Virtual Reality: A Potential Technology for Providing Novel Perspective to Novice Driver Education in Malaysia

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ABSTRACT

Three-dimensional virtual reality offers a number of unique attributes that are unavailable in any other existing educational media. Indeed, this technology if placed in a sound educational framework would provide a powerful and stimulating learning environment. This paper discusses some observations of the current methods of instruction for educating novice drivers in Malaysia, particularly from the cognitive aspect. It then highlights the potential of applying virtual reality technology to overcome the observed problems and the feasibility of its implementation.

1. 0 INTRODUCTION

In the present day, the benefits of utilizing three-dimensional virtual environment technology, commonly known as virtual reality, in education have increasingly gained recognition from many researchers and educational practitioners. The availability of relatively low cost desktop virtual environments has made this technology feasible to be widely utilized in education. Indeed, according to Youngblut in [1], this non-immersive technology is much more matured and ubiquitously used in many different application areas rather than the immersive technology.

Numerous researchers such as [2], [3], [4], and [5] found that virtual environment technology offers unique capabilities that is able to provide significant and positive support for education. Some of these capabilities include the ability to allow learners to visualize a three-dimensional representation of a problem, to visualize abstract concepts, to articulate their understanding of a phenomenon through their development of virtual environments, to visualize the dynamic relationships in a system, to obtain infinite number of viewpoints of a virtual environment, and to visit and interact with events that are unavailable or unfeasible due to distance, time, or safety factors. The power of a virtual environment as a tool for experiencing prebuilt worlds as well as for world building by learners, suggests that the technology will be widely applicable for education.

2. 0 ROAD TRAFFIC INJURIES PHENOMENA

In 1998, road traffic injuries caused the death of an estimated 1,171,000 human beings, representing the tenth leading cause of death world wide and accounting for the largest fraction of the global burden of injuries. By the year 2020, it is expected that road traffic crashes will account for the third highest cause of the global burden of disease, jumping from its current ranking of ninth. Developing countries will be largely responsible for this predicted sharp rise, having already experienced a significant increase in road deaths throughout the last decade while a steady decrease has been sustained by high income countries.

(World Health Organization (WHO) in [6])

Addressing the severity of road traffic casualties, the World Health Organization has chosen 'Safe Roads' as the theme for World Health Day 2004 to draw global attention on this major but neglected public health problem.

Malaysia is one of the developing countries that is experiencing a gradual increase of road accident situations. Statistics released by the Road Transport Department (RTD) of Malaysia shows that the number of road accidents has been increasing for the last 10 years. In the year 2001, for instance, a total of 265,175 road accidents were reported where 6,942 persons were killed and 42,856 persons injured [7]. These deaths and injuries result in substantial economic and social costs as well as serious grief and physical sufferings. The above figures are indeed worrying and prompted the need for effective and sustainable prevention since road traffic injuries are to a great extent, preventable. The Transport Ministry of Malaysia has stated the vision of the country to reduce the fatal accident rate from the present 5.17 deaths to 2 deaths per 10,000 registered vehicles [8]. Among the measures taken to reduce road accidents include improving the current driving curriculum and introducing more stringent driving test procedures.

3.0 NOVICE DRIVER EDUCATION IN MALAYSIA

RTD's main goal is to produce competent drivers. Currently, a candidate has to successfully complete four test components in order to be eligible for a driving license. These test components are divided into three parts: Part I consist of a theory test (oral or written) and compulsory attendance of a 6-hour basic practical lesson, Part II consists of a practical test, and Part III comprises an on road test. Part I of the test is generally meant to provide the candidate with all the necessary theoretical knowledge required by a competent driver while the other two parts focus on the driving skills.

A textbook known as the Driver Education Curriculum has been published by the Road Transport Department of Malaysia

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with the aim to provide each candidate with the essential knowledge required by a competent driver. Besides a large portion of text, this textbook also comprises various static images.

The following text will elaborate on observations of this textbook, the theory test and basic practical lesson, focusing particularly from the cognitive aspect. Cognitive domain, according to Reigeluth & Moore in [9], is defined as the domain that deals with the recall or recognition of knowledge, and the development of understandings, intellectual abilities and skills.

