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Reasons to Use Virtual Reality in Education and Training Courses and a Model to Determine When to Use Virtual Reality

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Abstract

Many studies have been conducted on the use of virtual reality in education and training. This article lists examples of such research. Reasons to use virtual reality are discussed. Advantages and disadvantages of using virtual reality are presented, as well as suggestions on when to use and when not to use virtual reality. A model that can be used to determine when to use virtual reality in an education or training course is presented.

Use of virtual reality in education

The use of virtual reality (VR) in education can be considered as one of the natural evolutions of computer-assisted instruction (CAI) or computer-based training (CBT). Use of computers as instructional aids has a long history going back to the early 1950s. Serious studies began in the early 1960s. Since the advent of the microcomputer in 1977, computers, particularly microcomputers or personal computers (PCs), have become a growing and recognized delivery system for many forms of education. Virtual reality, which can be used on all types of computers, has followed that trend. In her extensive bibliography on virtual reality in education and training, Pantelidis (1991-2009) lists over 800 printed resources, such as articles and reports, on this application of virtual reality, going back to 1989. The list is by no means complete and comprehensive.

Research on the use of virtual reality in education

Many studies have been conducted on the applications and effectiveness of virtual reality in education and training since the 1980s. McLellan (1996, 2003) provides

comprehensive and in-depth reviews of the literature related to the research and use of virtual reality for education and training in editions of *The Handbook of Research for Educational Communications and Technology*. McLellan traces early use of virtual reality in training to flight simulators with head-mounted displays developed at Wright-Patterson Air Force Base in Ohio in the 1960s and 1970s (1996, p. 458.).

Youngblut (1998) conducted an extensive survey of research and educational uses of virtual reality during the 1990's. The survey attempted to answer questions about the use and effectiveness of virtual reality in kindergarten through grade 12 education. Youngblut found that there are unique capabilities of virtual reality, and the majority of uses included aspects of constructivist learning (1998, p. 93). Studies showed potential educational effectiveness for special needs students (1998, p. 98). The role of the teacher changed to facilitator (1998, p. 100). Students enjoy using pre-developed applications and developing their own virtual worlds (1998, p. 100). The majority of the teachers in the studies reviewed said they would use virtual reality technology if it were affordable, available, and easy to use for students and teachers (1998, p. 101).

Chen (2006) asserts that "although VR is recognized as an impressive learning tool, there are still many issues that need further investigation including, identifying the appropriate theories and/or models to guide its design and development, investigating how its attributes are able to support learning, finding out whether its use can improve the intended performance and understanding, and investigating ways to reach more effective learning when using this technology, and investigating its impact on learners with different aptitudes". Her research resulted in insights to a feasible instructional design theoretical framework, as well as an instructional development framework for VR-based learning environments (2006, p. 39).

A model developed by Salzman, Dede, Loftin, and Chen (1999) describes how virtual reality aids complex conceptual learning, and how virtual reality's features and other factors shape the learning process and learning outcomes. The model resulted from a study to identify, use, and evaluate immersive virtual reality's affordances as a means to facilitate the mastery of complex, abstract concepts.

Studies show that a virtual environment can "stimulate learning and comprehension, because it provides a tight coupling between symbolic and experiential information" (Bowman, Hodges, Allison, & Wineman, 1998). Numerous studies have focused on how children and young learners interact and learn in a 3D environment. Children and young learners have been studied in high-end projection environments, such as a CAVE (Roussos, Johnson, Moher, Leigh, Vasilakis, & Barnes, 1999). Their activity within interactive virtual environments has been examined to learn how interaction and conceptual learning are related in the context of a virtual environment, the Virtual Playground (Roussou, 2004a; Roussou, 2004b; Roussou, Oliver, & Slater, 2006).

Chee (2001) argues for the need to root learning in experience, using physics as an example. He states that physics students have little "feel" and "understanding of the qualitative dimensions of the phenomena they study". Chee believes that virtual reality can be used to achieve this goal, "providing a foundation for students' conceptual and higher-order learning".

