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STEM and ICT Instructional Worlds: the 3D Experience, the Impact on Today's Students

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Abstract

STEM-ICT Instructional Worlds: The 3D Experience is a *National* Science Foundation funded ITEST program. The project translates the success of earlier projects and moves toward implementation of 3D virtual immersive environments that were replicated with middle schools in North and South Carolina. *STEM-ICT 3D* inspired middle school students to pursue studies and careers in science, technology, engineering, and mathematics (STEM), as well as prepare students with the skills necessary to succeed in STEM education and careers. This article presents the results of the evaluation of the STEM-ICT 3D project through the use of a mixed-methods approach including student interviews, focus groups, and multiple administrations of the previously validated *Attitudes of Middle School Students Towards STEM Survey* (MARS).

Keywords: *STEM, ICT, 3D, virtual immersive environment*

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Introduction

What is the impact on students with the implementation of 3D immersive virtual environments into instruction? What affect will this 3D immersive virtual environment have on student learning as well as changes in the way that students learn science, technology, engineering, and mathematics (STEM) material? The online environments have become more complex over the years due to higher bandwidth availability and new technology including the evolution of social networking sites such as Facebook, massive multiplayer online role-playing games (MMORPGs) such as the World of Warcraft and Minecraft and virtual worlds such as Second Life. Despite evidence that today's K-12 students are actively engaged in the use of virtual environments, typically in a non-school environment, there has been little to no effort to explore the roles that these settings can play in teaching, learning and collaboration. *STEM and ICT Instructional Worlds: The 3D Experience* (STEM-ICT 3D) is a National Science Foundation Innovative Technology Experiences for Students and Teachers (ITEST) strategies project that seeks to address and understand this need.

STEM-ICT 3D was an initiative of the Carolinas Virtual World Consortium composed of Appalachian State University and Clemson University in partnership with Davie and Catawba County Schools in North Carolina, and Oconee and Pickens County Schools in South Carolina, the Appalachian State University Mathematics and Science Education Center (MSEC), North Carolina Department of Environment and Natural Resources (NCDENR), and Teleplace, Inc. The project inspired middle school students to pursue studies and careers in science, technology, engineering, and mathematics (STEM) – particularly information and communication technology (ICT) fields - as well as prepare students with the skills necessary to succeed in STEM education and careers. *STEM-ICT 3D* incorporates a series of activities that provide an engaging, safe environment for middle school students and teachers to explore STEM concepts through a unique approach where students, serving as the technical experts, collaborate with their teachers to develop an inquiry-based learning project for use in a 3D immersive virtual environment.

The objective of this article is to present the impact on students and the outcomes of *STEM-ICT 3D*, and it examines the use of students as technical experts collaborating with teachers, the pedagogical experts, to build 3D virtual worlds for middle school instruction. The overview of the project including some of the literature and research that contributed to the conceptualization of the program will be covered, followed by a description of the impact and outcomes of the students following three years of the STEM-ICT Instructional Worlds: The 3D Experience project and the evaluations of the students.

The STEM-ICT 3D project used a mixed-methods approach including student interviews, focus groups, and multiple administrations of the previously validated *Attitudes of Middle School Students towards STEM Survey* (MARS). Results to date indicate significant increases from pre- to post-test results on the *MARS* in comfort level with technology and that math classes were preparing students for majors in engineering. Based on feedback throughout the year, students have expressed a greater interest in STEM. By placing students in the role of teacher, they have had the opportunity to transfer their 3D modeling skills in ways that were challenging, particularly by encouraging the students to become experts.

The STEM-ICT 3D project and findings are significant because there has been little effort to explore the role 3D immersive virtual environments play in teaching and learning, despite evidence that today's students are actively engaged in their use.

Evaluation of the STEM-ICT 3D project uses a mixed-methods approach including student interviews, focus groups, and multiple administrations of the previously validated *Attitudes of Middle School Students Towards STEM Survey* (MARS). Results to date indicate significant increases from pre- to post-test results on the *MARS* in comfort level with technology and that math classes were preparing students for engineering majors. Based on feedback throughout the year, students have expressed a greater interest in STEM. By placing students in the role of teacher, they have had the opportunity to transfer their 3D modeling skills in ways that were challenging, particularly by encouraging the students to become experts. One of the most lasting impacts of the program is that the STEM-ICT 3D project created an environment in which students felt moved to help others. The STEM-ICT 3D project and findings are significant because there has been little effort to explore the role 3D immersive virtual environments play in teaching and learning, despite evidence that today's students are actively engaged in their use.

Research Method

In response to a request from the STEM-ICT 3D project team consisting of faculty from Appalachian State University and Clemson University, a research team from Evaluation, Assessment, and Policy Connections (EvAP) in the School of Education at the University of North Carolina at Chapel Hill conducted a study to assess the extent to which STEM-ICT 3D met project goals of increasing STEM interest among middle school students and increasing the use of 3D immersive virtual world technology in classrooms. Twenty-three teachers in North Carolina and South Carolina and twenty-four seventh grade middle school teachers from North Carolina and South Carolina participated in the experience, beginning in June 2010 and continuing through June 2011.