3.1 Involve unnecessary levels of abstraction

Figure 1 exhibits an example of the two-dimensional plan view of a road scenario presented in the textbook while Figure 2 shows an example of the two-dimensional plan view of a road scenario used in the theory test. Generally, a candidate is taught and tested on the on-the-road rules based on this type of representation. Although these two figures show some inconsistencies in the presentation, both are still depicting the two-dimensional representation of the road scenarios, which is unrealistic. In a real context, the candidate will perceive the road in a three-dimensional view from various physically possible viewpoints. The use of a plan view in the two-dimensional representation has indeed presented a physically impossible viewpoint. Thus, transferring the learning gained from this representation to a real driving scenario would require another level of abstraction, which requires the candidate to mentally construct the respective three-dimensional road scenario from the plan view.

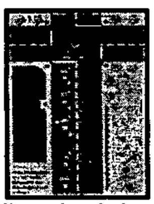

Figure 1: Two-dimensional plan view (textbook)

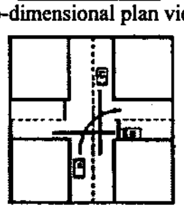

Figure 2: Two-dimensional plan view (theory test)

As defined by McGee in [10], spatial visualization is one of the major factors of spatial ability. This refers to the ability to mentally restructure or manipulate the components of the visual stimulus and involves recognizing, retaining, and recalling configurations when the figure or parts of the figure are moved. Indeed, the use of two-dimensional representation increases the candidate's cognitive load as this task entails the knowledge of isometric, parallel and perspective projections, elevations, materials, dimensioning and so on. The fact that different people have different spatial ability raises the ambiguity on the ability of the learning gained through the use of two-dimensional representations to be transferred to the real practice.

The current methods of instruction, which include lectures and readings (mostly text and static images), depend very much on two of the seven types of intelligence that were identified by the psychologist Howard Gardner, namely linguistics and spatial intelligence. These intelligences are required to enable the candidate to imagine the dynamics of the real road scenario, notwithstanding the fact that such intelligences are not mandatory in a real driving condition. In other words, much reliance on verbal language, text, and static images has decreased the fidelity of the learning system, which may cause adverse effect on motivation and transfer of learning although it may be beneficial for improving initial learning [11].

3.2 Employ decontextualized approach

The requirement for unnecessary levels of abstractions as described above has created a decontextualized environment. Schank, Berman, and Macpherson in [12] have highlighted that the shortcoming of lessons taught in decontextualized fashion, where the use of knowledge or skills is separated from how they would be used in real life. They emphasized that the only way we remember what we learned is by having similar experiences that trigger our memories. In the case of the novice driver's education, theoretical learning materials are contained in textbook and lecture, and tested on paper. Thus, a learner may have difficulty triggering their memories when facing a real driving situation.

The meaning of every traffic sign that is used in this country, for instance, is presented as an isolated entity in the textbook. In other words, the meaning of a particular traffic sign is explained beside its image. This is somehow consistent with the related test items posed in the theory test. This is indeed another example of decontextualization. Candidates are required to answer questions related to the few images of traffic signs that are shown. Information is presented and tested in isolation elicits the doubtfulness on the accuracy of the candidates' comprehension of those traffic signs. It encourages rote learning of those signs as the materials in the textbook do not incorporate them into real road situations, which could explicitly show their application in the real context. As pointed out by Ausubel as cited in [9], rote learning is a type of learning that will not permit the establishment of significant relationships among learned materials as these materials are discrete and relatively isolated entities. This could lead to the risk of solving problems (e.g. test items) without understanding them.

Learning is often contextualized, which means knowledge and skills learned in a particular context are easily repeated by learners as long as they are in that context [11]. Thus, embedding relevant, meaningful and real-world like context within the instructional strategies would enhance the transfer of learning to the real setting. Contextualization also reflects efforts to create motivating and relevant instruction [13]. Contextualized learning forms the basis for situated learning theory and anchored instructional approach.

3.3 Support limited kinds of learning styles

The values of current methods of instruction nevertheless cannot be denied as candidates have differences in their learning styles. Kolb has defined learning styles as one's preferred methods for perceiving and processing information. He has identified four learning modes: abstract conceptualization and concrete experience as the extreme ends on a continuum that represents how one prefers to perceive the environment, and reflective observation and active experimentation as the extreme ends on another continuum that represents how one prefers to process incoming information. The existing methods may be more suited for candidates with learning styles prone to the left end of both continuums. Therefore, to accommodate all those learning styles, methods that could provide concrete experience and active experimentation should be employed.