Dalgarno, Hedberg, and Harper (2002) believe that the most important potential contribution of 3D learning environments (3DLEs) to conceptual understanding is through facilitation of spatial knowledge development. They have identified aspects of a research agenda to test this, including "exploration of the characteristics of 3DLEs that are most important for spatial learning along with issues in designing appropriate learning tasks".

Selvarian (2004) researched the potential of spatial and social technologies in a virtual learning environment (VLE) through presence. She proposed a VLE model and hypotheses that correlated the spatial and social technologies with spatial and social presence, respectively, and with low- and high-level learning, respectively. Findings from her research "offer educators a valuable guide for the design of VLEs that enhance low- and high-level learning through spatial and social presence".

Reasons to use virtual reality in education and training

Reasons to use virtual reality can parallel all the reasons one would use a two-dimensional, computer-assisted instruction simulation (Pantelidis, 1993). At every level of education, virtual reality has the potential to make a difference, to lead learners to new discoveries, to motivate and encourage and excite. The learner can participate in the learning environment with a sense of presence, of being part of the environment.

The reasons to use virtual reality in education and training relate particularly to its capabilities. Winn (1993), in *A conceptual basis for educational applications of virtual reality*, states that

1) "Immersive VR furnishes first-person non-symbolic experiences that are specifically designed to help students learn material.
2) These experiences cannot be obtained in any other way in formal education.
3) This kind of experience makes up the bulk of our daily interaction with the world, though schools tend to promote third-person symbolic experiences.
4) Constructivism provides the best theory on which to develop educational applications of VR.
5) 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 in-

formation, and by the reification of abstract ideas that have so far defied representation".

Winn concludes that "VR promotes the best and probably only strategy that allows students to learn from non-symbolic first-person experience. Since a great many students fail in school because they do not master the symbol systems of the disciplines they study, although they are perfectly capable of mastering the concepts that lie at the heart of the disciplines, it can be concluded that VR provides a route to success for children who might otherwise fail in our education system as it is currently construed".

Pantelidis (1995) gives the following reasons to use virtual reality in education:

- Virtual reality provides new forms and methods of visualization, drawing on the strengths of visual representations. It provides an alternate method for presentation of material. In some instances, VR can more accurately illustrate some features, processes, and so forth than by other means, allowing extreme close-up examination of an object, observation from a great distance, and observation and examination of areas and events unavailable by other means.
- Virtual reality motivates students. It requires interaction and encourages active participation rather than passivity. Some types of virtual reality, for example, collaborative virtual reality using text input with virtual worlds, encourage or require collaboration and provide a social atmosphere.
- Virtual reality allows the learner to proceed through an experience during a broad time period not fixed by a regular class schedule, at their own pace. It allows the disabled to participate in an experiment or learning environment when they cannot do so otherwise. It transcends language barriers. VR with text access provides equal opportunity for communication with students in other cultures and allows the student to take on the role of a person in different cultures.

Mantovani (2001) discusses these potential benefits of the use of VR in education and training: visualization and reification, an alternate method for presentation of material; learning in contexts impossible or difficult to experience in real life; motivation enhancement; collaboration fostering; adaptability, offering the possibility for learning to be tailored to learner's characteristics and needs; and evaluation and assessment, offering great potential as a tool for evaluation because of easy monitoring and recording of sessions in a virtual environment.

Advantages of using virtual reality

The advantages of using VR to teach educational objectives are similar in many ways to the advantages of using a computer or interactive simulation, particularly a three-dimensional computer simulation. Computer-based simulations have been used for many years in computer-assisted instruction (CAI). In fact, advantages of computer-

based simulations are well known. Zacharia (2003), referring to Chou (1998) asserts that "researchers attribute success of simulations to the empowerment of students, the unique instructional capabilities, the support for new instructional approaches, the development of cognitive skills, and the development of attitudes". Ferry et al. (2004) state that "Whilst we acknowledge that a simulation is only a representation of real-life, there are features that can enhance real-life experience. For example, a simulation can provide authentic and relevant scenarios, make use of pressure situation that tap users' emotions and force them to act, they provide a sense of unrestricted options and they can be replayed", referencing Aldrich (2004). Steinberg (2000) contends that "students should know that simulations make it possible to explore new domains, make predictions, design experiments, and interpret results".

