A case study of engaging primary school students in learning science by using Active Worlds

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Underachiever students often have difficulties in focusing attention on learning and easily lose their interest. The purpose of this study was to explore how the three-dimensional (3D) Virtual Learning Environment (VLE), Active Worlds, could engage underachiever students in learning the scientific concept of the Solar System. A group of ten underachiever students from the primary 5 grade were selected to participate in this study. They were tasked to make use of Active Worlds to build 3D objects that could display information correctly about the Solar System. Results showed that the students were engaged in the learning task and expected more topics. The information presented in the virtual space was accurate. Some issues regarding student engagement and implications of using VLEs for teaching and learning are discussed.

Keywords: Virtual Learning Environment, VLE, 3D, online games, engaged learning, Active Worlds, under achievement, primary science

Introduction

In Singapore schools, students start to learn scientific concepts like Cell Division and the Solar System in primary 5. These concepts are rather abstract in nature since they are physically hard to be seen or touched. Consequently many students, particularly those underachievers whose performance scores in subject tests are consistently below the 25th percentile (cf Swanson & Lussier, 2001), have difficulties in learning Science. This may lead to them losing interest in the subject and eventually turning into a negative attitude towards learning.

However, a majority of primary school students are interested in playing computer games. A most striking feature of games is their ability to motivate and challenge the children (cf Kafai, 2001). Much research indicates that students were more engaged in learning and had greater retention when computer games were used compared to conventional classroom instruction (cf Knobloch, 2005; Randel, Morris, Wetzel, & Whitehill, 1992). Many children spend much time trying to master the rules, functionalities and strategies of the computer games just because they like the challenging activities involved. With the advancement of broadband technology, online gaming becomes more accessible than ever. It is common to see children gathering and gaming. Some of them even exhibit addictive behaviour towards computer game playing (Harris, 2001).

Online gaming in a virtual learning environment (VLE) has great potential in motivating students in learning Science. This new technology enables the teacher to present scientific knowledge in a way more appealing to students than traditional textbooks. This appeal may lead to an increased level of engagement with the content and improve the students' understanding of abstract scientific concepts. The main purpose of this study was to explore how the three-dimensional (3D) VLE, Active Worlds, could engage a group of underachieving primary 5 students in learning the scientific concept of the Solar System. In this study, the underachiever students were tasked to make use of Active Worlds to build 3D objects that could display information correctly about the Solar System. Through this learning task, hopefully they would better understand the concept of the Solar System. The research question of this study was:

Can the Virtual Learning Environment help to engage underachievers in learning the scientific concept of the Solar System?

Literature Review

Engaged learning

Engaged learning is not a new concept. It can be traced back to the earlier years of the twentieth century when Dewey (1933) argued for active and engaged learning through inquiry. Engagement is often defined as 'the mobilization of cognitive, affective and motivational strategies for interpretive transactions with text' (Bangert-Drowns & Pyke, 2001, p215). This definition is rather abstract to an extent. Jones, Valdez, Nowakowski and Rasmussen (1994) defined engaged learning by giving the following concrete indicators:

- Engaged learners are responsible for their own learning, and find excitement and pleasure in learning.
- The tasks for engaged learning are challenging, authentic, and multidisciplinary.
- The assessment of engaged learning is performance-based and generative, and it has equitable standards that apply to all students.
- The instructional strategies for engaged learning are interactive and generative.
- The context for engaged learning is a knowledge-building learning community, collaborative and empathetic.
- The grouping for engaged learning is heterogeneous, flexible and equitable.
- The roles of teachers are facilitators, guides, and co-learners; the roles of students are explorers, cognitive apprentices, and producers of knowledge.

The use of information and communication technology (ICT) can help to produce some of the above indicators and hence has potential to engage learners. For instance, an ICT-based learning environment designed for problem-based learning often involves challenging, ill-structured, and authentic problems to solve (Boud & Felleti, 1991; Savery & Duffy, 1995). It supports various types of interaction such as learner-content, learner-learner, and learner-teacher (Chou, 2003; Moore, 1989). These types of interaction make the learning process more interactive and the learners more active and engaged. An ICT-based learning environment also often supports collaborative learning, where students work in groups to share ideas, negotiate solutions, and construct knowledge collaboratively. Moreover, an ICT-based learning environment often involves more generative work, in which students produce multimedia programs, web sites, concept maps, or presentations.

