 71 from the conventional teaching and 60 from the VR lessons). The initial number was higher, but we decided to exclude students that did not participate in all lessons (e.g. because of sickness). Their distribution by grade, gender and type of course is shown in table 1.

The analysis of the relevant questionnaires resulted in a grade that represented each student's traffic autonomy in a scale from 1 to 5 (the higher, the more autonomous). As expected, older students and boys are more autonomous (*table 2*). In addition, the older the students are, the greater the difference between boys and girls becomes.

Grade	Gender	Type of course	N
4th	Boy	Control group	16
		Conventional	16
		VR	8
	Girl	Control group	12
		Conventional	13
		VR	13
5th	Boy	Control group	9
		Conventional	9
		VR	11
	Girl	Control group	8
		Conventional	11
		VR	7
6th	Boy	Control group	12
		Conventional	12
		VR	13
	Girl	Control group	10
		Conventional	10
		VR	8

Table 1. Distribution of students by grade, gender and type of course

			Traffic autonomy			
Grade	Gender	N	Min.	Max.	Mean	Std. dev.
4th	Boy	40	1	5	2.793	0.980
	Girl	38	1.25	4.5	2.447	0.872
5th	Boy	29	1.25	4.75	3.137	0.897
	Girl	26	1.25	4.5	2.644	0.778
6th	Boy	37	1.25	5	4.054	0.901
	Girl	28	2	4.75	3.330	0.729

Table 2. Traffic autonomy of students

An 11% of students, do not own or use at home game consoles or computers. On the other hand, all use them either at school (ICT lessons) or at their friends' homes. Boys use game consoles far more than girls do (64% to 36%). On average, students spend around 3 hours every week (mainly at weekends) playing with game consoles, with boys spending an hour more than girls do. There are no significant differences regarding the students' age and the usage of game consoles. The situation with computers is different. Boys and girls use them equally (51.13% to 48.57%) and for the same amount of time. An interesting point is that students use game consoles twice the time they use computers. The most common use of computers is for games (86.4%). Other activities accumulate smaller percentages (e.g. 45.7% for writing and 28.6% for educational uses). The above provide the first clue that students to become accustomed with the application was not a problem, since they were already quite familiar with computer games or game consoles.

The second clue comes from analyzing how much time students needed to master the handling of the Play station's type of controller and how well it was used. Data were obtained through observation (e.g. by taking notes of students' complains and recording how much time elapsed until a student could easily use the controller) and by analyzing the files created by the build-in recording system. Older students, boys and game console users needed less time. If a student was a computer user did not have an impact in how well she/he used the controller, a logical finding since the mouse and the keyboard are usually used in computer games. What is important is that from the third unit and thereafter, neither girls nor younger students had any problems (*figure 5*). The students' interviews also confirmed the above. Only a student reported that it was very difficult to use the controller, while another one reported that she was confused by the position of the controller's levers.

