Journal of Computer Science & Computational Mathematics, Volume 5, Issue 3, September 2015
DOI: 10.20967/jcscm.2015.03.002

Design Features and Success Factors for DesktopVR in Learning Environment

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***Abstract*:** Virtual Reality (VR) has been identified as one of the constructive medium to support the teaching-learning process. It is persistently explored by researchers in order to reap the most benefits from the technology in education. Among reasons for the usage of VR application in learning environment are due to its provision of interactivity among realistic complex structure of three-dimensional (3D) environment while giving the feel of being there to users. However, a broad framework and model to construct the theory and connection in this domain, particularly virtual reality for desktop or DesktopVR, has hardly been developed and evaluated. Therefore, the objective of this paper is to determine the features and relevant factors which may contribute to learning environment. This paper offers a theoretical model in designing DesktopVR for learning environment.

***Keywords*:** virtual environment, desktopVR, learning environment.

1. Introduction

The main concern of an educator is perhaps to find ways enhancing student learning outcomes through the usage of current technology. Medium to support teaching-learning process is persistently explored by researchers in order to maximize the technology outcomes in education. Virtual Reality (VR) has been identified as one of the constructive medium technologies. Among reasons for the usage of VR application in learning environment it can be pointed to the provision of interactivity among realistic complex structure of three-dimensional (3D) environment while giving the feel of being there to users [1, 2]. Compared to other VR systems, the desktop version of VR, also known as DesktopVR, begins to receive attention in modern education due to its ability in providing a real-time visualization and interaction in a virtual world which is similar to the real world [3-5].

The reasons to use virtual reality in education and training are related particularly to its capabilities as stated by Winn [6] in the following:

"*Immersive VR furnishes first-person non-symbolic experiences that are specifically designed to help students learn material. These experiences cannot be obtained in any other way in formal education. This kind of experience makes up the bulk of our daily interaction with the world, though schools tend to promote third-person symbolic experiences. Constructivism provides the best theory on which to develop educational applications of VR. The convergence of theories of knowledge construction with VR technology permits learning to be boosted by the manipulation of the relative size of objects in virtual worlds, by the transduction of otherwise imperceptible sources of information, and by the reification of abstract ideas that have so far defied representation.*"

Although the utilization of VR in education progresses rapidly, a broad framework and model to construct the theory and connection in this domain based on DesktopVR context is hardly developed and evaluated. Thus, this paper determines features and relevant factors which contribute to learning environment.

2. Problem Statement

Although the employment of VR for education is advancing progressively, the study on development of the application design model and evaluation towards learning outcomes based on the DesktopVR background is hardly developed and realized. Therefore, the relationship between the features and factors in application design and outcome assessment need to be evaluated since it can give a positive impact towards the learning process [7, 2].

Currently, the research activities of VR focused more on the improvement and enhancement of the application development, technical issues and the issue of 'immersion' or immersive rather than the research in studying the efficacy and cognitive dimensions of human experience in a virtual world [8]. The VR research in education starts at the end of 90s with the need of more researches; hence the benefit of the implementation of VR in education can be explored. Ausburn [1] stated that the research on the effectiveness of DesktopVR is still minimal and requires a firm empirical support. Moreover, the DesktopVR is much easier to be used by educators and students in schools as well as colleges because of its mobility and low expense [1, 9].

Although VR can support constructivist learning and researches has shown many of its positive impacts, there are still lack of studies in addressing the issue of "How DesktopVR technology can improve the learning outcomes" rather than "Does the DesktopVR technology influence the learning outcomes?". If DesktopVR is used to support meaningful learning, it is necessary to explore and develop the connection of VR features and design factors as well as the evaluation that encourage the goals achievement. Among the factors and features suggested, are the need to examine the learning component as well as the DesktopVR application system which are interactivity [10], accuracy [1, 11] and navigation [12].

3. Materials and Method

This study employs content analysis which integrates meta-analysis to achieve its objective as depicted in Figure 1.

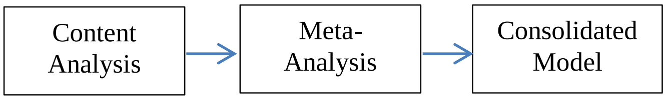

Figure 1. Research Methodology

The first process begins with identifying related previous studies by scholars. Generic keywords “DesktopVR features”, “DesktopVR elements in learning”, and “ educational components” were used at the initial stage of content analysis. Screening was conducted afterwards to ensure these articles are relevant to the scope of DesktopVR. Then, meta-analysis was conducted in order to obtain specific keywords for each DesktopVR features and factors (i.e. interaction, navigation, fidelity, educational component). Internet sources such as Google Scholar site, Research Gate and reputable digital databases such as ACM Digital Library and ScienceDirect were accessed to obtain the articles used in this study. There are articles found for DesktopVR features and factors in learning.

In the second process, all the identified features and factors were listed and classified by means of human senses capabilities towards DesktopVR learning environment. Lastly, a consolidated model of DesktopVR in learning is proposed based on these findings. The consolidated model classifies the identified DesktopVR in learning environment that originates from human senses.