Much research evidence also confirms that ICT can promote students' engaged learning. For example, in a research study on the uses and effects of mobile computing devices in K-8 classrooms, Swan, Van Hooft, Kratcoski, and Unger (2005) reported that the students' motivation to learn and engagement in learning activities was improved by the use of mobile computing. In another study on the use of the video game *Morrowind,* Kadakia (2005) found student engagement in the content and the instructional process was greatly increased. Lim and Tay (2003) also observed higher students' engagement in higher-order thinking when they were using ICT tools.

Virtual Learning Environments (VLEs)

VLE, sometimes called virtual reality, is usually a network-based computer program in which users move and interact in simulated 3D spaces (Dickey, 2005). It is characterized by a high degree of immersion and interaction, which makes the users feel they are actually inside the artificial environment (Trindade, Fiolhais, & Almeida, 2002). A VLE often involves a variety of tools for educational purposes, such as conferencing software, interactive simulations, shared whiteboards, and asynchronous and synchronous discussion forums (Britain & Liber, 1999).

VLEs offer a wide range of advantages over the traditional classroom environment. Some of the advantages include convenience, flexibility, easy access to materials, elimination of geographical boundaries, and increased retention of knowledge. Additionally, VLEs enable learning to become more student-centred, and emphasize interaction and collaboration between students and academics (Harasim, Hiltz, Teles, & Turoff, 1995).

Educators believe that VLEs can benefit people with intellectual disabilities in special education (cf Standen, Brown & Cromby, 2001). Pantelidis (1993) argued that VLEs could encourage active involvement in learning and give users an experience of control over the learning process. This is crucial for people with intellectual disabilities who have a tendency to passive behavior, because VLEs can i) create opportunities for them to learn by making mistakes but without suffering the consequences of errors; ii) be manipulated in ways the real world cannot be; iii) convey rules and abstract concepts without the use of language or other symbols (Cromby, Standen, & Brown, 1996; Sims, 1994).

Many concrete research studies have confirmed the potential of using VLEs to engage learners. Dede, Salzman, and Loftin (1996) reported higher learner engagement, surprise and understanding of the alternative representations of the concepts provided in the ScienceSpace worlds, where students explored the kinematics and dynamics of motion, electrostatic forces, and other physics concepts. In a comparison between immersive groups using a VLE designed to teach children about the structure and function of cells and non-immersive treatment groups, the immersive subjects demonstrated better retention of symbolic information, and indicated more interest in taking a free biology class as a result of the experience (Gay & Greschler, 1994). In the Virtual Gorilla project where users could adopt the role of an adolescent gorilla to navigate the environment and observe other gorillas' reactions, interviews with users also elicited favorable responses in the sense of immersion, enjoyment, and successful communication of learning goals (Allison, Wills, Bowman, Wineman, & Hodges, 1997).

Little research has reported whether VLEs can motive underachiever students to learn and perform better. As VLEs have a number of positive features such as flexibility and allowing students to learn at their own pace, therefore slower students are no longer pushed by the faster or more experienced peers. VLEs have the possibility to benefit underachiever students. In this study, we examined the use of a VLE (Active Worlds) to motivate and engage underachiever students.

Method

Participants

This study was carried out in a primary 5 class at a neighborhood school in Singapore. On average, this class had lower performances than the other seven classes at the same grade level. This class consisted of thirty students. All of them had basic ICT literacy skills in using the Internet, Microsoft Word, and PowerPoint.

A group of ten students (4 boys and 6 girls) were selected to participate in this study. Their average age was about 11. These students often forgot to do their homework or bring their textbooks to school. Moreover, they consistently performed poorly in topical tests. They were commonly considered as underachievers by subject teachers.

