Virtual Reality in Education: A Theoretical Approach for Road Safety Training to Students

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Abstracts

English

The unsystematic way Road Safety is taught in Greece's primary schools led us to reassess the teaching framework of the subject, examining ways in which Information and Communication Technologies (ICT) might provide solutions that are more efficient. Among the various technologies considered, Virtual Reality (VR) seems to amass a number of interesting characteristics. The article discusses, from a theoretical and cognitive perspective, the advantages and disadvantages of the use of VR in Road Safety Education, in comparison to the conventional and ICT based alternatives. It is concluded that VR can be a serious tool of use in road safety education if some parameters are met.

Greek

Ο μη συστηματικός τρόπος με τον οποίο προσεγγίζεται η Κυκλοφοριακή Αγωγή στα δημοτικά σχολεία της Ελλάδας, αποτέλεσε την αιτία για μια προσπάθεια επαναπροσδιορισμού της μεθοδολογίας με την οποία διδάσκεται το θέμα αυτό, με κύρια εστίαση στη δυνατότητα των Τεχνολογιών της Πληροφορίας και της Επικοινωνίας (ΤΠΕ) να προσφέρουν αποδοτικές λύσεις. Το άρθρο πραγματεύεται από θεωρητική και γνωστική οπτική τα πλεονεκτήματα και τα μειονεκτήματα της χρήσης της Εικονικής Πραγματικότητας (ΕΠ) στην Κυκλοφοριακή Αγωγή, συγκριτικά με συμβατικές προσεγγίσεις και άλλες λύσεις οι οποίες βασίζονται σε διαφορετικές εφαρμογές των ΤΠΕ. Κύριο συμπέρασμα είναι ότι, εφ' όσον τηρηθούν κάποιες προϋποθέσεις, η ΕΠ μπορεί να αποτελέσει αποτελεσματικό εργαλείο στην Κυκλοφοριακή Αγωγή.

Keywords

Constructivism, Road Safety Education, Simulation, Virtual Reality

List of topics

Introduction

Greece is among the countries with a large number of traffic related accidents in proportion to its population. Although nowadays there is a slight decline in the number of these accidents compared to previous years -mainly due to constant traffic inspections and harsh safety measures- statistical data overwhelmingly indicates that traffic accidents are an urgent problem. According to 2007's data, there were 14,626 incidents with 1,449 deaths and 18,223 light or seriousinjuries (Ministry of Public Order, 2007) in a population of around 11 million and the total cost of these incidents is around 3 billion euros each year (4Weels Magazine, 2004). Most of these accidents occur due to human error and can be attributed to the aggressive and irresponsible behaviour of Greek drivers. It is quite safe to assume that most accidents could be avoided if drivers, pedestrians and passengers were better trained and more responsible, in other words if they had a well-developed traffic culture.

Traffic culture refers to all the skills, attitudes, knowledge, and good practices that a person needs in order to be safe in the traffic environment. In the long run, prevention is always better than the treatment of a problem, so the solution to the problem of traffic accidents depends on the development of traffic culture as early in one's life as possible. Therefore, Road Safety Education in primary school can be very significant. Unfortunately, in Greece, this is a neglected subject, taught in a non-systematic way. It is obvious that the whole teaching framework of Road Safety Education needs to be reassessed.

Considering the means that can be applied for teaching Road Safety, one soon faces the constant changes in the ways we view knowledge acquisition and teaching methodologies accordingly. Information and Communication technologies (ICT) contribute a lot in the formation and materialisation of new beliefs. Among ICT innovations, VR is regarded as a promising technology that has a substantial -though not yet fully realised- potential. We decided to explore this potential, thus making VR the focal point of our efforts. Nevertheless, the use of VR in Road Safety Education raises a number of issues concerning both the theoretical and the technical aspects of the matter, that need to be clarified. The main questions that have to be answered are: (i) whether VR has clear advantages compared to other conventional ICT supported teaching methods and (ii) what are the possible negative aspects. These are analysed in the following sections.