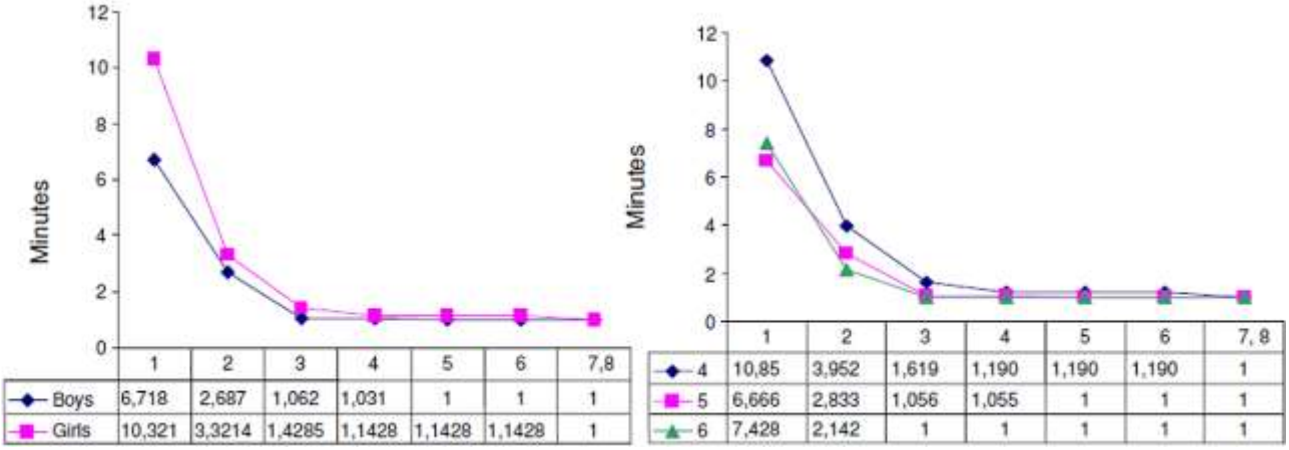

Figure 5. Time needed for mastering the controller

More than half of the students (50%, 55% and 53.3% respectively in each interview) stated that they did not have any problems in understanding and performing the activities in the virtual world. The rest had minor complaints, while none had extreme problems. Observation remarks revealed that the most common cause of problems was that the students did not wait to hear all the audio instructions before performing an activity, which lead to misinterpretations and frustration because they had to repeat the whole process. When they were asked what was "the thing they liked most", the most common spontaneous answer was "everything" (53.3%, 31.7% and 38.3% respectively in each interview). When asked to be more specific, they gave a variety of answers that included almost all the elements of the virtual world. As to what they did not like, the most common answers regarded traffic in the streets (e.g. "cars are running fast", "I can get killed by a car", "there are too many cars and I cannot cross the street", "why some traffic lights are not working?").

A 6.77% of students had the opinion that the virtual world had no resemblance with the real one; a 16.67% considered the resemblance small and the rest (69.89%) characterized the resemblance as high or very high. Only two students had a very negative attitude towards the VR courses, stating that they already know enough about road safety. The rest stated that they learned quite a lot, that they were helped in feeling more secure in the streets and that they already apply some of the things they learned. It is worth mentioning that similar answers were given in the interviews by the conventional teaching students.

In total there were 86 "deaths" in the virtual world at all units, excluding the introductory one. As a variable it is not connected with how well the controller was handled. In addition, it does not correlate with gender with the exception of the last unit where the girls had a comparatively larger number of "deaths" than boys. Generally speaking, the number of "deaths" was small and no useful conclusions can be drawn. Consequently, we believe that the students' virtual accidents can be attributed to their carelessness while crossing the streets. A total of 2,968 street crossings were made from the third to the last unit (the introductory unit and the second which had very few crossings were excluded from the analysis). From these crossings, 2,054 were right (69.2%). The most common mistake was partial checking before crossing (63.24% of wrong cases). All types of right and wrong actions in the virtual world are shown in table 3.

Action	N
Road crossing with/without traffic lights with no mistakes	2054
Passing of an obstacle in the pavement from the inside (from the side of the pavement)	227
Walking on a road without a pavement at the right side of the street	142
Rejection of a crossing point with limited visibility due to an obstacle	128
Selection of the right crossing point when two crossing points were available	64

Crossing a zebra crossing with incomplete check	578
Crossing a zebra crossing without checking at all	116
Crossing a road with traffic lights without checking if cars have stopped	74
Crossing a zebra crossing looking at the wrong direction	74
Selection of the wrong crossing point when two crossing points were available	48
Walking on a road without a pavement at the wrong side of the street	42
Usage of crossing point with limited visibility due to an obstacle	30
Crossing a street at a random point	29
Crossing a road with traffic lights while the pedestrian light was still red	13
Passing of an obstacle in the pavement from the outside (from the side of the road)	0

Table 3. Right and wrong actions at the virtual world

Regarding the right and erroneous actions of students per unit, a constant decrease of the percentage of wrong actions was observed that became more intense in the last unit, despite the fact that this was the most difficult and extensive. In fact, from a very high percentage in the introductory unit, errors drop to 31.79% in the 3rd and to 14.17% in the last unit.

In order to form an opinion on how well collaboration functioned, penalty points were given each time members of a team had problems in working together. Comparison of the final results shows that, in both types of courses, collaboration was smooth ($M_{conventional}$=4.24175, M_{VR}=4.3487, max.=5), and most problems were solved after the first two lessons. The same method was used in determining how interested students were. Again, it seems that the two teaching methods captured the students' interest ($M_{conventional}$=4.43806, M_{VR}=4,8028, max.=5).

The first indication that the two types of courses had different cognitive results came from the analysis of the in-classroom activities and of the students' handbooks. We have to stress out that all the oral, written, in-virtual world and in-classroom activities were not graded on the basis of how well they were done (e.g. how nice a drawing was, how well an essay was written or how well a sketch was presented). Instead, they were graded on the basis of if and to what extend basic road safety concepts were apprehended. Having that in mind, it seems that there are significant differences in the activities and exercises in the students' handbooks ($M_{conventional}$=3.68234, M_{VR}=4.24117, max.=5) and in the in-classroom activities ($M_{conventional}$=3.35387, M_{VR}=4.09792, max.=5).