Learning Task

As a remedial learning activity, these students as a group were given a learning task of building a 3D Solar World by using the Active Worlds (http://www.activeworlds.com/) platform in eight sessions of two hours each. All of the eight sessions were conducted in a computer lab during their off-class time within a month. They were required to create nine 3D planets in a virtual space and give correct descriptions to the planets. After completing this learning task, they were expected to be able to: i) describe the nine planets correctly; and ii) become more interested in learning Science. We hoped to achieve the following positive indicators of engaged learning (Jones et al, 1994):

i) The students found excitement and pleasure in learning the topic.
ii) The task was authentic and challenging.
iii) The learning context was interactive and collaborative.
iv) The learning activity was more student-centred.

Instruments

Data were collected by using the following instruments: lesson observations, interview with students, and students' project assessment.

Lesson observations
During the eight sessions, the teacher, who was also a researcher of the study, observed what the students were doing, and took notes on their activities and questions. The observation notes would help the researchers examine students' engagement.

Focus group interview
After finishing the learning task, a two-hour focus group interview was conducted to elicit these students' in-depth perceptions towards the use of the VLE. Five participants were selected for the interview, as these students were more willing to share their feelings.

Assessment of the students' project
The students' artifact was assessed by following the Iowa Diorama Rubric (http://soli.inav.net/~rpmic/iowa/rubrics/diorub.htm). The assessment focused on appearance of the artifact, content, images, labeling, organization, knowledge, and resources.

Results

Observational results

The students were very excited when they were first introduced to the Active Worlds program. They were curious what the program was about, what functions it had, and how to control objects in the virtual space. When the tutor was demonstrating some basic features of the program, they were totally attracted, engrossed, and also very quiet. They behaved quite differently compared to how they performed in traditional classes, where they were very disruptive, talkative, and showing no interest in lessons.

Another encouraging phenomenon was that the students attended all the sessions on time without any absence. This was quite unusual as they often late or even absent. Moreover, this was the first time that these students showed initiative coming together after school to discuss design and layout of their projects. They also managed to meet the deadline of the project.

The multimedia capability of the virtual environment motivated the students to explore further. The students were intrigued with the graphics, animation, and sound effects of Active Worlds, which mimics real world features like ponds with flowing water, buildings and signposts. Sounds of flowing water and chirping of birds could be heard as the students were exploring Active Worlds. The multimedia feature such as 3D graphics, animation, and sound effects kept the students excited throughout the sessions. In addition, interactivity was another factor that helped to engage the students in learning. The students were observed actively interacting with the virtual space. They enjoyed the teleport machine that brought them from one world to another world.

We observed that the chat and online discussion functions in the program promoted further collaboration. Even though they were in one computer lab, they still loved to talk to others through the chat function. Also, they often used the online discussion forum to share information or discuss with others, even with overseas people who visited their project space. Furthermore, the students liked to see an avatar, which was a visual representation of the person they were chatting with.

The students became very active in the learning process as the learning task was authentic and rather challenging for them. They went to the Internet to search for relevant information, to compare and discuss the information collected, and decide if the information was accurate and hence could be used. They were not passive information receivers any more.

However, the students were also observed with some technical problems when they were creating the virtual space. The access to the Active Worlds platform sometimes was slow. Also, as Active Worlds involved many animated graphics and sound effects, it often took much time to download the multimedia elements. The slow access to the VLE often frustrated the students.

Focus group interview

The student interview confirmed that the students were very excited with the use of the 3D space in Active Worlds. One student commented that it was his first time that he enjoyed such a learning task because he loved the game-like environment. Another student felt empowered since he was able to control the avatar's movements and actions in the virtual space. The other students also stated that they enjoyed building the 3D world as they found it more interesting than learning from the textbook.

The students also stated that creating a 3D space in Active Worlds helped them understand the subject content better. One student reported that 'Although I have to spend much more time in learning the scientific concepts but I think I have learnt better because Active Worlds allows us to explore and discover information.' Another student said that 'Now I know different planets have different sizes. Jupiter is the biggest planet in the Solar System. We have to take this into consideration when building the Solar World.' An additional student commented, 'Now I am able to visualize how the nine planets revolve around the Sun. I prefer to study Science in this way than the normal tradition classroom teaching.'

Active Worlds provided a platform that enabled inquiry-based learning. One student stated that he was able to make use of the search engine more effectively in gathering information. This encouraged him to go online to search for information whenever he faced problems in understanding abstract scientific concepts. Another student stated that she even went to the National Library to borrow books for this project.