Road Safety Education: Providing the skills

It is obvious that students need to know the rules that govern traffic. They also have to apply this knowledge in real conditions and for that reason; they need a set of skills. They also need to utilize these skills in diverse ways depending on traffic conditions, in other words to use different strategies. Because most of the skills in question develop through time, children are at a disadvantaged position compared to adults. According to a thorough study regarding Road Safety Education (Thomson et al., 1996), the most important skills needed for someone to be safe in the streets are:

- Detecting the presence of traffic. It seems that children cross streets without properly checking traffic at a percentage that varies but is always significant (Molen, 1981) and can rise up to 50% (Scottish Development Department, 1989). There is a similar problem with children checking in only one direction or not in all directions in the case of crossroads. There is an issue in that children do not comprehend what their teachers mean when they say 'look before crossing' and that they simply follow a ritual of moving their heads left and right. They act impulsively, their attention is easily distracted, they focus on some attributes of traffic at the expense of others and their visual search strategies are inadequate (Thomson et al., 1996).
- Co-ordinating information from different directions. Vehicles usually come from two, three or more directions simultaneously. Consequently, attention has to be divided in each direction. Next, information is processed and almost instantaneously the decision for crossing (or not) the street must be made. Therefore, short-term memory and information processing speed are crucial. Response time is age related, with significant changes occurring between the ages of 6-12. For example, a five-year-old child needs five times more time to react in a stimulus than a seventeen-year-old teenager (Surwillo, 1977).

Visual timing judgements are made by coordinating perception and action. After the detection of traffic, a number of judgments will take place. It must be decided if a vehicle is moving, if it is approaching, how fast, how much time is needed before its trajectory is intersected with that of the pedestrian. Dense traffic makes the control of the above parameters more difficult. In addition, when the pedestrian is crossing the street, the distance that he has to travel and his speed are also variables in the complex equation of calculating safe-to-cross 'gaps' in traffic. The ability to accurately calculate distance and speed is a skill that reaches near adult levels around the age of eleven (Lee et al., 1984).

One might expect that since children lack skills, the main objective of Road Safety Education would be acquisition of training skills rather than knowledge acquisition. Unfortunately, this is not the case. The teaching of Road Safety is conducted within the boundaries of a classroom and almost exclusively by verbal or written means. To make things even worst, Road Safety Education in each grade is just one chapter in Environmental Education consisting of few pages, which is limiting the amount of time that can be allocated for the subject. Furthermore, teachers' handbooks give vague guidelines on how to teach Road Safety. For example, teachers are advised to use the photographs and the drawings of the schoolbooks as a starting point for their teaching (Georgokostas et al., 1996), but what to teach, how much time to allocate to the subject and how to teach this subject is not covered. They are urged to use additional instructive material (Kazazi-Patinioti et al., 1996), but none is suggested. It is also recommended that instruction take place under real traffic conditions and that teachers should take advantage of any chance to do so (i.e. during an educational excursion) (Georgokostas et al., 1993). However, in reality children will rarely have the opportunity to indulge in real traffic conditions under supervision and in an educational environment, apart from a few possible hours in a parking lot, throughout their entire six year elementary education.

After all, one has to ask if classroom instruction is adequate for teaching Road Safety. Studies have proved that verbal teaching and printed material are poor ways to do so. Childrens' knowledge may improve, but that does not mean that there are behavioural changes regarding Road Safety (Ampofo-Boateng & Thomson, 1990). Moreover, knowledge can be a misleading factor. For instance, children with poor traffic performance exhibited good knowledge on Road Safety issues (Ryhammer & Berglund, 1980). Furthermore, among in-classroom teaching techniques, the use of films and video can lead to a behavioural improvement, especially when children see their own road behaviour, yet still on a limited level (Valavuo, 1976). It seems that in-classroom teaching is such an ineffective method that it is like trying to teach basketball to a group of students without ever letting them touch the ball.

On the other hand, there are a number of outdoor teaching procedures that try to simulate a real traffic environment. By doing so and by allowing active participation of students, part or all of the necessary skills are developed, leading to behavioural changes. The essential element in these procedures is how well the real traffic environment is simulated. The better the simulation is, the better the results. For example, training in streets close to traffic produces better results than training in the schoolyard or in a traffic park (Sandels, 1975). The 'pretend road' method (Young & Lee, 1987), a hypothetical road parallel to a real one, where children observe traffic of a real road, but cross the pretended one, improved visual timing judgements and the coordination of perception and action. On the negative side, since the 'pretend road' is parallel to the real one, students do not have a direct feeling and perception of the traffic and do not act exactly as they would on a real road. Variations of the 'pretend road', such as having the children stand at the kerb of a real road making judgements when to cross but not actually crossing (Demetre et al., 1993), produced similarly interesting results.