Cognitive results were also evaluated using video clips and photographs as it was mentioned in the previous chapter. No bonus points were awarded for the right answers, while for the wrong 1, 2, 5 or 10 penalty points were given, depending on the error's seriousness. This kind of point system was applied because children often have the tendency to consider as erroneous a traffic situation, even if there is not really a problem (Lewis, Dunbar, & Hill, 1999). For instance, a number of students thought that pressing the button at a pelican crossing is wrong because by their experience most of these systems do not function. A first glance at the results shows significant differences between the three groups of students ($M_{Control\ group}$=60.10, $M_{Conventional}$=48.25, M_{VR}= 19.03, M_{Total}=43.41). An interesting finding is that for the same type of course boys and girls had the same amount of error points (*table 4*).

Gender	Course type	N	Min.	Max.	Mean	Std. dev.
Boy	Control group	37	15	128	62.59	26.771
	Conventional	37	0	91	48.24	22.797
	VR	32	0	56	18.25	15.616
Girl	Control group	30	0	189	57.03	33.808
	Conventional	34	0	122	48.26	26.659
	VR	28	0	74	19.93	20.461

Table 4. Errors by gender and course type

Statistical Analysis

One way of interpreting the results is to examine one by one all the factors that influenced the errors of students. Applying one-way ANOVA analysis, a common statistical procedure in the social sciences, it seems that there is a significant correlation between the number of errors made at the post-courses evaluation (the evaluation with video clips and a photo album) and the type of course (control group, conventional and VR) or between the number of errors and the students' age, while gender is not a factor. However, by comparing one factor each time with the results of the evaluation, it is not taken into consideration the impact of other factors. Therefore, a multiple regression model was formed to help to identify the relationship between several independent/predictor variables and the dependent variable (the results of the students' post-courses evaluation). The independent variables we used were: the student's age, gender, the degree of "traffic autonomy", elements of the psychological-intellectual profile (e.g. curiosity, self-confidence, eagerness, critical thinking) and finally the type of course. Stepwise regression analysis was used that lead to the factors that were significant.

The coefficient of determination (0.658) and the adjusted coefficient of determination (0.638) show that the model can explain around 65% of the dependent's variable (*table 5*). This percentage is high, especially in the case where categorical variables are used as explanatory factors as in our case (Montgomery, 1976). The Durbin-Watson test used to detect the presence of autocorrelation in the residuals from the regression analysis, produces a value very close to 2 (1.984), therefore it is safe to use the model for drawing conclusions.

R	R Square	Adjusted R Square	Durbin-Watson
0.811	0.658	0.638	1.984

Table 5. R Square, Adjusted R Square and Durbin-Watson test of the post-courses evaluation model

The independent variables that were included in the model are presented in table 6. By far, the most important factor in reducing the number of errors made in post-courses evaluation is considered to be teaching using the VR application. There is also a reduction in the number of errors when a student has good oral expression, is persistent and eager. At this point one has to make clear that characterizing a student's personality is a subjective matter and allows for various interpretations. A schoolteacher might judge a student not only by what he observes but also by his personal views and opinions. Thus, "eagerness" can be interpreted as willingness in helping others, but also as a zeal for learning. Respectively, "insistence" might be the tendency of a child not to be discouraged easily or an inclination to work with attention until difficulties are overcome.

	B	Std. Error	t	Sig.
VR courses	-24.712	3.736	-6.615	.000
Good oral expression	-7.416	2.457	-3.018	.003
Insistence	-4.208	1.888	-2.228	.029
Eagerness	-6.895	2.176	-3.169	.002
$M_{Control\ group}$=60,10, $M_{Conventional}$=48,25, M_{VR}= 19,03, M_{Total}=43,41				

Table 6. Factors that influenced the results in students' of the post-courses evaluation

Conventional teaching was not included as a statistically important factor. Therefore, it can be assumed that conventional teaching does not influence the evaluation of students, positively or negatively. The same applies for the control group. The students' age, gender and traffic autonomy were also absent from the model.