The interview result indicated that the students loved the interactivity feature of the virtual learning environment. They enjoyed the online discussions among themselves and with others around the world because they seldom got the chance to interact with others in other countries. They thought that building the 3D space gave them an opportunity to communicate with other people.

The students also expected that this virtual learning environment would be used in other science topics or other subjects. A student commented that building a virtual space in Active Worlds was so interesting and enjoyable that more learning tasks would adopt this approach. They agreed that using game-like VLEs could make learning more fun.

The students interviewed also confirmed the difficulties they met in building the Solar System. One student stated that he had spent a lot of time online figuring the different tools available to build the Solar World. He even tried to chat with the other users in Active Worlds to find out more about how to make the planets rotate. Another student commented that he did not have broadband at home. It took him a long time to load up graphics. Eventually, he decided to stay in school and used the school library computer to complete the project.

The students' project

The students spent eight sessions (16 hours) building the Solar World. They managed to complete the learning task within the time frame. Also the final artifact was amazing. Figure 1 shows a screen shot. They were able to obtain a good score for each category in the Iowa Diorama Rubric as shown in Table 1. Most importantly, all the information displayed in the Solar World was accurate and free from grammatical errors, which indicated that the students had put in great effort in doing the learning task and mastered the scientific concepts well.

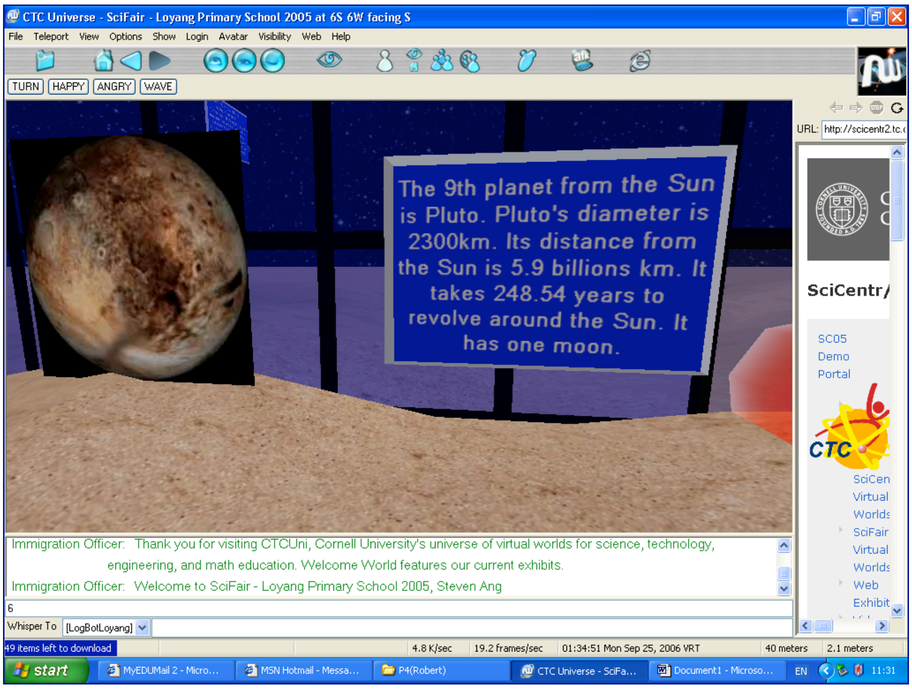

Figure 1: A screen shot of the students' project

Table 1: Assessment result of the students' artifact

Category	Score (1..7)	Description
Creativity & Appearance	5	Good creative effort. Project is neat and shows evidence of time spent on it.
Content Facts	5	The project content is good and suggests the student has discovered most of the important facts of the topic.
Images & Models	7	All images or models are effective and balanced with text use.
Content Labeling	7	There is no spelling or labeling error. All labels are neatly written.
Style & Organization	5	Display is interesting and attractive. Materials are complete and well organized.
Knowledge	5	The diorama demonstrates good knowledge of the topic investigated.
Resources	5	The diorama shows the use of several sources of information.