Road Safety Education depends heavily in the development of motor skills, perception and time judgements, thus training in conditions as close to real traffic as possible seems to be probably the only effective teaching method available.

Teaching Road Safety using computer applications

A substantial amount of Road Safety teaching material consists of multimedia and hypermedia applications. What is easily ascertained is that almost all of them focus on knowledge acquisition. Very few include some form of road simulation (i.e. Renault Auto Industries; Department for Transport; Scottish Road Safety Campaign, 2002), even so, children's active participation is limited. In general, these applications present traffic situations with the use of static or animated graphics and ask children to make judgments about what to do next, if there is something wrong, what should have been done and so on. Even if this can be considered as a form of training in detecting dangerous situations, it does not train any of the crucial pedestrian skills.

Yet, two research projects came to our attention that used computers for training specific skills.

The first one investigated the problem of distraction in children's attention and how audiovisual search strategies can be applied to help in partially solving this problem. This was achieved by using videos of real traffic scenes, a multimedia application that simulated 24 traffic scenes and roadside tests (Tolmie et al., 1998). As it is noted in the results of the study, '...Perhaps the most striking point to emerge from the study is the hard evidence that training children in pedestrian skills via problem based computer simulations (i.e.

under circumstances which are both practicable and safe) has the potential to produce real benefits at the roadside. What is significant is that the effects were systematic, and provide clear indications as to how interventions might be designed to increase their effectiveness...'

The second research project examined how the pedestrian skills of *safe place finding, roadside search,gap timing and perception of others' intentions can be improved (*Tolmie et al., 2002). *Training in each of the above skills was a separate module of the application, with four training sessions in each one. All modules* shared the same small town setting and a common cast of characters to emphasise the relationship between the skills. The activities in each training session were about making decisions on if, when or how the character that represented the child in the application should cross the street. When a decision was made, the character crossed the street and the computer demonstrated the consequences of that decision. Testing was carried out at the roadside in order to evaluate the effects of training on actual behaviour.

The results of the project are quite important. Simulation training resulted in significant conceptual and behavioural changes in all the examined skills. The only exception was in the group of 6-year-old children and only for the skill of *safe place finding.* Despite the significant improvements, the level of the skills did not reach that of the adults. Children became more autonomous and more efficient but still in need of an adult's supervision. Another interesting outcome was that none of the skills trained with the simulation proved to be too hard to learn for younger children or too easy to grasp for the older ones. Therefore, computer simulations can be used in a wide range of ages. Although it is noted that simulations cannot be considered as the only training resource but can be used in conjunction with training in real streets, the research team draws attention to a key point: '... Simulations permit the practise of skills which could not really be addressed at the roadside because of the difficulty of setting up the right conditions' (Tolmie et al., 2002).

Virtual Reality

Almost every computer application regarding Road Safety depends on the use of two-dimensional (2D) graphics. If we introduce a third dimension in these applications, in other words if we use 3D graphics, we enter the realm of another computer technology, called Virtual Reality. The term is subject to various interpretations and definitions and has prevailed over some other terms such as 'Synthetic Environment', 'Cyberspace', 'Artificial Reality', 'Simulation Technology' (Samir, 1998). VR is the sum of hardware and software, which enables the visualisation and interaction with data. Visualisation means the capability of computers to give users visual, auditory and other stimuli from a world inside the computer. Users can interact with this world and directly handle the objects it includes (Wolf-D, 1997).

Taking into account the human factor, one could say that VR is a situation created in the mind that can, with varying success, hold humans' attention in a way similar to that of the natural environment. The equipment used contributes to the creation of such a situation (Macpherson & Keppell, 1998). In brief, VR is not simply a new form of computer technology. It is an intellectual situation where the subject-user is immersed -partly or totally- in an artificial environment, which can be closely similar to, or vastly different from reality. From a psychological perspective, VR is a perceptual tool that enables users to feel 'present' in an artificial environment the same way they feel present in a real environment. This artificial environment responds to movements and other data input from the user (Chou et al., 1997). Cognitively speaking, the user has the conviction that the virtual world is sound, though different from the real one (Bricken, 1990). The same thing happens when we watch a movie: we know that what we see is not real, yet we emotionally participate as if it was.