Various exercises in the students' handbooks, as well as in-classroom activities were used for evaluation purposes. Consequently, we examined whether the two types of courses had any statistically important impact in the evaluation outcomes of the handbooks and the in-classroom activities. The same method was used as in the post-courses evaluation, using the same independent variables. The coefficients of determination and the adjusted coefficients of determination show that the models can explain pretty much (around 50-60%) the variability of the dependent variables (*table 7*).

Model	R	R Square	Adjusted R Square
Handbook evaluation	0.799	0.639	0.621
In-classroom activities evaluation	0.712	0.507	0.487

Table 7. R Square and Adjusted R Square of the handbooks and in-classroom activities evaluation models

Handbook evaluation results were better when students had attended the VR courses. Boys and students with a good record in science subjects also had better results, while younger students (of 4th and 5th grade) had worst (*table 8*). It seems that the various exercises in the handbooks needed to be better adjusted to these ages.

	B	Std. Error	t	Sig.
VR courses	0.553	0.053	10.417	0.000
4th grade	-0.564	0.063	-8.930	0.000
Gender (boys)	0.157	0.054	2.923	0.004
Good in science lessons	0.108	0.026	4.191	0.000
5th grade	-0.176	0.067	-2.619	0.010
$M_{conventional}$=3,68234, M_{VR}=4,24117, max.=5				

Table 8. Factors that influenced the results in students' handbooks evaluation

As for the in-classroom activities, once again the VR courses lead to better results. Students well adapted in school environment, with a good record in science and theoretical subjects, also had good results (*table 9*). An interesting element is that students who are good in written expression did not produce equally well results. One has to keep in mind that these activities did not involve writing to a great extend, since they were theatrical sketches, presentation of subjects, debates and drawings. It is possible that students that are not so good in written expression had the chance to show virtues that are usually outshined by the importance teachers attribute to written expression.

	B	Std. Error	t	Sig.
VR courses	0.814	0.098	8.282	0.000
Well adapted in school environment	0.236	0.061	3.880	0.000
Good in theoretical subjects	0.265	0.082	3.231	0.002
Good in writing	-0.317	0.077	-4.106	0.000
Good in science subjects	0.189	0.079	2.382	0.019
$M_{conventional}$=3,35387, M_{VR}=4,09792, max.=5				

Table 9. Factors that influenced the results in the in-classroom activities evaluation

Since the VR courses were the critical factor in having better results in both students' handbooks and in-classroom activities, we believe that they also had an impact in meta-cognitive level. All the "exercises" were not like the standardized and somewhat mechanistic ones students are used to. They required comprehension and assimilation of the initial knowledge, critical thinking and application of this knowledge in a similar or in a totally different field. A characteristic example is an activity at the traffic signs unit. Students were asked to draw their own imaginary and humorous traffic sign. They had to understand the meaning and the rules that govern traffic signs (color and shape) and think of something original that follows these rules (without having been told to do so). This activity was executed much better by the students that attended the VR courses.

As mentioned in a previous chapter, students made in the VR world roughly 3,000 street crossings, most of them being two-way ones. For each crossing and for each student, the number of times traffic was checked and the type of "traffic gap" selected for crossing were recorded. Traffic gaps were placed in the following categories: i) below 6 seconds (unsafe crossing), ii) 6-8 seconds (marginally safe crossing), iii) 8-10 seconds (safe crossing) and iv) above 10 seconds (hesitant crossing). The above resulted in the following variables:

1. Times of checking before crossing a street
2. Ratio of <6" crossings to the total number of crossings

3. Ratio of 6-8" crossings to the total number of crossings
4. Ratio of 8-10" crossings to the total number of crossings
5. Ratio of >10" crossings to the total number of crossings

One can make the hypothesis that these variables are influenced by the knowledge and dexterities of children (e.g. traffic autonomy), the age and their sex. On the other hand, one might think that these variables depend on the students' experience in using game consoles and computers, since the application resembles a computer game. Tables 10 to 14 present the variables.