Discussion

The study showed that the underachiever students were interested and engaged in completing the learning task. The interview results also confirmed that they enjoyed completing the learning task in Active Worlds. They also expected more scientific topics would be conducted in such a way. The information presented in the virtual world was accurate. In this concluding section, some issues regarding student engagement and implications for instructional design will be discussed.

Engaged learning

Underachiever students usually possess lower interest and motivation compared to those high-performance students. However, in this study they showed engagement in the learning process. Three reasons might contribute to this result: i) curiosity; ii) student-centred; and iii) collaboration and interaction.

Completing a learning task in a virtual learning environment was a completely new experience for the students. This study indicated that curiosity was a strong motivational factor for student engagement. They were very excited when they were first introduced to Active Worlds. Even in the following sessions, they kept high curiosity about what the virtual environment could offer and how they could build a virtual space. The students enjoyed exploring the game-like unknown virtual environment.

These reasons for engaging students revealed in this study were consistent with the positive indicators reported by the Jones, et al (1994). The whole learning process was more student-centred, where the students took more responsibility for their own learning, and the learning task was planned with the students as key players. After being given the learning task, they purposely searched for relevant information on the Internet, negotiated, and made decisions. They became active explorers and knowledge constructors in the learning process, not passive information receivers or rote learners as they used to be in a classroom setting. It is most likely that 3D VLEs can promote constructivist learning and help students construct meaningful knowledge (Dickey, 2005; Okan, 2003). The virtual learning environment supported collaborative and interactive learning. According to social constructivism, knowledge is collaboratively constructed in a social context mediated by social discourse (cf. Hirumi, 2002; Liaw, 2004). Learning is fostered through interactive processes of discussion, negotiation, and sharing with others such as peers and teachers. The Virtual Worlds platform in this study allowed the students to communicate and collaborate with others.

It is important to differentiate engagement in playing the game and engagement in completing learning tasks and activities. The most commonly articulated argument for the use of game-like VLEs and other edutainment materials is that such programs motivate students to explore topics in greater depth (Gee, 2003; Okan, 2003). However, putting students in a VLE will not make in-depth learning naturally follow (Earle, 2002). The pedagogical design of the learning tasks or activities is more important than the availability of the VLE as the virtual environment is basically a catalyst to help students complete the learning tasks and fulfil the learning objectives in the end. In addition, we acknowledge that some web-based systems like LAMS (Learning Activity Management System) may help teachers design pedagogically sound learning activities. As educators, we hope that the students cannot just enjoy playing the games in the VLE, but forget about the most important educational purpose of using the VLE, which is to learn the topic (cf. Mandell, Sorge & Russell, 2002).

Time

It seems that learning subject topics by using the Active Worlds environment may take more time than by using the traditional teacher-centered approach. In this study, these students spent 16 additional hours to study the topic of Solar System. Compared to the other students who took about two hours to learn this topic in a classroom, these students spent much more time indeed. However, they were low ability students and they could hardly concentrate on topic learning for more than half an hour in a classroom setting. By using the virtual learning environment, a two-hour learning experience became enjoyable for them. More importantly, by using the VLE they were not only engaged in the learning tasks, but also willing to spend more time on learning and hence developed a positive attitude towards learning. Additionally, they could also develop other skills like communication skills, social skills and higher order thinking skills (Lim & Tay, 2003).

Integrating the technology of VLEs into the curriculum needs a longer time frame. It is hardly possible to use a VLE in only one or two lesson periods, because learning how to use a new software program and use it to develop artifacts requires for much time. It seems that a more feasible way of incorporating a VLE into teaching and learning is to get students work in groups for a long period such as a whole semester by following the project-based learning approach.

It is most likely that time is also a challenge for the teachers who intend to implement VLEs in their teaching. In Singapore, teachers often complain that there is insufficient time to complete the syllabus, with the numerous worksheets and examination practice papers. The time of two and a half hours per week allocated for Science at the primary 5 level is too short for teachers to practice using VLEs in class time. Furthermore, the teachers need time to familiarize with the program and prepare resources for their students. This supports the notion that more easy-to-use and effective authoring systems like LAMS should be developed to help teachers easily create learning activities.