Virtual Reality, symbols and the notion of experience

The two research applications presented in the previous chapter derive their theoretical background mainly from the theory of constructivism as it was shaped by Piaget and Vygotsky (Tolmie et al., 1998; Tolmie et al., 2002). This is a common place for multimedia and hypermedia applications, because ideas of constructivism are easily realised. A basic attribute of multimedia and hypermedia applications that renders them compatible with the theory of constructivism is that they allow non-linear access to the content, thus leaving students free to select their course. In general, the main characteristics of a constructivist teaching approach -computer based or otherwise- as noted by Jonassen (1994) are:

- It offers multiple and complex presentations of reality, avoiding simplifications.
- It engages students with authentic tasks.
- It helps knowledge to be constructed in relation to its content.
- It encourages practices based in reflection.
- It supports collaborative learning instead of competition amongst students.

VR applications encapsulate all the features of multimedia; hence, they also have close relationship with constructivism. However, VR holds a significant advantage over multimedia applications: it can present vastly more complex and realistic presentations of reality. The basis for this attribute is mainly technological, but from a cognitive perspective this happens because VR offers a specific type of experience and does not require the use of symbols (Winn, 1993).

It is worth analyzing this assertion. First we have to indicate the value of an experience. The experience (virtual or real) with which an idea or a portion of knowledge is associated is important for the comprehension of the idea/portion of knowledge as much as for the use of it (Jonassen, 1992). The experience is the 'vehicle' for the construction of knowledge. Secondly, we have to point out the role of symbols. Cognitive theories in general perceive the human brain as a computer whose basic operation is the intellectual handling of symbols (Siegler, 1983; Johnson-Laird, 1988). From a certain point of view, knowledge is nothing more than the efficient handling of symbols. The problem with this cognitive view is that it does not completely explain all the logical processes, nor the way we handle situations where there is no use of symbols.

As Winn points out, we get to know the world in two ways, from first person and third person experiences (Winn, 1993). The former are derived from everyday contact with the surrounding world; they are direct, personal and subjective, in a way 'silent' because we do not realize we have learnt something and they do not require the use of any symbols. The latter are derived from someone else's descriptions, they are indirect and we always realize that we have learnt something because someone taught us. In order r communication between the person that explains and the person that learns to be possible, symbols, such as language, letters and numbers are necessary. For example, first person experiences are what we feel and think when we watch a film. We have third person experiences when someone else explains to us the plot of the film, what the actors did and so on.

First person experiences do not require any particular thoughts by the person. In reality, this is the way we face most actions in our everyday lives. We do not plan beforehand the way we wash, dress, eat or sleep. We simply take action that stems directly from the perception we have about the world, without the intervention of immediate conscious thinking. A second important element that emerges from the above film paradigm is that first person experiences are more 'whole' than their counterpart is. Too much meaning, too much useful data is lost when a third party tries to communicate to us complex ideas, concepts or situations. It is much better 'seeing something with your own eyes', than having a faint/incomplete description of it. First person experiences give the opportunity to the learner to instinctively apprehend an idea/portion of knowledge, without the use of symbolic representations.

Computers offer third person experiences mainly because information contained in them is not directly accessible, but is accessed through the interface. In essence, the interface is the means of communication between the computer and the user through the operating system, programmes, input and output devices. All these, devices and programmes alike, use sets of symbols, other than the ordinary ones. For example, left, right, double click and drag-and-drop are symbols used by the mouse, each of them having specific uses. Therefore, one has to master these symbols first, to give some thought to them, in order to use them effectively. The next step is to understand the written or oral symbols in order to grasp their meaning. Therefore, there are two layers of symbols between the user and the computer, making the process of knowledge acquisition a little bit more intricate.

The ideal would be to remove the second layer of symbols imposed by programmes and devices, so that the bilateral man-machine communication is conducted in a more 'natural' way, like the way we interact with the real environment. This is the case for VR. Even though conventional devices are not excluded, in VR specialised ones enable - the mimicking of the movements and actions we obtain in real life. For instance, with a data glove it is possible to manipulate virtual objects the way we manipulate real ones. By doing so, the interface can become almost invisible and the user can have experiences that are closer to real ones.

Other characteristics of Virtual Reality

The high degree of interaction is a unique characteristic of VR applications. This means that within a virtual environment free navigation and exploration is permitted. The user can observe elements of the virtual world from any desirable angle and can interact with its objects, as long as the application's developer has made provisions for that. VR offers experiences through the 'actual' use of the virtual objects. Interaction is mandatory; the learner actively participates and is given the ability to control the learning process (Pantelidis, 1993).