Grade/Age		Times of checking before crossing	<6 sec	6-8 sec	8-10 sec	>10 sec
4th	Mean	2.76962	0.0729	0.1530	0.6255	0.1524
5th	Mean	2.10407	0.0881	0.1525	0.6409	0.1191
6th	Mean	1.58841	0.1145	0.2559	0.5529	0.0772

Table 10. Crossings in relation to age

Gender		Times of checking before crossing	< 6 sec	6-8 sec	8-10 sec	>10 sec
Boy	Mean	1.87977	0.0817	0.2212	0.5951	0.1042
Girl	Mean	2.47283	0.1038	0.1519	0.6156	0.1297

Table 11. Crossings in relation to gender

Game console		Times of checking before crossing	<6 sec	6-8 sec	8-10 sec	>10 sec
No	Mean	2.39133	0.0841	0.1958	0.6234	0.0977
Yes	Mean	1.98882	0.0976	0.1839	0.5913	0.1293

Table 12. Crossings in relation to usage of game consoles

Computer		Times of checking before crossing	< 6 sec	6-8 sec	8-10 sec	>10 sec
No	Mean	2.02779	0.0633	0.1864	0.6400	0.1112
Yes	Mean	2.21620	0.1053	0.1900	0.5883	0.1184

Table 13. Crossings in relation to usage of computers

Instructive unit		Times of checking before crossing	< 6 sec	6-8 sec	8-10 sec	>10 sec
3	Mean	2.35050	0.1102	0.1852	0.4058	0.2988
4	Mean	2.24252	0.1025	0.184	0.4491	0.2644
5	Mean	2.11458	0.1031	0.1803	0.5012	0.2154
6	Mean	2.05460	0.1005	0.1932	0.5519	0.1545
7	Mean	2.17983	0.1123	0.2023	0.6002	0.0853
8	Mean	2.23517	0.0632	0.1685	0.6598	0.1085

Table 14. Crossings in relation to instructive units

In order to find out which factors play an important role, a generalized linear model was applied having as dependent variables the ones that measured crossing time and times of checking and as independent variables the grade/age, the gender, if students use game consoles, if they use computers, their traffic autonomy and the instructive units (3rd to 8th). Scatter plots revealed that traffic autonomy did not have any form of cross-correlation (linear or not-linear) with the under review dependent variables, therefore it was excluded from the analysis. Tables 15-19 show the results of the generalized linear model for the statistically important factors.

	Type III Sum of squares	df	Mean square	F	Sig.
Grade/Age	34.037	2	17.019	12.363	0.000

Table 15. Factors that influence times of checking before crossing

	Type III Sum of squares	df	Mean square	F	Sig.
Computer	0.081	1	0.081	3.952	0.048

Table 16. Factors that influence crossings <6"

	Type III Sum of squares	df	Mean square	F	Sig.
Grade/Age	0.382	2	0.191	7.864	0.001
Gender	0.198	1	0.198	8.139	0.005

Table 17. Factors that influence crossings 6-8"

	Type III Sum of squares	df	Mean square	F	Sig.
Grade/Age	0.411	2	0.206	5.223	0.006
Computer	0.190	1	0.190	4.816	0.030
Instructive unit	0.350	5	0.175	4.446	0.013

Table 18. Factors that influence crossings 8-10"

	Type III Sum of squares	df	Mean square	F	Sig.
Grade/Age	0.156	2	0.078	3.493	0.033
Instructive unit	0.149	5	0.074	3.321	0.038

Table 19. Factors that influence crossings >10"

The most important parameter was the crossings between 8 -10 seconds that were the ideal. As it was observed, older students and the ones that use computers, made statistically fewer crossings within this time range. However, unit by unit, a statistically important increase in "right" time crossings was noted. Girls made fewer marginal crossings (6-8"), while older students made more. As for the unsafe crossings (<6"), computer users made more (although marginally). Hesitant crossings were influenced by the students' age and the instructive unit (decreasing while age and unit increased). Finally, the students' age affected the times of checking before crossing (older students checked fewer times). The usage of game consoles did not affect any of the dependent variables, which is a positive finding, given the great resemblance of the application with computer games. On the other hand, computer usage seems to have a negative influence, leading to more unsafe crossings and less "right" ones.

A generalized linear model was also applied for checking whether errors made in the virtual world (expressed as the ratio of the number of errors to the total number of crossings) were affected by the independent variables used for analyzing crossings. As previously, traffic autonomy was not included in the analysis because once again scatter plots showed that it does not have any form of cross-correlation with the dependent variables. Table 20 presents the variables and table 21 presents the results of the model.