Teacher training and support

Teachers' proficiency level in technology is a crucial factor for successful ICT integration into teaching and learning. Honey, Culp and Carrigg (2000) reported that teacher professional development is one of the six factors that affect ICT integration. The other five factors included leadership, solid educational objectives, adequate technology resources, time, and evaluation. Standen, Brown and Cromby (2001) stated that technology will be ineffective without support for staff even if availability and accessibility issues have been resolved. Light (1997) argued that the failure of technology in education was partly because teachers did not receive adequate training in how to use the technology nor how to use it properly to achieve the learning objectives. In this study, the teacher was keen in using ICT in instruction and had sufficient competency in using the technology. Otherwise, the study would be less successful.

In addition, the use of technology in a computer lab requires the teacher to have sufficient lab management skills. Managing students in a computer lab is different from managing them in the classroom. The availability of computers in a lab may distract the students from concentrating on the teacher's instruction or learning tasks. If the teacher cannot manage the students in a lab effectively, it is hard for such a lesson to be effective (Wong & Wettasinghe, 2003). The typical class size is thirty students in Singapore schools. The computer lab might be in chaos if the teacher lacked student management skills in computer labs. We find that the monitor function of LAMS can help the teacher to keep an eye on the learning progress and therefore effectively manage students.

This study indicates that immediate teacher support is important in an ICT-based learning environment. Although the students had basic computer literacy skills in this study, they still encountered numerous technical problems when they were using Active Worlds. These technical difficulties stalled their learning if they could not get immediate support from the teacher. Consequently, the students might disengage and embark on other activities not relevant to the learning task.

Limitations and future research

This study faced some limitations. First, novel effect of the VLE on student learning might exist in this study. The students completed the learning task of building a virtual space in eight sessions within a month. This relatively short time period might have novel effect on the student interest and learning outcomes. Additional studies can be carried out in a longer time frame in the future to examine whether the students can still sustain a high interest level along a longer time period.

Second, this study only examined the engagement of a small number of students in learning a specific topic of Solar System in the subject of Science. The results cannot be generalized to other dissimilar contexts. More studies can be conducted to explore the possibilities of using Active Worlds to engage students in learning other topics of Science or in learning other subjects. Also, additional studies can be done on a broader population of students including higher and average ability students.

References

Allison, D., Wills, B., Bowman, D., Wineman, J., & Hodges, L. (1997). The virtual reality gorilla exhibit. *IEEE Computer Graphics & Applications, 17*(6), 30-38.

Bangert-Drowns, R. L., & Pyke, C. (2001). A taxonomy of student engagement with educational software: An exploration of literate thinking with electronic text. *Journal of Educational Computing Research, 24*(3), 213-234.

Boud, D., & Felleti, G. (1991). *The challenge of problem-based learning*. London: Kogan.

Britain, S., & Liber, O. (1999). *A framework for pedagogical evaluation of virtual learning environments*. http://www.leeds.ac.uk/educol/documents/00001237.htm [Viewed 2 March 2, 2006]

Chou, C. (2003). Interactivity and interactive functions in web-based learning systems: A technical framework for designers. *British Journal of Educational Technology, 34*(3), 265-279.