4. Features and Relevant Factors Used in DesktopVR

Research results on the use of Virtual Reality Environment for educational communities are very encouraging. However, upon examination into virtual reality, it has been found that desirable characteristics for an educational virtual environment are not clearly stated or defined. This is a major concern that these defined characteristics are desperately needed for proper implementation to be fully realized and the design process is not one of the confusion and probabilities.

To implement this major concern, it is important to create a guideline in term of the understanding, cooperation and also acceptance for a characteristic of VR in engineering education application [13]. Without this guideline development, all educators or instructors will not have a proper and accurate formula to explain the design and the implementation of a virtual environment and this usually will result in confusion among them. Therefore, this paper aims to examine the characteristics of a virtual environment to develop suitable and accurate engineering education applications. The study on characteristics were categorized into four main groups, namely:

1. Educational Component
2. Interaction
3. Navigation
4. Fidelity

It should be noted that these categories define a broad expanse and while some elements may overlap, they are listed in a manner to aid in the implementation and understanding of their use. The following sections are intended to cover the elements in each category and the desired characteristics.

4.1 Educational Component

The implication of virtual reality environment in education demands a specific analysis in educational component. Although there is no statement or approval to the use of virtual reality environments in the field of education, there are several ideas that have been proposed by Johnson et al.[14] which can be used as an initial step. Johnson et al.[14] claimed that there are four criteria for the implications of virtual reality which are:

- The goal of study must be important.
- The goal of learning must be hard.
- The goal of study must be strenghten with the introduction of virtual reality technology.
- The virtual reality based on learning environment must be related to the contemporary research in the learning sciences and educational [11, 14]. In addition, the collaboration aspect also must be classified as a component of education.

4.2 Interaction

The interactive elements in the VR application were mentioned in a previous study [15] as useful since they allow users to engage with the related content information, presented in different formats. It also allows users to apply their ability to learn at their own pace as they had control over what they do or do not want to see. Interactions can be categorized into two types which are "object selection" and "object manipulation" [16]. "Object selection" is a situation where the user has a full control over an object or a group of objects. Meanwhile, the "object manipulation" is defined as a performed operation on an object or a group of objects after being selected [17]. Therefore, the selection of an object is called a precursor to the "object manipulation".

4.2.1 Object Selection

In this category, there are several variables that work as interaction keys in the environment. One of them is the spatial relationships between the users in the environment and the selected object. This should be decided from the behavior of the objects and also the types of applied manipulations. For example, if the object is a tower and a user is selecting objects for visual queries, spatial relationships will exist within the line of sight. This is also simplifying the definition of "object selection" where physical contact in an environment is not fully required. What to do is to select the object and to tell the user that the object has been selected [16].

An example of this characteristic is to select the object by using a mouse cursor and highlighting the object after it is selected. Another important factor in this characteristic is that the polygon restrictions for each object must be properly adjusted according to the size and accessibility of the object, ie, smaller objects may require a larger polygon restrictions for the distance selection. However, this restriction should not be too large in order to avoid overlapping with nearby objects, thus creating confusion.

4.2.2 Object Manipulation

“Object manipulation” is a type of available action for a given object to the user that can be seen as an element which defines the power and usefulness of the completely virtual environment. One of the modes in manipulating an object is described in detail in a sub topic above (object selection) which is the tower example. From this example, it is necessary for the user to receive the information everytime they select an object, whether by text or sound, depending on the selection made by the user. Other forms of manipulation include the ability to rotate, to reposition the object and also to change the format and behavior of objects [11]. One example of the rotation and repositioning of objects that can be practiced in education is to recognize and to choose the right vial among several of them (with the same appearance) by referring to the label, and place it on another table area for the next task.

4.3 Navigation

The most common problem that always happens in the environment is the ability to handle a navigation. In handling a navigation, a problem that always happens is that it takes a lot of time and is very confusing where the user must move all over the places in the environment and always gets lost and had to think of a way to find the right direction. There are several ways to overcome this issue in order to maintain the educational environment in terms of its integrity. This navigation tool should not be seen as a hierarchy approach but to help navigate the environment without distracting the attention of the user from the real purpose of the environment [13]. Other than maintaining a consistent floor plan, there are other factors that can help to navigate which are the layout of the environment, directional cues and key location points.

4.3.1 Layout of the Environment

Every environment should have a floor plan designed with spacious living room, doors, and suitable room between objects such as tables, chairs, trees, etc., so that the user can conveniently move. The users also must have enough room for the rotation in every space built in the environment. By considering these factors in developing an environment, this will strenghten the navigation process and also at the same time can reduce the problems [13].

4.3.2 Directional Cues

Another component that must be considered is the use of directional cues as a landmark, a sign, map or compass. A landmark may represent a prominent structure like a giant sculpture, a person, the frescoes that were placed in one of the key locations or any kind of signs that could be used as reference for the users. An example of a directional cues that is easy to be inserted in the environment is called ”markers” such as a street name or the "EXIT" sign which are easily recognized and understood by all users. In addition, a map or a compass is among the elements that should have been given greater consideration if made for a landmark, as it can provide a good reference for users to find their way in the environment. The user can also use the map or compass to know their location in the environment. Navigation will be much easier to handle the existence of directional cues [13].