One major advantage of using virtual reality to teach objectives is that it is highly motivating. An investigation by Mikropoulos, Chalkidis, Katsikis, and Emvalotis (1998) of the attitude of education students towards virtual reality as a tool in the educational process, and towards virtual learning environments on specific disciplines, found students had a favourable attitude towards virtual reality in the educational process.

VR grabs and holds the attention of students. This has been documented in the reports of a number of research studies. Students find it exciting and challenging to walk through an environment in three dimensions, interact with an environment, and create their own three dimensional (3D) worlds.

Virtual reality can more accurately illustrate some features, processes, and so forth than by other means. VR allows extreme close-up examination of an object. VR gives the opportunity for insights based on new perspectives. Looking at the model of an object from the inside or the top or bottom shows areas never seen before. For example, once a molecule is modeled in VR, students can study it in detail, go inside the molecule, walk around, and become familiar with its parts. VR allows examination of an object from a distance, showing the whole rather than a part. A VR model of a neighborhood gives the inhabitants a different perspective on the interconnections between buildings, streets, and open areas.

VR can change the way a learner interacts with the subject matter. VR requires interaction. It encourages active participation rather than passivity. The participant who interacts with the virtual environment is encouraged to continue interacting by seeing the results immediately. VR provides an opportunity for the learner to make discoveries previously unknown. New perspectives are made possible by modeling the real world, and studying the model can provide insights never before realized. VR allows the disabled to participate in an experiment or learning environment when they cannot do so otherwise. They can do chemistry and physics lab experiments and learn by doing. VR allows a learner to proceed through an experience at his or her own pace. The learner decides what to do when interacting with the virtual environ-

ment. VR allows a learner to proceed through an experience during a broad time period not fixed by a regular class schedule.

VR allows a learner to learn by doing, a constructivist approach. VR provides experience with new technologies through actual use. A simulation of a new process with a new piece of equipment can train a worker. VR provides a way for some objectives to be taught via distance education which were previously impossible to teach in that way.

Disadvantages of using virtual reality

The disadvantages of using virtual reality are primarily related to cost, time necessary for learning how to use hardware and software, possible health and safety effects, and dealing with possible reluctance to use and integrate new technology into a course or curriculum. As with all new technology, each of these issues may fade as time goes by and virtual reality becomes more commonly used in areas outside of education.

When to use and when not to use virtual reality

Virtual reality is not appropriate for every instructional objective. There are some teaching scenarios when VR can be used and some when it should not be used. Pantelidis (1996) makes the following suggestions on when to use and when not to use virtual reality in education.

Use or consider using virtual reality when

- a simulation could be used.
- teaching or training using the real thing is dangerous, impossible, inconvenient, or difficult.
- a model of an environment will teach or train as well as the real thing.
- interacting with a model is as motivating as or more motivating than interacting with the real thing.
- travel, cost, and/or logistics of gathering a class for training make an alternative attractive.
- shared experiences of a group in a shared environment are important.
- the experience of creating a simulated environment or model is important to the learning objective.
- information visualization is needed, manipulating and rearranging information, using graphic symbols, so it can be more easily understood.

- a training situation needs to be made really real.
- needed to make perceptible the imperceptible.
- developing participatory environments and activities that can only exist as computer-generated worlds.
- teaching tasks involving manual dexterity or physical movement.
- essential to make learning more interesting and fun.
- needed to give the disabled the opportunity to do experiments, and activities that they cannot do otherwise.
- mistakes made by the learner or trainee using the real thing could be devastating and/or demoralizing to the learner, harmful to the environment, capable of causing unintended property damage, capable of causing damage to equipment, or costly.