Cromby, J., Standen, P. & Brown, D.J. (1996). The potentials of virtual environments in the education and training of people with learning disabilities. *Journal of Intellectual Disability Research,* 40(6), 489-501.
Dede, C., Salzman, M., and Loftin, B. (1996). ScienceSpace: Virtual realities for learning complex and abstract scientific concepts. *Proceedings of IEEE Virtual Reality Annual International Symposium* (pp. 246-253). New York: IEEE Press.
Dewey, J. (1933). *How we think: a restatement of the relation of reflective thinking to the educative process*. Lexington, Mass: D.C. Health.
Dickey, M.D. (2005). Three-dimensional virtual worlds and distance learning: two case studies of Active Worlds as a medium for distance education. *British Journal of Educational Technology, 36*(3), 439-451.
Earle, R.S. (2002). The Integration of instructional technology into public education: Promises and challenges. *Educational Technology,* 42(1), 5-13.
Gay, E., & Greschler, D. (1994). *Is virtual reality a good teaching tool?* Boston Computer Museum.
Gee, J.P. (2003). *What video games have to teach us about learning and literacy*. New York: Palgrave/St. Martin's.
Harris, J. (2001). *The effects of computer games on young children: A review of the research*. http://www.homeoffice.gov.uk/rds/pdfs/occ72-compgames.pdf [Viewed 1 March, 2006]
Harasim, L., Hiltz, S., Teles, L. & Turoff, M. (1995). *Learning networks: A field guide to teaching and learning online*. Cambridge, Mass: MIT Press.
Hirumi, A. (2002). Student-centered, technology-rich learning environments (SCenTRLE): operationalizing constructivist approaches to teaching and learning. *Journal of Technology and Teacher Education,* 10(4), 497-537.
Honey, M., Culp, K. M., & Carrigg, F. (2000). Perspectives on technology and education research: Lessons from the past and present. *Educational Computing Research*, 23(1), 5–14.
Jones, B., Valdez, G., Nowakowski, J., & Rasmussen, C. (1994). *Designing Learning and Technology for Educational Reform*. Oak Brook, IL: North Central Regional Educational Laboratory.
Kadakia, M. (2005). Increasing student engagement by using *Morrowind* to analyze choices and consequences. *TechTrends,* 49(5), 29-32.
Kafai, Y. (2001). *The Educational Potential of Electronic Games: from games-to-teach to games-to-learn*. Retrieved March1, 2006, from http://culturalpolicy.uchicago.edu/conf2001/papers/kafai.html
Knobloch, B. (2005). Reap the benefits of games and simulations in the classroom. *The Agricultural Education Magazine,* 78(2), 21-23.
Liaw, S. (2004). Considerations for developing constructivist web-based learning. *International Journal of Instructional Media,* 31(3), 309-321.
Light, P. (1997). Annotation: computers for learning: Psychological perspectives. *Journal of Child Psychology and Psychiatry,* 38(5), 497-504.
Lim, C., & Tay, L.(2003). Information and communication technologies (ICT) in an elementary school: Students' engagement in higher order thinking. *Journal of Educational Multimedia and Hypermedia, 12*(4), 425-451.
Mandell, S., Sorge, D., & Russell, J. (2002). Tips for technology integration. *TechTrends,* 46(5), 39-43.
Moore, M. (1989). Three types of interaction. *The American Journal of Distance Education,* 3(2), 1-6.
Okan, Z. (2003). Edutainment: is learning a risk? *British Journal of Educational Technology,* 34(3), 255-264.
Pantelidis, V.S. (1993). Virtual reality in the classroom. *Educational Technology,* 33(4), 23-27.
Randel, J., Morris, B., Wetzel, C., & Whitehill, B. (1992). The effectiveness of games for educational purposes: a review of the research. *Simulation and Gaming*, 25, 261-276.
Savery, J., & Duffy, T. (1995). Problem based learning: an instructional model and its constructivist framework. *Educational Technology,* 35(5), 31-38.
Sims, D. (1994). Multimedia camp empowers disabled kids. *IEEE Computer Graphics Approaches*, 14, 13-14.
Standen, P., Brown, D., & Cromby, J.(2001). The effective use of virtual environments in the education and rehabilitation of students with intellectual disabilities. *British Journal of Educational Technology,* 32(3), 289-299.
Swanson, H., & Lussier, C. (2001). A selective synthesis of the experimental literature on dynamic assessment. *Review of Educational Research,* 71(2), 321-363.
Swan, K., Van Hooft, M., Kratcoski, A., & Unger, D. (2005). Uses and effects of mobile computing devices in K-8 classrooms. *Journal of Research on Technology in Education*, 38(1), 99-112.

Trindade. J., Fiolhais, C., & Almeida, L. (2002). Science learning in virtual environments: a descriptive study. *British Journal of Educational Technology,* 33(4), 471-488.
Wong, P., & Wettasinghe, M. (2003). Managing IT-Based learning environments. In S.C. Tan & F.L. Wong (Eds.), *Teaching and learning with technology: an Asia-pacific perspective* (pp60-76). Singapore: Prentice Hall.

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