4.3.3 Key Location Points

There are several key location points in the environment which play an important role for users. By accessing these points, users can be brought to that location automatically. At the same time, it will save time for the users. This concept also can be implemented because the key location points is the only way to explore the environment and the user is only allowed to move around by bouncing from one location to another location point, as used in "Ocean Walk" [18]. In this way, various issues and problems of navigation can be avoided. However, the user is not able to move freely in the environment and this method should be implemented only if it helps the educational objectives through the static layout.

4.4 Fidelity

Fidelity is one of the most elements that identify a realistic approach to the environment. These elements can change a person's perception of the environment whether the objectives has been achieved or not. These elements mentioned are a frame rate, user opinions, an introduction to avatar and agents, colors and textures, sounds, and a temporal change.

4.4.1 Frame Rate

A concept of "scanned viewpoint" or the ability of mind to describe the movement of a static image is one of the most important elements in a media, such as video and film [13]. A standard frame rate in a media has been set up to 24 fps for movies and 30 fps for videos. 24 fps also can be set up for virtual reality applications but the results are not really realistic at this stage. However, the view of the environment must reach from a minimum level to "no follow-up" to exclude disturbing elements. In this way, the frame rate for at least 15 fps must be achieved for the users to see the image as fluid and not as the evolving of the image.

There are several techniques that can support these elements, such as texture mapping, customized presentations and animated video clips. These techniques are designed to accelerate the development process by increasing the frame rate of the environment and also indirectly will allow the users to interact, explore, and achieve educational goals that have been set up without any interference like a problem of slow frame rates and others.

4.4.2 Point of View

There are two ways to identify a user’s point of view which are egocentric and exocentric [12]. Both of these elements have their respective interests in the environment. Egocentric way is a first person’s point of view (also called as "first-person shooter" in a gaming language) which allows the user to see from a person's/character's point of view inside the environment, while exocentric way is a third person's point of view (also called as "third-person shooter" in a gaming language), which allows the user to see the view from around a person/character in the environment.

4.4.3 Colors and Textures

The factors behind these elements should be based on the content and purpose of the environment created. In most cases, these elements must be represented as clear and realistic. For example, in a color scheme selection for the environment, it should be known that a green sky will be the main focus of all users because it is odd and unnatural in real life and at the same time it will mislead the learning objectives [13]. An example of the use of colors and correlation of the users understanding and desired effect from the environment is the choice of blue and green throughout the virtual environment "Ocean Walk" [18].

4.4.4 Sound

Sound is one of the elements in a virtual environment that is rarely used. This element can be a nuisance just like other elements in the environment if it is placed incorrectly. For example, the use of sound effect like a glass falling on the floor when opening the door could distract the user from the real purpose of the environment [13]. Beside sound effect, sound also included music and voice [19].

4.4.5 Temporal Change

Temporal change can be defined as a quality of the dynamic object in the environment. Two examples of a temporal change concept are plants that are growing in the garden [10] or the movement/flow of water waves [20]. Other examples that also indirectly referr to this concept are the changes from day to night and changes of weather such as rain in the environment. This dynamic quality is usually the main key in the educational goals as it allows the environment to show time changes. Without this characteristic, the virtual reality concept cannot be fully achieved.

As a result, a research framework as shown in Figure 2 is proposed to guide the development of virtual learning environment.

5. Conclusion

Desirable characteristics are easily recognized once some thought has been placed into the implementation and outcome. However, not much has been done in the labeling and setting of guidelines for virtual environment characteristics for reaching new heights in education. It should be understood that these guidelines are important for the use and success of virtual reality in educational practice, and must be placed in the forefront if virtual reality to succeed and grow in this area. Once set, these guidelines will enable collaboration and understanding in all sectors of the educational field. With this collaboration, understanding, and continual implementation, virtual reality will offer tremendous benefits to global educational communities, and thus improve as we move forward each day.

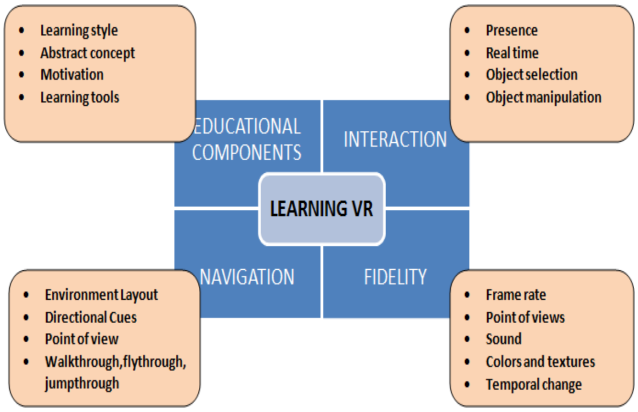

Figure 2. A research framework for determining the factors and features of a DesktopVR based learning environment.

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