Grade/Age	Mean	Std. dev.
4th	0.2393	0.14352
5th	0.2742	0.18574
6th	0.1903	0.12645
Game consoles	**Mean**	**Std. dev.**
No	0.2129	0.12845
Yes	0.2467	0.17100

Gender	Mean	Std. dev.
Boy	0.2082	0.14345
Girl	0.2606	0.16405

Computers	Mean	Std. dev.
No	0.2364	0.15830
Yes	0.2018	0.15435

Instructive unit	Mean	Std. dev.
3	0.3179	0.1578
4	0.2704	0.1626
5	0.2437	0.15389
6	0.2034	0.15871
7	0.1738	0.16307
8	0.1416	0.06927

Table 20.Errors in the virtual world in relation to age, gender, usage of game consoles-computers and instructive unit

	Type III Sum of Squares	df	Mean Square	F	Sig.
Grade/Age	0.249	2	0.125	7.025	0.001
Gender	0.258	1	0.258	14.547	0.000
Consoles	0.156	1	0.156	8.769	0.003
Computer	0.095	1	0.095	5.324	0.022
Instructive unit	1.029	5	0.343	19.325	0.000

Table 21. Factors that influence errors in the virtual world

All the under review factors played an important role in the errors that students made when crossing the streets of the virtual world. Computer users made fewer errors. However, those that play with game consoles made more. This result is not contradictory. Game consoles are used exclusively for games. It is possible that students considered street crossing as another form of game, despite the fact that game console usage did not seem to influence crossing times. Nevertheless, one has to remember that neither game consoles nor computers played an important role in all forms of students' evaluation. The same observations hold true for the students' gender and age. Girls made more errors and older students less.

By combining the results of the statistical analysis, various profiles of the students that used the application can be outlined. An older student is expected to check fewer times before crossing, will take less time in crossing a street, will not hesitate, will make more marginal crossings and consequently will make less "right" time crossings, but eventually will make fewer mistakes. Precisely the opposite is expected from a younger student. Girls are more careful than boys regarding marginal crossings, but make more mistakes. Students that play with game consoles will make more errors and the ones that use computers will make less "right" time crossings, but will make fewer errors (in comparison to game console users). We cannot come to a definite conclusion whether the use of these electronic appliances affected negatively or positively. What is certain is that during the application's implementation there was a constant improvement of all the critical factors.

CONCLUSION

Greece is among the E.U. countries with a very high number of deaths and injuries due to traffic accidents, in proportion to its population. Certainly there is the need for educational intervention. Conventional road safety programs well organized and with reasonable results do exist, but are inapplicable because of long duration, small numbers of pupils that can participate, or the requirement of special infrastructure. The luxury for the above is not affordable. The principal idea of the present work was to investigate for a solution that is fast, easy to apply and effective. Also, the basic assumption was that the use of virtual reality for teaching road safety can produce better cognitive results and develop the necessary skills better than conventional teaching. In favor to this assumption were findings the most important of which are listed below:

Technical issues concerning the VR application

1. The application is compatible with the knowledge and dexterities students already have by using game consoles or computers.
2. The time taken for learning the controls of the application and becoming familiarized with it, sharply dropped from the first to the second session. Girls and students of the fourth grade had the greatest difficulties. From the third lesson and thereafter there were no problems.
3. More than half of the students reported that they had no problems in using the interactive system that provided the cognitive elements and guidelines and in comprehending the various activities. The rest reported minor problems at the first two units, because they did not listen to the entire audio instructions before proceeding.
4. The "presence" of students in the virtual world was active, meaning that they participated with enthusiasm in all activities.
5. Around 70% of students described the virtual world as having high or very high resemblance with the real one.
6. The application proved to be exceptionally stable and no crashes or problems were reported.
7. Replacement of the computers' graphics cards was needed for the application to run. The total cost of 1300€ (including the earphones and controllers) is considered well within the capacity of the school's budget.