3.4 Employ teacher-directed approach

The 6-hour basic practical lesson is basically a lengthy lecture conducted by a certified trainer or driving instructors. This creates a teacher-directed environment where the instructional decisions lie mainly in the hands of the instructor, not the learners. In such an environment, instructional design procedures are being controlled more by the material to be taught rather than by the persons receiving the instruction. This content-oriented instruction is against the current trends in learner-directed (or jointly directed) instruction where learning is perceived as an active process in which people actively construct knowledge on the basis of experience [14]. In another extreme approach, the learner is given total control to both the instructional process as well as his or her own learning processes. However, many instructional designers such as [11] and [15] prefer a moderate approach that gives shared control over the instructional processes to both the instructor and the learner, although the learner always control his or her own learning processes.

The observations made above, have indeed raised doubts on the effectiveness of current methods of instruction in assisting learners in recalling or recognizing knowledge, and developing their understandings, intellectual abilities and skills. These include

1. support learners with different spatial ability
2. support current paradigm of education and training, which needs to shift from passive to active learning and from teacher-directed to learner-directed (or jointly directed) learning; teacher initiative, control, and responsibility to shared initiative, control, and responsibility; decontextualized learning to authentic, meaningful tasks.

Educational researchers and practitioners who hold to the belief of constructivism and situated cognition criticize the notion of knowledge as a substance that can be transmitted to learners. Instead, they stress the idea that knowledge is constructed by learners as a result of being involved in authentic activities. According to Jonassen in [16], constructivist learning environments focus on problems because learners learn through their attempt to solve the problems. In fact, the fundamental difference between constructivist learning environments and objectivist instruction is that learners learn domain content to solve a problem, rather than solving a problem to apply the learning. The current methods of instruction seem to fit more to the objectivist approach. Although the educational benefits offered by current instructional methods are not deniable, the possibility to incorporate appropriate constructivist methods could also be considered in order to take the educational advantages of both approaches.

4.0 POTENTIAL OF VIRTUAL REALITY IN OVERCOMING THE OBSERVED PROBLEMS

4.1 Three-dimensional representation

The use of virtual reality could provide learners the environments within which they can actively construct knowledge. These environments can either be real or artificial but simulate aspects of the real world, which may not be accessible through direct experience. In this case, desktop virtual reality could present a three-dimensional representation of a road scenario or problem in a visual and auditory form. This type of problem representation is definitely more appealing, interesting and engaging compared with other representation methods such as narrative, text, or picture form.

4.2 Authentic representation

The ability of a virtual environment to simulate the real road scenario also means that it could be used to present authentic problems. Authentic is interpreted as how learners should engage in activities, which present the same type of cognitive challenges as those in the real world (Haonebein et al., 1993; Savery & Duffy, 1996 as cited in [16]). For example, incorporating appropriate traffic signs in a simulated road scenario presents a similar cognitive challenge that is faced in real driving conditions. Through the process of visiting or exploring the simulated environment, learner can further comprehend the real uses of those signs and codes in contrast to learning them in isolation through text. Thus, providing an environment within which the learner could actively constructs knowledge would engage a learner with more meaningful learning.

4.3 Visualization tool

A virtual environment could act as an excellent visualization tool where it enables the learners to visualise the three-dimensional representation of a simulated road scenario. As the virtual environment is inherently three-dimensional, it helps reducing the learner's cognitive load in constructing mental images and performing visualizing activities. Conversely, if the learner is presented with only the plan view of a road scenario, he or she will be demanded to mentally reconstruct the three-dimensional road scenario from the two-dimensional representation. Thus, the use of a three-dimensional virtual environment, which mimics a real world representation, will be extremely helpful, particularly for individuals with low spatial abilities

4.4 Multiple perspectives

A unique feature of a virtual environment, which is unavailable in any other traditional educational media, is its ability to provide infinite or unlimited number of viewpoints of the three-dimensional environment to the learner. The viewpoint of the learner who is maneuvering a vehicle can be tailored to the respective driver's viewpoint. He or she can also take the viewpoints of other drivers and even other meaningful physically-impossible viewpoint, such as bird-eyes view to gain an overall understanding of the whole road scenario. Indeed, having multiple perspectives of the world can thus encourage diverse ways of thinking. As pointed out by Duffy and Jonassen in [17], there are many ways to structure the world, and there are many meanings or perspectives for any event or concept.

4.5 Controlled complexity

Cognitive scientists have also pointed out the ability of virtual environments to make the abstract more concrete and visible by providing symbols not available in the non-symbolic real world. Focus can be given on salient aspects of a situation, so learners do not get lost in the complexity. This is in line with Pantelidis in [18] views that the designer of a virtual environment is free to exclude any secondary elements that may divert the learner's attention from the elements of primary importance. This helps in the attempt to represent the concepts that are the first steps toward the construction of an abstracted idea. In other words, a virtual environment is a cognitive tool that is capable of making imperceptible things perceptible. This attribute enables the design of various road scenarios with controlled level of complexity or even incorporating elements that are not in existence in a real situation, such as the use of text, and artificial feedback in order to scaffold the learning process. Although the inclusion of such elements will decrease the fidelity of the learning environment, it is known to be beneficial for improving initial learning for a novice learner [11].

