Using Virtual Reality and Telepresence Robotics in Making

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Abstract: The Nebraska Innovation Maker Co-Laboratory (NiMC) project is developing a model to establish and support makerspaces in rural communities. As makerspaces gain in popularity a chasm has developing between urban access and lack thereof for rural populations. The MiMC model supports collaboration between university faculty and staff and rural makerspaces by utilizing virtual reality and telepresence robots. The exploratory research project deployed telepresence robotics to teach, co-teach and provide project support to a rural community (pop. 7,000) makerspace. Virtual reality was used to teach creativity concepts, VR digital creation and digital to physical manifestation of projects. The NiMC project will continue to explore the model of connection and support of rural makerspaces.

Introduction

The maker movement, which combines learning communities with physical community workspaces called Makerspaces, has gained momentum in recent years through school and community events like Maker Faires (Hlubinka, et al., 2013). The physical makerspace is an important gathering point for tools, projects, mentors/experts that enables a rich learning environment. However, the point of making is not just to have an abundance of tools in one space; rather, it is about helping participants create personally meaningful projects with the periodic help of mentors, experts, and peers in ad-hoc learning communities. The makerspace movement has been successful in large

diverse community centers with ample population bases and local expertise. Currently there exists many high-quality making programs in metropolitan areas across the United States. However, geographic distance in rural states like Nebraska is one of the largest barriers to student participation in Makerspaces, and this issue is compounded further by a general lack of mentors in these areas who have the skills necessary to lead and guide communities of learners (Barniskis, 2014). Rural communities often struggle with digital equity issues and e-connectivity issues that causes them to be left behind in technology-related economic and educational areas (Townsend, Sathiaseelan, Fairhurst, & Wallace, 2013). Rural populations remain isolated from the science, technology, engineering, and mathematics (STEM) resources available in more urban, industrialized regions of the country. Contributing to these inequities is the lack of accessibility to advanced-technology businesses and higher education institutions which isolate youth and declining tax bases in once agriculturally rich communities (Petrin, Schafft, & Meece, 2014).

The NiMC project

To overcome the lack of opportunity to join the maker movement, the University of Nebraska-Lincoln has embarked on the development of Nebraska Innovation Maker Co-Laboratory (NiMC) exploratory project using virtual collaborative spaces and robotic telepresence, to provide rural students and their community access to the movement. Overall, the goal of the project, funded by the National Science Foundation (DRL #723520) is to provide opportunities for teams of youth and mentors to collaborate regardless of geographic location and to creatively problem solve and innovate with cooperating members from the Nebraska Innovation Studio (NIS), a university-based makerspace at the University of Nebraska-Lincoln. Through the project a makerspace was established in Sidney, Nebraska a rural town in Western Nebraska. The second component of the model utilizes telepresence robotics for more focused one-on-one collaboration with experts and mentors in the physical makerspace.

The Makerspace

In collaboration with, Nebraska 4-H/Extension, Sidney Public Library and *Sidney Create!,* a community collaborative which supports the creativity and entrepreneurship of the members within the community the makerspace was installed in the library. Project technology focus areas include: 1) *electronics* (from basic circuit design to microcontrollers and robotics), 2) *textiles* (all flexible materials such as cloth, vinyl, leather, rope, and string, including soft circuits and wearable electronics), 3) *computers* (hardware and software necessary for planning, design, and fabrication), 4) *digital media creation* (filmmaking and digital photography), 5) *music technology* (recording and creating music using technology tools), and 6) *digital fabrication* (3D printing, laser cutting, and computer numerical controlled [CNC] routers).