Another interesting characteristic is the viewpoint of the virtual environment the user has. In multimedia applications, it is common for the user to see an avatar, a figure that represents him. The user controls the avatar in order to navigate and use objects. This viewpoint is called 'third person view' and it is like having a camera positioned above and behind the user's avatar. Nevertheless, third person view is somewhat irregular. Due to the camera's position, the user can 'see' things that in reality would be beyond the actual field of view. In contrast, in VR, 'first person view' is used. The user does not see his avatar, because the camera is positioned at the eye level. The field of view is more or less, what one sees -or does not see- in reality.

3D graphics, first person view and the high degree of interaction lead to the most important, yet the most controversial element of VR, immersion. The term describes a mental state in which -due to controlled sensory input-, the user feels present/immersed in the virtual environment. Technically speaking, immersion depends on two factors. The first one is the realism of the virtual world, how accurately a real or an imaginary environment is illustrated and is related to the application's 3D graphics quality. The second factor is the devices used for the conveyance of the virtual world to the user's senses. It must be noted that it is not yet possible to provide sensory input for taste and smell, therefore absolute immersion is not yet feasible. Still, since sight and hearing are the predominant senses, their manipulation leads to a high degree of immersion. Giving the definitions of VR, we emphasised that it is a mental situation. Indeed, psychological factors such as imagination, concentration and self-control affect the extent that one feels immersed in a virtual world (Psotka & Davison, 1993). The degree of immersion is also affected by the user's acquaintance with the real or virtual environment (Held & Durlach, 1992), as well as the age and mental or physical abilities (Stanney et al., 1998).

The role of immersion is debatable. A number of studies endorse the idea that an elevated degree of immersion results in better cognitive outcomes (i.e. Winn, 1994a; Winn, 1994b). Other studies support that immersion is not such an important factor or that the combination of immersion and interaction provide the significant pedagogic value of VR (i.e. Byrne, 1996; Gay, 1994). Whatever the case is, there is no need to drastically modify an application in order to change the degree of immersion. What changes are the devices that are used.

Cooperative learning is also an important factor in VR. There is a general feeling that with this teaching method, better cognitive outcomes can be achieved due to the increased number of cognitive recourses (Slavin, 1991). Yet, in most applications, the problem is the development of the necessary skills that endorse collaboration, such as the feeling of personal responsibility in a group, team spirit, the undertaking of initiatives and responsibilities. Furthermore, equal effort among the team members is not assured. However, a VR learning environment supports collaboration in a more complete way than multimedia and hypermedia. Through network connections, other users can coexist in the same virtual world, have the same audio and visual stimuli, interact with each other's avatars, share the control of events and communicate with each other.

The incentives for learning play an important role in the educational process and must be taken into account when designing an educational environment. In this case, attention focuses not on what is learned, but on what makes a learner eager to learn. An application must be designed in such a way that it provides elements that stir the learner's interest and has a long lasting appeal as well. Indeed, most people find VR an interesting experience (i.e. Byrne, 1996; Mikropoulos et al., 1998). However, it is not just the interest that provides incentives for learning in VR. As Psotka points out, VR combines interaction and realism with the spur of imagination and with a challenging and playful environment (Psotka, 1996).

Discussion-Conclusions

Students need to develop the necessary skills and methods that will eventually render them capable of tackling complicated traffic situations. The most effective teaching method is expected to be one that simulates nearly real traffic conditions. Solutions, like traffic parks, roads closed to traffic and even a 'pretend road' method, were tested by research teams for their effectiveness and found to produce positive outcomes. Nonetheless, it is impractical to incorporate such methods in everyday school teaching. Such solutions would require a number of actions and prerequisites that are time consuming, expensive and depend on imponderable factors. Among others, the requirements include finding the appropriate location for the 'pretend road', construction of the necessary infrastructure, transportation of students to and from that location, hiring and training a sufficient number of adults who will act as guides-tutors to students, revision of the school's curriculum and timetable and finally good weather that is needed for outdoor activities.

Considering all the above on a national scale it is obvious that a more practical, feasible and cost effective solution is needed.