4.6 Active learning

According to Jonassen in [16], learning is not the passive acceptance of knowledge but requires learners to manipulate something such as constructing a product, manipulating parameters or making decisions. To create an engaging problem manipulation space, it should also provide a realistic physical simulation of the real-world task where learners can directly manipulate or explore the objects or activities in the problem space. The learners could also receive feedback from their manipulation through changes in the physical appearance of the physical objects or in the representations of their actions.

Virtual environments could be used to present a road scenario that serves as a problem manipulation space that allows free exploration of the environment and manipulation of virtual vehicles by the learners. Learners can learn from the process of visiting or exploring the virtual environment. A learner in a virtual environment could gain virtual experience instead of just words or pictures that largely relied on the human cognitive abilities with relatively low bandwidths between the learner and medium. A textual description, for instance, requires reading skills, a picture can be recognized immediately but is not interactive, but a physical space allows the learner to explore and walkthrough it. More importantly, it has natural semantics that provide meaning to the user without any explanation. Virtual environments will initially teach meaning through experience, then (if necessary) teach the symbolic abstraction of our experiences [19].

4.7 Learner-centered

Unlike many other educational tools, a virtual environment is designed without a specified sequence. Its focus shifts from the design of prescribed interactions with the learning environment to the design of environments that permit the learner with various types of interaction that the system is capable of. This complies with the learner-centered approach where a learner can keep control over what he or she wants to explore or manipulate. In other words, the learner can choose to navigate through the simulated environment or interact with the objects of his or her interest for further observation. In doing so, the learner may make mistakes and wrong predictions. These experiences will provide the conditions for modifying existing knowledge and thus, construct new knowledge [20]. This is also known as discovery or experiential learning where it is based on the assumption that a learner discovers principles through experimentation and practice [11].

4.8 Motivation

As mentioned earlier, virtual environments allows the learner to control and interact directly with objects within the virtual world. Such control and interaction, together with free exploration, provide a greater sense of empowerment. They feel free and empowered and empowerment is indeed a factor that contributes to motivation. As pointed out by Bricken in [19], one surprising result from virtual reality research is that subjects have a strong positive emotional reaction. Research studies by [21], [22] and [23] have also proven the motivating factor of the desktop virtual environments technology. In addition, a virtual environment can also always be configured to allow repetitive testing of ideas and self-paced learning. This once again grants learners responsibility for their learning process and creates understanding [24].

5.0 FEASIBILITY OF VIRTUAL REALITY IMPLEMENTATION

5.1 Economic feasibility

The availability of the desktop virtual environment system, provides an alternative, although not entirely, to costly immersive technology. This technology is advancing very rapidly due to the development of desktop computers with ever-increasing computing power and with the widespread availability of three-dimensional (3D) graphics accelerators, which are capable to handle most of the graphics rendering 'pipeline'. Consequently, this has enabled the creation of visually rich and perceptually realistic virtual environment applications at relatively low cost. Virtually, any personal computer can be used for the desktop viewing and manipulation of non-immersive virtual worlds. This basic level of technology should be within the reach of most driving institution budgets.

5.2 Social feasibility

The current practice in this country allows a person with the minimum age of 17 to undergo the driving test procedure. The introduction of this type of learning system as a complement to the current methods of instruction does not seem to impose major acceptance problems. This group of the population is mostly computer literate since computing subjects have been incorporated into the school curriculum. However, it is still indispensable to employ appropriate usability techniques during the design and development of the virtual learning system to ensure the system is well-fitted to various learners' mental models.

6.0 CONCLUSIONS

A three-dimensional virtual environment is indeed one of the latest innovations in the long line of technology, which can be used for teaching and learning. As with any other technological advancement, the introduction of this technology brings about excitement and high expectations among educators of its potentials. However, it is indispensable to remember that this technology is merely a tool, as is a chalkboard, television, overhead projector, or Internet. Tools by themselves do not teach. They have to be carefully and effectively implemented to assist in the learning process. With the advent of this sophisticated virtual environment technology, educators are now urged to decide on how to make this new tool work effectively. In other words, the use of this technology has to be based on sound pedagogical principles to yield effective learning.

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