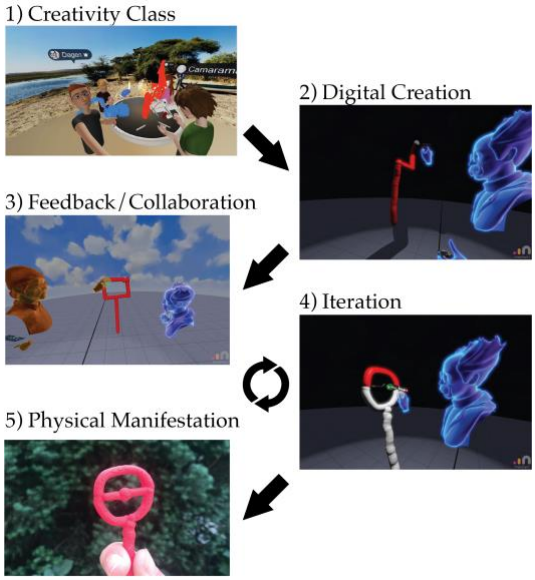
The project has developed opportunities and ways to collaborate with participants and mentors that are geographically isolated through the Oculus Rift + Touch virtual reality (VR) platform. Past research into VR has shown that participants reported a sense of co-presence that facilitates communication and interaction (Alahuhta, Nordbäck, Sivunen, & Surakka, 2014). This ability to cooperatively create and explore 3D objects supports the making process for youth and adults. In addition, the ease with which complex prototypes can be created using virtual tools encourages the exploration of multiple potential solutions to a problem. The software used to collaborate in VR provides the users with a virtual face-to-face interaction which also provides an interpersonal focus within a functional and shared workspace. Immersive VR applications such as *Facebook Spaces*, *High Fidelity*, and *Minecraft VR* enables users to talk, share, and interact with other participants and their virtual artifacts. The VR software applications, *Medium* and *MasterPiece VR,* paired with Oculus Rift + Touch platform, allows participants to draw and sculpt 3D models in the VR environment. Extending and enhancing the digital creation of 3D models in VR is the opportunity to also fabricate these models in the real world using digital fabrication equipment like a 3D printer. In the first year of the project (2017-2018), the use of VR has allowed students to develop project ideas and engage in collaborative problem solving.

In addition, the project utilized two telepresence robotics manufactured by Suitable Technologies, with one being housed at NIS in Lincoln the other at the Sidney makerspace some 400 miles distant. The telepresence robots were used to lead workshops and trainings at the Sidney makerspace with staff from NIS. In February of 2018 the project began a Tinkering Tuesday workshop with youth at the Sidney Makerspace using the robot to provide instructors from Lincoln a presence in Sidney. Faculty from UNL used the robot to guide students in the creation of a Raspberry PI project called the *magic mirror*. The project consisted of taking a two-way mirror and installing a computer monitor connected to a Raspberry PI computer behind one side of the mirror. NIS faculty developed the same project in parallel with the participants in Sidney over the course of eight weeks on Tuesday evenings.

The VR Creative Design Process

The project has formulated a creative design process that starts in the virtual world and is finished as a physical manifestation using digital fabrication equipment. Within this process a learning community is formed using Facebook Spaces and a mentor from NIS. The process (Image 1.0) has five steps including: 1) an introductory collaborative VR Skills course conducted in Facebook Spaces, 2) Digital creation/model development using MasterPieceVR/Medium software programs, 3) Feedback and collaboration in the VR environment, 4) Iteration of the model in MasterPieceVR/Medium, and 5) Sending the file to a physical device (e.g. 3D pinter, CNC router, laser cutter). In this course learners sculpt 3D designs based on the course parameters and share these designs with the other participants. Participants within the space can rotate, move around and generally manipulate the design and provide feedback. In the piloting of the VR creation process a course called *Creative Behavior* which focused on the topic of delaying judgment was delivered to students by project staff. The course began with a short video (within Facebook Spaces) about what it means to showcase delayed judgment. Participants were then encouraged to think creatively, without judgement, to create a fictional animal using the 3D drawing/sculpting tool in Facebook Spaces. Within the VR environment the newly created animal sculptures were passed around and manipulated by the other students in the Facebook Spaces and followed by a discussion of how participants delayed judgement. In the next part of the activity participants used MasterpieceVR, a collaborative sculpting and painting tool to design a "bubble wand" a device that allows students to add soapy water and form bubbles. Collaboratively, the students each designed their bubble wands in MasterpieceVR and then once complete the virtual designs were exported as .obj or .stl formatted files and printed on a 3D printer. The files were transferred seamlessly to MakerBot, a 3D printing software application for printing.