In the field of ICT, Internet and multimedia are the prevailing type of applications. The problem is that applications of this type aim at knowledge acquisition, which is not the major factor in Road Safety. A very limited number of them focus on training skills, with encouraging results. These applications can be described as 2D simulations of an environment, in which the user/student has to face a number of traffic situations. Simulation is the key element of their success. But simulations are more closely related to 3D rather than to 2D graphics. Therefore one has to examine the possibility of using VR (a broader type of 3D simulations) in order to provide skill training.

From a theoretical perspective, the underlying cognitive theory both in multimedia and in VR is constructivism. This theory suggests that knowledge is constructed and not simply transmitted through teaching, admits that each individual creates their own representations of the world, acknowledges that we learn via active exploration and finally points out that learning is a dialectic and interactive activity with our social environment. VR encapsulates these ideas, through the non-linear exploration of the content, the provision of elements that arouse the learner's interest, interaction-collaboration with other users present and through manipulation of the environment's objects. All of these characteristics can also be found in multimedia applications. Nevertheless, the capabilities of VR extend even more, since it is possible to present vastly more complex and realistic environments. Furthermore, first person view puts the user literally inside the virtual world, giving him/her the chance to have first person experiences, with the additional advantage -with the use of specialised hardware- of not having the need to use symbols for interaction with the virtual objects. These elements are not present in multimedia applications (table 1).

The benefits of using VR for Road Safety Education become apparent:

- Training needs to be done in a manner very close to real traffic conditions. No other training form -conventional or ICT based- can provide students with enough elements that will help them improve co-ordination of information from different directions, visual timing judgments, coordination of perception and action. An obvious example is pilot training using simulators.
- It is possible to simulate traffic situations that are very complicated to be presented in reality, or extremely dangerous for students to be exposed.
- Contrary to other teaching techniques, in VR, students are not limited to third person experiences in order to acquire the necessary knowledge, thus missing, to a large extent, the benefits offered by first person experiences.
- The elevated degree of interaction with the virtual world gives students the chance to test alternative approaches in a traffic situation, to experiment and learn from their mistakes.
- The playful character -VR applications are, up to a degree, very similar to modern computer games- stimulates students' interest and gives extra incentives for learning.
- The teacher can be present in the virtual world. Therefore, different teaching styles can be implemented. For example, collaboration between students, guided tutoring, or a combination of collaboration and tutoring is possible.

Table 1. Cognitive and technical comparison of Multimedia and VR applications

	Multimedia applications	**VR applications**
Type of environment	2D	3D
Realism of environment	low	varying, medium-high
Degree of immersion	low	varying, medium-high
Degree of interaction	varying, programming dependant	potentially unlimited, programming dependant
Degree of environment's exploration	varying, programming dependant	potentially unlimited, programming dependant
Collaboration-interaction of users	yes	yes
First person experiences	no	yes
Third person experiences	yes	yes/no by choice
Usage of symbols	yes	yes/no, hardware dependant
Time for developing an application	little	large
Easiness of an application's development	easy-difficult	difficult

Hardware-software cost	low	medium-very high, hardware dependant

VR immediately affects the senses. Thus, it acts in the initial phase of the training process, functioning more as a 'vehicle' of senses, an amplifier of experiences, and not just as a cognitive tool (Mikropoulos, 1997). This fact alone renders it independent from educational theories. In addition, with minor changes, a VR application can satisfy the characteristics of one or more learning theories. If the virtual environment can be completely explored and if it is fully interactive, then it satisfies the concepts of constructivism. If we add elements of reward to students, such as the number of right answers, with the form of a score, perhaps some aspects distinguishes influences from behaviourism. Parts of the same application are possible to move towards either direction.

There are a few issues to be tackled here.

Although, theoretically speaking, VR can be a powerful teaching tool there are certain technical aspects that need to be addressed. A probable VR environment for teaching Road Safety would be that of a city's streets. This means that within the VR world buildings, roads, pavements, traffic lights, cars, pedestrians etc have to be included. The fact that there will be moving objects (i.e. cars, avatars of other users) will certainly put stress on hardware capabilities, since it is necessary to constantly calculate their position. The amount of individual elements involved in the VR, and the level of detail attributed to these elements will heavily stress the hardware requirements of such a VR system. Hence, a trade off between realism and equipment's capabilities need to be achieved.

Since the application in mind is intended for students, no special equipment should be necessary and desktop VR applications should be considered.

Furthermore, any given solution has to have three major attributes: massiveness, cost effectiveness and ease of use.

It is hoped that with the selection of appropriate software a real solution to the problem of road safety education can be achieved.

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