The Impact of Using Video Games and/or Virtual Environments in Pre-service Elementary Teacher Science Education

Janice L. Anderson, University of North Carolina at Chapel Hill, Peabody Hall 307A, CB#3500, Chapel Hill, NC 27599-3500, Email – anderjl@email.unc.edu

Abstract: The purpose of this work is to share findings in using video games and/or virtual environments to facilitate the understanding of basic science concepts with pre-service elementary teachers. We explored the impact of using a game called *Supercharged!* on pre-service teachers' understanding of electromagnetic concepts compared to students who conducted more traditional inquiry oriented investigations. Additionally, we looked at how students responded to learning about water quality through their participation in the virtual environment known as *Quest Atlantis.*

The Major Issue

Many scientific domains deal with abstract and multi-dimensional phenomena that students have difficulty with both in comprehension and application. Mastery of abstract scientific concepts requires that students build flexible and testable mental models (Barnett, Keating, Barab & Hay, 2000; Redish, 1993). Digital technologies can immerse the learner in worlds that not only represent scientific phenomena, but also behave according to the rules of physics and other scientific phenomenon. By representing the simulation through digital gaming conventions, educators can potentially increase engagement while also fostering deeper learning, as learners engage in critical and recursive game play, whereby they generate hypotheses about the game system, develop plans and strategies, observe their results and adjust their hypotheses about the game system (Annetta, 2008; Gee, 2003; Mayo, 2009; Squire, 2008). Supporting future elementary teachers in learning basic science concepts has proven to be challenging (e.g. McDermott & Shaffer 2000; Schoon & Boone, 1998). In fact, many science educators have recognized that elementary teachers struggle teaching science topics conceptually (Forbus, 1997; diSessa, 2000). Elementary teachers have particular difficulty in comprehending physics concepts, such as the basics of electrostatics, which have very few real-life referents and incorporate invisible factors, forces operating at a distance, complex abstractions (Chi, et al., 1991). We believe that educators might use gaming structures such as fantasy, challenges, cooperation, or competition to create even more powerful learning tools, coupling the intrinsically rewarding aspects of games with the pedagogical power of simulations in order to teach complex conceptual science topics (e.g. Cordova & Lepper, 1996).

Context, Methods, and Analysis

This study examined the pedagogical potential of *Supercharged!* and pre-service teachers engagement with *Quest Atlantis*. We first examined the classroom practices that emerged when *Supercharged!* was used to teach an electrostatics unit in an undergraduate content course designed for future elementary teachers. The control group (n=65) participated in a series of scientific investigations that were designed to help them learn the same concepts as their experimental group (n=71) peers. These investigations included understanding the force of a magnetic field on a charged particle, the relationship between force on a test charge and distance, and the impact of electric fields on charges. The experimental group was expected to complete five levels of the *Supercharged!* game where at each level there was increased difficulty or the introduction of a new concept. The quantitative data was analyzed using ANOVA and ANCOVA analysis. The qualitative data was analyzed using naturalistic methods (Lincoln & Guba, 1985) to examine how learning unfolded during game play. Using the constant-comparative method (Glaser & Strauss, 1967), researchers generated assertions from the data, consulting video tapes and field notes to search for supporting and disconfirming evidence.

The second part of this study examined how pre-service elementary education teachers perceived and interacted with an immersive, 3D virtual world – *Quest Atlantis.* Students in a elementary science methods course engaged with *Quest Atlantis* using the *Taiga* unit on water quality. The students (n=75) participated in the water quality activities while, learning the science content as well as the pedagogical tool. This qualitative data was analyzed using naturalistic methods (Lincoln & Guba, 1985) to understand students' perceptions of how these environments could be used in the classroom setting. Researchers generated assertions from the data, consulting field notes in order to search for supporting and disconfirming evidence.

Results

In general the experimental group outperformed the control group on the conceptual assessment questions.

Table 1: Pre-Post Assessment Results.

Group	N	N_M	N_F	Pre-Test	Std. Dev	Post-Test	Std. Dev	Change
Experimental	71	30	41	6.2	1.70	9.4	1.20	3.2
Control	65	20	45	5.9	1.72	8.3	1.27	2.8

A two-way ANOVA was also calculated with post-test scores as the dependent variable. Intervention (Experimental or Control) and Gender (Male or Female) were between-subjects variables. There was a significant difference between the experimental and control groups, $F(2,134) = 4.8$, $p < 0.05$, $\eta 2=0.59$. The qualitative data supported the idea that the students in the experimental group began to see themselves as the charge experiencing forces which influenced their understanding of how magnetic fields effect charged particles. Additionally it was shown that the game play supported student conversations on "force vs. distance" and the trajectory of moving charges and superposition of forces. Finally, despite the positive learning gains, students in the experimental group disliked the playing of the game versus traditional instruction.

In the *Quest Atlantis* experience, students engaged in the 3D water quality environment. The qualitative data exposed the notion that the students were concerned about "the role of the teacher." They had difficulty understanding the paradigm shift in their role from being the "distributer" to the "facilitator of inquiry." Additionally, students became concerned about student play versus what they perceived to be learning in the environment. While content was presented on topics of water quality (dissolved oxygen, pH, turbidity, etc) and ecosystems, this educational value appeared to be lost on these students. Students had very traditional ideas about what constituted classroom learning.

Conclusions

Our findings suggest that video game designers should embed meta-cognitive activities such as reflective opportunities into educational video games to provide scaffolds for students and to reinforce that they are engaged in an educational learning experience. For example, most educational video games that are being used in classrooms have an implicit assumption that learning and skill development, such as scientific argumentation practices, will unfold organically. Steinkuhler and Duncan (2008) found that game-related forums were rich sites for social knowledge construction where "discursive practices include argument, counter-argument and the use of evidence to warrant one's claims"(p.541) was prevalent and where "the predominant epistemological disposition exhibited in the forum posts was 'evaluative' and therefore appropriate to science" (p. 541). This study supports these notions purported by Steinkuhler and Duncan (2008), but we include the caveat that learning would be supported if appropriate scaffolds are purposively built into video games.

Additionally, in the *Supercharged!* study, we were concerned that the experimental group of students did not find playing the game to be a learning experience. This perspective was also demonstrated with the *Quest Atlantis* pre-service teachers. There are several reasons for these viewpoints. First, *Supercharged!* has a relatively unpolished graphical interface compared to what students may experience in game consoles (3D), television (HD), or movies. Another reason could be that the game-based lab was vastly different from their expectations and experiences of a typical lab resulting in the students being disconnected from the learning aspect of the game, instead judging it solely on "entertainment" value. However, the students' writing and comments suggested that their discomfort with the video game and virtual world was due to the fact that neither group perceived that video games or virtual worlds could have educational value. This perspective is potentially problematic; if pre-service teachers do not see video games and virtual environments as a learning tools during their teacher education years, then it is unlikely that they will experiment with games or use them as a part of their own practice once they have their own classroom (e.g. Russell, Bebell, O'Dwyer, & O'Connor, 2003).

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