Image 1.0 Digital Creation Process



Project Results

Telepresence Robotics

As an exploratory project, data collection has consisted of short on-line surveys and structured interview questions. To determine the effectiveness of the telepresence robots each session time length piloted by NIS faculty was recorded. Overall, the robots were used for 44 hours to teach and build community with the Sidney makerspace participants both youth and adults. Participants and instructors in Sidney were interviewed to determine their perceptions of using the telepresence robots in the space. When asked how they employed the robots, one respondent noted: "We've used the robot in all kinds of ways. In terms of teaching, it has been used to teach part of the class, while someone else is there to answer questions and do some of the hands-on components." The robots were also used to support the Sidney makerspace with technical questions on the digital fabrication equipment. As a Sidney Library staff member recalled: "We also use it from a technical perspective as well. Just now we were having problems with cutting the acrylic and so staff from Lincoln (through the telepresence robot) helped me identify a different setting that potentially we needed to use, and it worked really well. It allowed to get real time, expert assistance through the robot." The library also reported that the robot was capable of traversing the entire library and interact with library patrons. They noted: "Anytime we have the opportunity to show the robot in a real life setting with people we try to do that. The kids get very excited when the robot comes out too. Then the novelty wears off, and they learn to interact with it, and ask questions as they would with other adults." The use of telepresence robots in the maker environment has enhanced our understanding of building presence in a makerspace using this technology. In addition, the technology has provided an avenue to teach and learn from a distance while building a sense of community. Moreover, the technology has been used successfully to close the geographic distance between experts and learners.

Virtual Reality

As previously mentioned, in the first year of the project, the collaborative VR Creation process was tested with students and teachers. During the pilot phase teachers from three nearby school districts transported 2-3 student to Nebraska Innovation Studio in Lincoln, Nebraska on three separate occasions. These pilot sessions lasted three hours and were followed by a focused interview session at the end of each pilot. The sessions followed the VR Creative Design Process shown above and included content centered on *Creative Behavior*, specifically delayed judgement. In the activity students watched a tutorial in the Facebook Spaces VR application on the behavior of delayed judgement. Next, students completed a tutorial on using the Oculus Rift + Touch platform to sculpt objects in the VR space. Once the activity was complete participants were interviewed using a structured interview process. Overall, seven student and three teachers participated in the interviews immediately after the activity. The interviews were recorded, transcribed and coded in-vivo using MAXQDA Plus version 12.

When asked what they found most interesting students responded that the enjoyed being able to draw and sculpt artifacts, another student noted that were able to create "a ton" of things and manipulate those creations in the VR environment. One student reported that VR was a lot like real life which was surprising to the student. One adult felt that the VR system gave students an opportunity to explore and collaborate. Another felt the system would be an advantage to students who are visual learners. Students reported some negative aspects of the VR activity including the blurry or clouded goggles which made seeing difficult. Clunky navigation systems were hard to figure out in the beginning of the activities.

A frequent theme in the interviews was around creativity and how the VR environment encouraged students to think creatively. On student described it as it set their "imagination on the loose," and they enjoyed being able to rapidly sculpt and "grab things" using the Oculus system. When asked about collaboration in the virtual environment one student noted that they liked the ability to collaborate and that they had to collaborate on a number of different parts during the activity. Another student noted that collaboration was a bit confusing with the ability to manipulate all the objects in the space even those they had not created. One student noted that there was a distinct advantage working collaboratively in the VR environment, noting they could work on the artifact at the same time "without getting in the way of each other." Another student shared a specific example of how they collaborated in the space. In the example, two students were building a butterfly in Facebook Spaces, one student had sculpted the wings while the other had sculpted the butterfly body. Within the VR world, students were able to combine the two separate sculptures into one artifact.

Summary

The NiMC project is an effort to overcome digital inequities in rural communities through the establishment and support of makerspaces using VR and telepresence robotics. This exploratory project established a makerspace in Sidney, Nebraska and have successfully supported the space at a distance using the two technologies. In addition, the project has documented the VR creation process moving digital projects from their inception in VR all the way to their physical manifestation using digital fabrication equipment. The NiMC project will continue to examine the process and look at ways to more closely integrate VR and telepresence robotics. For example, how can the telepresence robot be using to guide students in the digital fabrication process once the student has designed and tested their artifact in the VR world?

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