The components of the STEM-ICT 3D project included a collaborative summer workshop experience for students and teachers, virtual meetings for teachers, a student Tech Team, and the first Virtual World Conference for Educators. The first half of the nine-day summer workshop for students included an introduction to 3D immersive virtual world technological skills, introduction to Google sketch-up, virtual collaboration with students in a different location, and field trips to introduce students to STEM careers. Teachers joined students for the second half of the workshop, and the students acted as teachers and coaches to facilitate teacher learning of 3D immersive virtual world technological skills. During the four-day workshop for teachers, participants were introduced to 3D technological skills, Teleplace, and Presence Pedagogy. Teachers also began development of lesson plans using Teleplace, the 3D immersive virtual world technology. Data were collected regarding each component of the teachers' and students' experiences and included questionnaires, virtual interviews, and review of program documents.

The purpose of the evaluation was to determine the extent to which STEM-ICT 3D met project goals and objectives, as well as provide information about how the program can be improved. To that end, Evaluation, Assessment, and Policy Connections (EvAP), a unit within the School of Education at the University of North Carolina at Chapel Hill proposed a collaborative evaluation approach (O'Sullivan, 2004) to ensure that evaluation efforts engaged and benefited the program's key stakeholders. EvAP proposed to work collaboratively with program staff to a) develop evaluation instruments, b) implement data collection, c) analyze data, and d) provide a summary report of findings that highlight program strengths, identify challenges, and consider unexpected outcomes. EvAP met with STEM-ICT 3D program staff throughout the project's duration to review strategies, data collection methods, and evaluation progress. Data included in this report were collected during the first year of the STEM-ICT 3D program 2009-2010 (O'Sullivan, Kendall, Campbell, Brown & Milton, 2010-2011.)

Parental comments suggest changes in student participants. For example, one parent explained that her daughter went from a D in science to a high B average in school after attending the summer academy on the university campus. That gave the parents the incentive to go ahead and purchase a laptop computer for their daughter. The parents have told us that their daughter now wants to enter a STEM position after she graduates from college.

One of the values of using a 3D space is the capability to communicate and collaborate with other people across a distance. The students were able to work and learn with students from across state lines as well as work with other students from across county lines in North and South Carolina. The impact of this experience on the student has been exceptional. Students from two different county schools in North Carolina met online to work collaboratively and learn together. The lesson dealt with "SUCCESSFUL ENTREPRENEURS" which uses statistics, research, ICT skills, collaboration, and the 3D virtual world to learn and write a presentation. The learning experience the students received has been positive. The classroom instructor has reported that the students ask every day when will they be able to have another lesson in the virtual world with another school in North Carolina. The more we involve our students inside the 3D virtual world; the greater the impact we have on their future outlook for college and the STEM profession. Studies have shown that learner engagement is paramount to learning success (Lim, et al 2006). The 3D immersive virtual worlds keep the student engaged and interested in the subject being taught in the environment. With this engagement we are making an impact on the student through learning, and the STEM subjects being taught.

The influence on these students has been very positive. It was so positive that we started a "Technology Team" for the students, where attendance is strictly voluntary for the cohort 1 & 2 students. Out of forty-eight students; the attendance has been twenty to twenty-four students a week in attendance. We are teaching the students how to use different types of technology inside the virtual world to make instructional videos and how to edit the videos using free software. The students are also learning how to use photo-editing software to reduce the size of pictures to be used inside the virtual space. The students used their skills learned in the summer academy and during the technology team lessons to build six new educational forums to be used by teacher from both North and South Carolina dealing with different STEM subject that meet both state's curriculum guidelines and standards. The

educational forums the students created while being members of the Technology Team were also used as training examples of the types of courses that can be taught in the virtual world, during the 2011 Virtual World Conference for Educators held at Appalachian State University, Boone, North Carolina on June 23-24, 2011. During the conference on June 23rd, 2011, an EvAP (Evaluation, Assessment, and Policy Connections) University of North Carolina at Chapel Hill, North Carolina, School of Education) evaluator met with 15 students from the STEM-ICT 3D Tech Team in Teleplace, an immersive virtual world space. The virtual focus groups took place during the STEM-ICT 3D Virtual World Conference for Educators. Two separate focus groups were held back-to-back, while a third was conducted the following hour. Seven students were present in the first group, five in the second, and three in the third. Eleven of the participants were male, while four were female.

Results

A summary of the answers to the following questions show a very positive outcome for this program and the people who were involved during the summer academies, the student Technology Team, and the Virtual World Conference (O'Sullivan, Kendall, Campbell, Brown & Milton, 2010-2011.)

1. *What, if any, impact has your participation in Tech Team activities (e.g., after-school club, Virtual World Conference) had on you in or out of school?*

A variety of responses were given to this question, ranging from specific skills students have learned to more general effects. One student stated, *"I didn't care about school before joining the program, but now I want to know more about STEM."* Similarly, another student stated that to join the program, "*my mom made me improve my grades, and I did."* Another participant seconded that comment. Two students remarked that the experience made them realize how much STEM-related knowledge is used in the world. Students specifically mentioned learning more about nano-technology, engineering, science, and math. One student felt smarter. Two students mentioned learning social skills like communication, teamwork, and respect.