General Issues concerning the VR application

1. The most common answer in the interviews (nearly 40%) was that students liked everything in the VR world. The elements that were not appealing were the difficulties students faced in the streets such as some traffic lights that were not functioning (on purpose), the high speed of a number of cars and those cars that could "kill". These were important teaching elements for the purpose of the application.
2. The errors in crossing the virtual streets from a very high percentage in the first unit, dropped to 30% in the third and to 14% in the last.
3. More than half of the errors in crossing were there partial/incomplete checking of the traffic. Only 5.32% of crossings were made without checking. At this point the present work differs considerably from the findings of previous studies that indicate that 25-50% of crossings are made without checking (Thomson, Tolmie, & McLaren, 1996; Tolmie, Thomson, & Foot, 2002).
4. Besides crossing streets, there were other situations a pedestrian might face. Students did not make errors in handling obstacles at the pavement (e.g. cars parked vertically). When students had to choose between two nearby crossing points where one of them had a problem, 57% made the right choice. On 80% of the situations that presented obstacles in visibility when crossing (e.g. advertisement boards and parked cars) and streets with no pavements, the pupils behaved correctly.
5. The analysis of the errors made in the virtual world reveals that boys and the older students made fewer errors. There is no cross-correlation with the traffic autonomy of a child. This means that students with small autonomy (no rich experience in crossing real streets) were profited by the courses, together with students with enough autonomy, that probably knew how to use the streets but initially made mistakes.
6. Game consoles seem to have a negative influence. Students that use them often, made more mistakes and this is an indication that the application was considered a form of a game. What is puzzling is the fact that students who use computers often, made fewer crossing errors, but also made fewer "right" time crossings. In any case, it would be very difficult for a desktop VR application not to be affected by the perceptions game consoles and computer games impose to children.
7. Older students checked fewer times and were bolder in the virtual streets by making many marginal crossings. This fact was more or less expected, since they are more confident and experienced than the younger ones. This was verified by the hesitant crossings (e.g. checking many times or waiting for a large traffic gap), where the younger children made more. As expected, girls

were more careful than boys, making less marginal crossings, but eventually made more mistakes. The above match the findings of studies regarding the behavior of children in real streets (Ampofo, & Thomson, 1990; Molen, 1981; Tolmie, & Thomson, 2002). This allows us to conclude that the students transferred in the virtual streets elements of their behavior in the real ones.

Comparison between the Two Types of Courses and Factors Influencing the Results

How well collaboration functioned during the in-classroom activities was not influenced by either type of courses. "Guided collaboration" is suitable for both course types. However, more time was needed in the VR courses for students to get accustomed to this form of teaching.

1. Almost all students in their interviews stated that they were considerably helped and that they already apply in the real streets what they have learned. Similar were the answers of the students that participated in conventional teaching.
2. The role of the schoolteacher was considerably different in the VR courses. He was able to provide individualized assistance, but on the other hand it was more difficult to get the attention of a student or a group of students because of the earphones they were wearing.
3. Students faced both courses with particular joy and enthusiasm. The students' interest was also very high.
4. Teaching with the use of the VR application resulted in significantly less errors in all forms of evaluation compared to conventional teaching.
5. Since conventional teaching was not included as a statistically important factor in any case, we can assume that this form of teaching had neither positive nor negative influence in the evaluation. This means that, students in conventional teaching are not expected to make either more nor fewer errors after the lessons.
6. The pupils' age, gender and traffic autonomy were not statistically important in the evaluation.
7. Factors of a student's idiosyncrasy/characteristics that played a statistically important role in the reduction of errors or in having better results in the in-classroom activities and in the handbooks were insistence, eagerness, good record in science lessons and good oral expression. In any case, the weight of the positive influence these factors had was -by far- less than teaching with the VR application.
8. The answers of the exercises that were included in the students' handbooks were more "complete" and thorough in the VR courses. The same applied for the in-classroom activities. Taking into account that the exercises, as well as the activities, required comprehension and assimilation of the initial knowledge, it can be said that the VR courses had an impact in meta-cognitive level, something that the conventional teaching accomplished in a lesser degree.

Other Issues

1. The program was put into operation for the last three grades of primary school. The timetable of the last three grades had to be changed to schedule the VR lessons. The reason was the small number of computers in the school labs, which necessitated in splitting each grade in groups so that each person could work on one computer.
2. The research focused on students. Though data concerning teachers' reactions were not recorded, our sense is that teachers, as well as students, wish the general teaching framework to be changed. The effervescent interest of schoolteachers for the VR courses was the first indication. The fact that they accepted the upset in their program for two months was a second.
3. Cost-effectiveness. In terms of economic cost for the implementation of a project such as this, one can point out that it is well within the school's budget. In terms of cost for developing the application, one can use freeware or open source software, but a lot working-hours are needed in order to produce a complete and versatile end-product, including the accompanying printed material.

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KEY TERMS & DEFINITIONS

3D game: An electronic game that simulates a three dimensional environment and involves interaction with a user interface to generate visual feedback on a video device. The electronic systems used to play 3D games and video games in general, are known as platforms (computers and video game consoles).

Constructivism: A psychological theory of knowledge which argues that humans generate knowledge and meaning from their experiences. Constructivism although not a specific pedagogy, is an underlying theme of many education reform movements

First/third person view. The viewpoint the user has of the virtual world. It involves the use of an imaginary camera. When this camera is placed in front of the user's representation (avatar) and at the height of his head, first person view is achieved. When the camera is placed behind and above the user's avatar, third person view is achieved.