Do not use virtual reality if

- no substitution is possible for teaching/training with the real thing.
- interaction with real humans, either teachers or students, is necessary.
- using a virtual environment could be physically or emotionally damaging.
- using a virtual environment can result in "literalization" (Stuart, 1992), a simulation so convincing that some users could confuse model with reality.
- virtual reality is too expensive to justify using, considering the expected learning outcome.

A model to determine when to use virtual reality in education and training courses

Educators and trainers make use of many instructional aids in teaching courses, such as textbooks, videotapes, films, computer software, and, increasingly, the Internet and the World Wide Web with podcasts, blogs, and virtual environments. Learning theory, instructional theory, learning styles, and types of intelligence are used to help determine which type of aid or medium should be used. What is being taught, how it is being taught, the behavioral outcome, and other factors also help determine the medium chosen.

A course of study can be composed of hundreds of specific objectives, each of which must be mastered by the student. Traditionally, objectives have been taught using textbooks, lectures, discussions, and some forms of media. Virtual reality can be used to teach some of these objectives, and it can be used to determine whether certain objectives have been mastered.

The educator or trainer must decide when and where to use VR. A model for determining when to use VR in any one course can help in making these decisions. Deciding when to use VR leads to decisions on where to use VR.

The author proposes such a model. The model considers the research on the reasons to use and advantages of using simulations, particularly computer-generated simulations. Findings on reasons to use and advantages of using virtual reality are then considered. The author believes that using research findings for both computer-generated simulations and virtual reality makes the model more flexible. Although specific, the model is broad enough to adjust for changes in the technology of virtual reality in the future.

The 10-step model to determine when to use virtual reality includes the following steps.

Step 1. The specific course objectives are defined.

Step 2. The objectives that could use a simulation, a computer-generated simulation, or virtual reality (a 3D simulation) as a measurement or means for attainment are selected. Reasons to use and advantages of using simulations and virtual reality are considered when making the selections.

Step 3. Refine the selection list by choosing those that can use a 3D simulation, using virtual reality, as a measurement or means for attainment of course objectives.

Step 4. For every objective in the list, perform the following substeps:

Substep 1. Determine level of realism required, on a scale from very symbolic to very real.

Substep 2. Determine type of immersion and presence needed, on a scale from no immersion into the 3D environment (for example, desktop VR) to full immersion (using head-mounted display, gloves, and so forth), and no feeling of presence to strong feeling of presence.

Substep 3. Determine type of interaction with, and sensory input and output to and from, the virtual world or environment needed, (for example, haptic - tactile or feeling, 3D sound, audio, visual, text, gesture).

Step 5. According to Step 5 choices, VR software, hardware and/or delivery system (for example, Internet/World Wide Web) are chosen.

Step 6. The virtual environment (VE) is designed and built.

- According to requirements of the objective, it may be built
- by instructor or virtual world builder,
- by the students,
- or obtained prebuilt and modified.

Step 7. The resulting virtual environment is evaluated using a pilot group of students.

Step 8. Evaluation results are used to modify the virtual environment. Steps 7 and 8 are repeated until the virtual environment is shown to successfully measure or aid in attainment of the objective.

Step 9. The virtual environment is evaluated using the target population.

Step 10. Evaluation results are used to modify the virtual environment. Steps 9 and 10 are repeated as needed to keep the virtual environment relevant to the objective. Evaluation and modification continues as long as the virtual environment is used with the target population.

The model is shown in Figure 1.

The author has used this model as part of student assignments in virtual reality courses since 1995. It has been revised a number of times. The model is based on the work of Dr. Leslie J. Briggs and Dr. Robert Gagné (see Gagné & Briggs, 1979, for a thorough explanation of their model for instructional design).

It is a tribute to the work of Briggs and Gagné, and to that of leaders in the use of simulation in teaching, such as Dr. Martha Jane K. Zachert (see Zachert, 1975; Zachert & Pantelidis, 1971), that their models and the results of their work, can be adapted and used with the still evolving technology of virtual reality at the beginning of the 21st century.