2. *What was the most memorable part of the Virtual World Conference for you?*

Four participants noted that interactions with other people were a highlight of the conference. One specifically stated that the most memorable part of the conference was "*working with other people through technology."* Five students remarked that creating and editing utopias was most memorable. Another student indicated that teaching the teachers was a memorable experience, stating that the *teachers "were like us."* Four students from the second group were unable to comment on this question due to technology issues.

3. *What is the one thing you learned from this experience that will stay with you in the future?*

Four students specifically mentioned that Google Sketch-up is the one thing they learned that will stay with them in the future. Two of these students mentioned Google Earth. Two students mentioned that learning about STEM and 3D worlds will stay with them in the future. Group three participants remarked that this experience had implications for what they want to pursue in the future. These students mentioned they want to be a video game designer, virtual world designer, computer technician, or "something with technology." One participant could not mention just one thing, and instead gave several things learned. This student indicated that he learned about STEM, nano technology, MAYA, ALICE, and new career choices.

4. *What, if any, plans do you have to pursue STEM-ICT activities in the future?*

Five students specifically indicated that they are interested in pursuing STEM careers (careers included; computer engineer; architect or biology teacher; electrical engineer; STEM career -2). Three participants noted that they are members of a Robotics team at school. One student shared that he has been invited to participate in Duke University's TIP program, where he will go to San Antonio, TX, to help make Facebook apps. This particular student indicated that he became interested in STEM after participating in the STEM-ICT 3D program. Two students indicated that they are unsure, but noted that there are lots of opportunities. One student said that she wants to be invited back to camp or do related activities, if available.

5. *Is there anything else you would like to share at this time?*

Three participants offered final thoughts. These included a recounting of the mad-scientist project disappearing and how they had to problem-solve to figure out how to address the problem. The other student remarked, *"I hope Teleplace continues, and that I can be a part of it. I really enjoyed the*

program."* Another student stated, *"I liked that it was based at colleges. College students look at us and they just wonder, 'why didn't we get an opportunity like that?' I realized early on that we are so lucky to be here."*

Discussion

In our project, 3D immersive virtual worlds have been implemented in middle schools for instruction in science, technology, engineering, and mathematics (STEM). The learning and playing, as a curricular tool, has enormous potential for engaging children of all ages in deep learning (Lim, Nonis, & Hedberg 2006). *STEM /ICT Instructional Worlds: The 3D Experience (STEM-ICT 3D)* is funded by the National Science Foundation Innovative Technology Experiences for Students and Teachers (ITEST) program. The project is intended to inspire middle school students to pursue studies and careers in science, technology, engineering, and mathematics – particularly information and communication technology (ICT) fields - as well as prepare students with the skills necessary to succeed in STEM education and careers. The project, based on research suggesting student gains in engagement, efficacy, and achievement (Barab, et al, 2005; Educause, 2006; Ketelhut, et al, 2006) proposes to translate the success of an earlier pilot toward a model that can be replicated in other middle schools over time.

STEM-ICT 3D incorporates a series of activities that provide an engaging, safe environment for middle school students and teachers to explore STEM concepts within 3D immersive virtual worlds. Sixth grade teachers nominate rising 7th grade students to attend face-to-face workshops in the summer. During the first week of the *STEM-ICT 3D* Summer Academy, the students learn 3D virtual world modeling and design using Google Sketch-up and Teleplace, a 3D virtual environment. Seventh grade teachers then join their students during the second week of the summer workshops at which time students serve as the technical experts while the teachers learn the pedagogy for using 3D virtual worlds. Teachers and students collaboratively develop a STEM-based learning project for use in a 3D immersive virtual environment. After the Summer Academy, students and teachers return to their respective schools and implement their projects during the academic school year. Appalachian State University provides ongoing weekly training, conference calls, and in person guidance and refresher courses, where appropriate. In the learning communities formed during the summer workshop, both students and teachers mentor each other during the implementation process. University faculty and other experts are active participants in the community and provide assistance as needed.

Conclusion

According to the columnist Jack Hough for the Wall Street Journal magazine, Smart Money, the demands for STEM jobs are increasing. He states STEM employment grew 7.9 percent from 2000 to 2011 which is triple the non-STEM rate. Unemployment among STEM workers is half that of non-STEM workers. Lastly STEM workers out earned their non-STEM peers by 26 percent in 2010. The future of 3D immersive virtual worlds is very positive from our studies and the reports we have received from our teachers, students, and their parents of the impact that we have made in these students lives and their learning experience. This program needs to expand and grow to be able to make a greater impact on students through this educating marvel called 3D immersive virtual worlds. To be able to expand and grow the program, will either be through another federal grant, or there are possible grants through individual states for the those states where you are willing to expand. The other possibility would be to run the program as a summer camp for the students, perhaps in conjunction with colleges located in regional areas or affiliated with Duke Talent Identification Program, or other STEM-focused programs.

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