Game editor: A software tool used for the creation or modification of games. Can be either platform depended or not. It can also be game specific (allowing the alteration of a specific game, in-game editor), or not (allowing the creation of a variety of games).

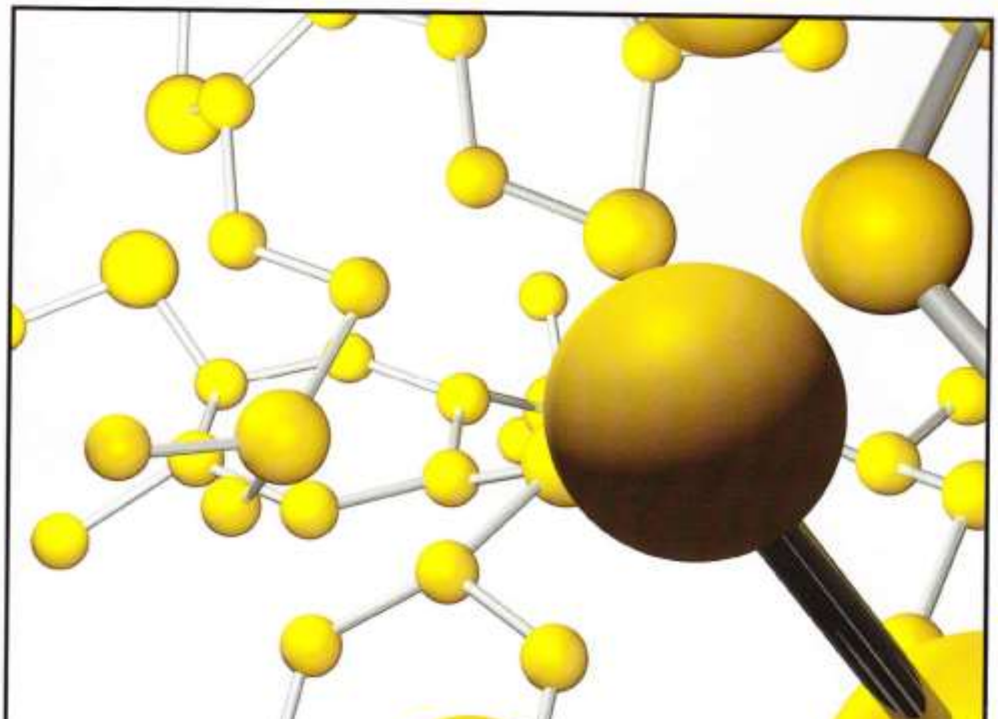
Road safety education: An educational framework that provides an opportunity for achieving an improvement in behavior of pedestrians and drivers, change and reduction in road trauma (especially for children and young people).

Trigger: An entity in the virtual world, associated with entities, models or other triggers. By setting its attributes, the developer determines when it is triggered (i.e. by the collision of the user with an object). Its triggering allows the materialization of simple or complex events.

Virtual Reality: A technology which allows a user to interact with a computer-simulated environment, whether this environment is a simulation of the real world or an imaginary world.

PREMIER REFERENCE SOURCE

Cases on Technology Enhanced Learning through Collaborative Opportunities



SIRAN MUKERJI & PURNENDU TRIPATHI

This case by Francis and Douglas looks into the effective use of blogging for teacher for a course in English as a Second Language (ESL) using discourse to explore how teacher candidates use and perceive blogs within a course on ESL teaching methods.

This case study attempts to investigate the use of synchronous audiographic web conferencing (Elluminate) as a learning and teaching tool at the two Australian regional universities and compares the issues and challenges relating to software trials in educational environments and provides recommendations for others who may be considering the adoption of similar technologies

It is an action research case study describing a successful marketing effort for a Blended University Program to recruit prospective graduate students from a culturally diverse urban and suburban adult non-traditional population.

The need to educate instructors, lecturers and teachers in how to integrate technology into education has been duly emphasized globally, leading to initiatives taken by quite a few higher education institutions by introducing professional development programmes in educational technology to ensure that technology is effectively utilised so as to enhance the quality of the educational practices. This case study portrays the implementation component of the e-TUTO programme in Tshwane University of Technology, South Africa.

This case by Emmanuel and Costas portrays issue of road safety education through desktop virtual mode using a 3D video game tested by the students of the last three grades of a primary school in Athens. It