Conclusion

Virtual reality has a place in education and training. Research on educational applications of VR, as well as research on the educational use of simulations has shown its value. There are many reasons to use VR and advantages to using VR. The educator or trainer has only to determine when to use it. The use of a model can help make that determination. Such a model can play a part in the continuing search for ways to use virtual reality in education and training courses.

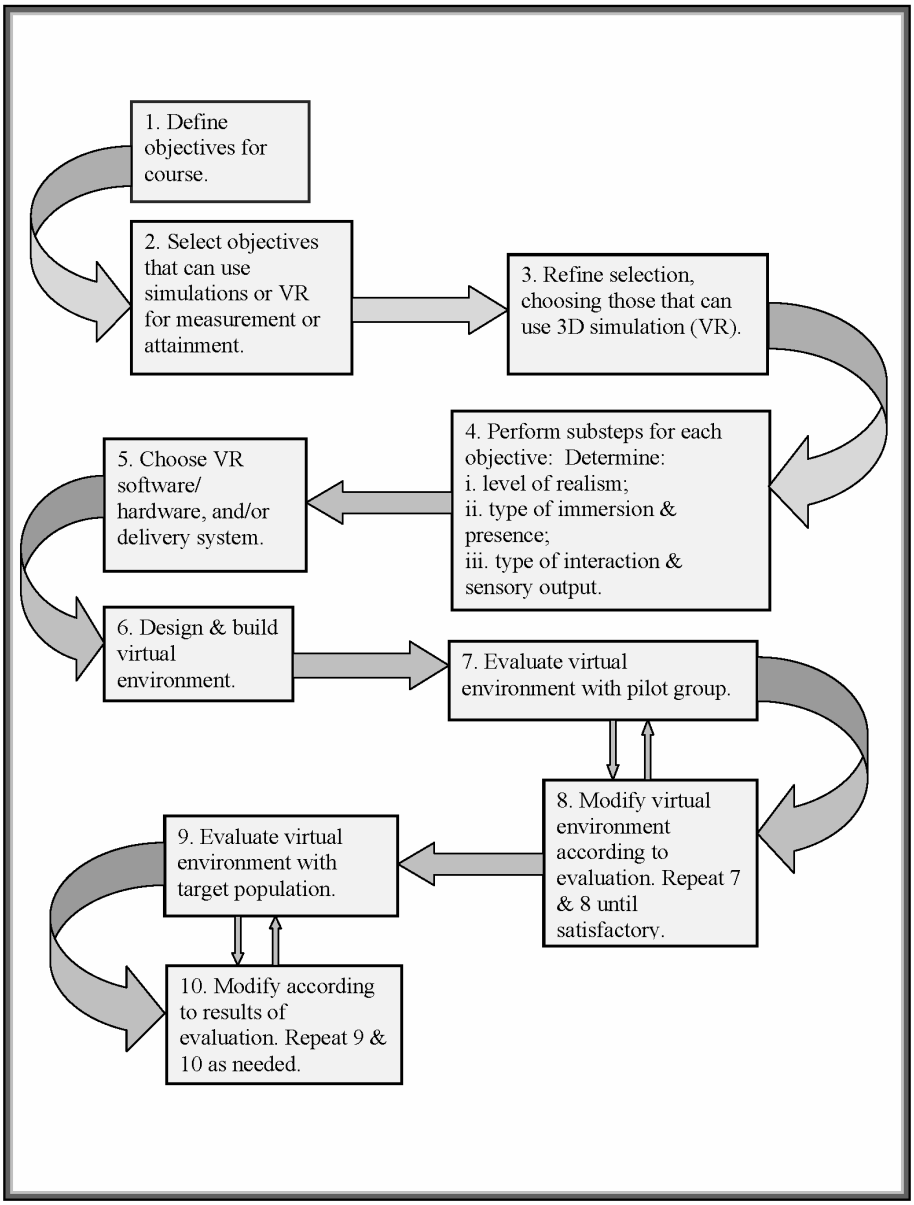

Figure 1. Model for determining when to use virtual reality in education and training courses. Copyright 1997, 2009 by Veronica Sexauer Pantelidis.

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