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Global collaboration and team-building through 3D virtual environments

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Abstract

Certain aspects of healthcare education are difficult to teach in real world environments or in isolated classroom settings. These include, but are not limited to, collaboration and interdisciplinary teamwork skills that are necessary for improved team performance and patient care outcomes. Virtual simulation is a growing field for training and continuous professional development activities and is conducive to local and international clinical training and collaborative projects.

The authors examine theories of collaboration applied to virtual worlds, along with case studies, to demonstrate virtual simulation's applicability to a variety of teaching environments.

In addition, virtual environments have applications to interprofessional healthcare training and team formation. International partnerships for education can benefit from using virtual environments to foster team-building activities without geographic boundaries.

Virtual environments have been instrumental in the growth and sustainability of international networks of educators and, when feasible, should be utilized as a tool for the development of international partnerships.

Keywords

simulation; virtual environment; healthcare education; medical education; interprofessional education; global collaboration

Introduction to virtual environments

Virtual environments or virtual worlds are terms that have been used interchangeably to describe online,

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three-dimensional spaces where users interact with objects, the computer-generated environment, and each other by using an avatar, or virtual body. A user-controlled character can affect its surroundings or other players by interacting with them via collisions or manipulations or weapons. Virtual worlds used in education have a few special properties that make them particularly advantageous when compared to 3D games.

Those properties include the ability of the users to "build" content, such as programmable behavior, as well as the ability to upload specific custom content, such as graphics files or avatar animations, into the world. The contextual setting of the environment can also be used to evoke emotional states, such as melancholy, sadness, happiness, and wonder. These latter virtual worlds also have a well-integrated social communication system. Finally, designated avatars in the virtual world can be in charge of the virtual real estate, which is especially important for creating access rules and customizing a specific location.

Importantly, the educator can customize the environment to a suitable purpose that is ideal for simulations involving groups of students interacting with each other or environmental objects. Lastly, if elements of game play seem suitable to the educational purpose, these 3D virtual worlds have the ability to support quests, point systems, reward delivery, and fight systems. The constellation of these features provides educators the opportunity to make specialized interactive environments that can be effective for immersive learning.

Virtual worlds applications in health professional education

Educational methodologies, such as 3D virtual simulations, are increasingly utilized to teach skills that are difficult to acquire in 'actual' healthcare education settings, such as simulation centers, due to limitations in cost and scheduling. The use of virtual simulations has been reported in many health professional schools, including medicine,[1,2] nursing,[3–5] dentistry,[6] and public health.[7] Virtual simulations have been used for faculty training in simulation management,[8] to ease the learners' transition to mannequin-based simulation and clinical practice,[9] and as a student assessment tool.[10,11]

Trainees have the opportunity to learn and practice acute care skills in pre-hospital/disaster preparation[12–15] and in-hospital resuscitation,[16–18] as well as in outpatient settings, such as geriatric home assessment.[19] Virtual simulations have also been described as enhancing health professionals' skills in communication and teamwork. They have been used for team training,[13,20–22] training in empathy and delivering bad news,[23–25] motivational interviewing,[26] and cross-cultural communication.[27]

Several platforms exist that support immersive 3D virtual worlds (see Supplemental Table 1). Many people are casually familiar with game-based virtual worlds including Everquest, Halo, or Sonic the Hedgehog. In 2003, Linden Lab released Second Life®, a virtual world in which users can alter the environment by creating and animating their own objects. In 2007, Second Life® released its client and a group of programmers created OpenSimulator, an open-source virtual world program that has been used by many educators to create their own worlds. One advantage of OpenSimulator, due to its open-source license, is that universities, institutions, and individuals can host it themselves, bypassing the cost of renting land and incorporating it into their own networks, as they see fit.

Other benefits of using immersive 3D virtual worlds include more efficient use of clinical sites, cost savings, improved preparation for clinical activities, availability through the internet, and standardization of learning or testing experiences.[28–32] The costs include orientation time required to function in a virtual environment, inability to practice manual motor skills, and costs of instructional development.[33]

Collaborative learning theory in virtual environments

Virtual simulation supports learning within immersive environments by facilitating the creation of knowledge, such as using experimentation cited in experiential learning theory.[34] Concrete experience afforded in realistic virtual environments supports performance by going beyond 'learning by doing' found in many non-immersive training approaches. Situated learning using virtual simulation characterizes the *situatedness* of rich environmental context that promotes conceptualization and

reflection used in experiential learning.[35] Behavior and cognitive theories more commonly used in technology-mediated learning approaches continue to apply to virtual simulation, but situated experiential learning promotes a holistic, integrative approach necessary for engaging cognitive, affective, and psychomotor training and fulfilling education requirements.[34]

The merits of using virtual simulation and immersion also support the development of adaptability, as needed for effective communication within diverse groups. Applying new understanding, based on appreciation of viewpoints used across communities of practice and disciplines, creates greater flexibility among learners.[25] Constructive virtual environments enable learners to model actions (interactions) and to create material artifacts (objects) that may not be possible to make physically, due to limitations in cost or safety. Through facilitating virtual collaboration, leaders foster participation in communities of practice, which can help learners move beyond internalization of learning by promoting members to act as a whole person in the world.[35] The development of distributed, virtual communities has led to empowerment, shared aspirations and mutually understood ideals.[25]

De Freitas et al.[36] described using virtual worlds and serious games as a shift to learning centered on experience and exploration. Learning experiences emphasized learner control, content-generation, and peer-support, representing a process shift from instructional design to choreography.[36] Furthermore, interactions between the context and the learner became important, as students could be simultaneously in a physical and virtual environment.[36]

This shift in learner-centeredness using virtual environments posed an opportunity to apply *experiential design*. Such design of medical learning activities involving simulation-based training was shown to decrease patient and family member complaints.[37] Other experiential design principles, practiced in the discipline of marketing, built emotional understanding and appealed to the user's self-concept through recognition, achievement, and advancement.[37]

Connection with transdisciplinarity

Virtual simulation and virtual environments are inherently more complex than the teaching and learning approaches that are dependent upon a sole academic discipline. Realistic or rich simulated context also provides the ability to support multiple disciplines that are commonly required in training where judgment is practiced. Involving diverse stakeholders and enabling interdisciplinary collaboration may lead to new knowledge creation that goes *beyond* the disciplines. This aspirational collaboration has been described as transdisciplinarity and, when applied in virtual environments using avatars, can result in virtual self-actualization over time (Figure 1).

The Institute for the Future, an independent organization in the United States, produced a report in 2011 suggesting that transdisciplinarity would be a skill necessary for the future work force in 2020.[38] While considered a future workforce skill, transdisciplinarity has been suggested as a theoretical framework and pragmatic approach to solving wickedly difficult problems. Grant agencies often seek transdisciplinary research approaches that require the means to assess collaborative contributions.

Theoretically, transdisciplinarity embraces complexity and is influenced by the quantum revolution in which multiple levels of reality and "betweenness," defined as the logic of the included middle, is necessary to understand representations of meaning (beyond A *or* B, black *or* white).[39] Transdisciplinarity involves that which is at once between the disciplines, across the different disciplines, and beyond all disciplines.[39] Truman[40] explored the use of complex, context-rich, virtual environments where some groups collaboratively prototyped the design and development of virtual simulations. Avatar users described feelings of inseparability and attachment to groups when dialogue was used in virtual environments, which led to transdisciplinary self-actualization.[40] It was necessary for avatar users to have sufficient time in the virtual environment in order to obtain the attachment leading to group engagement and empowerment. Transdisciplinarity was associated

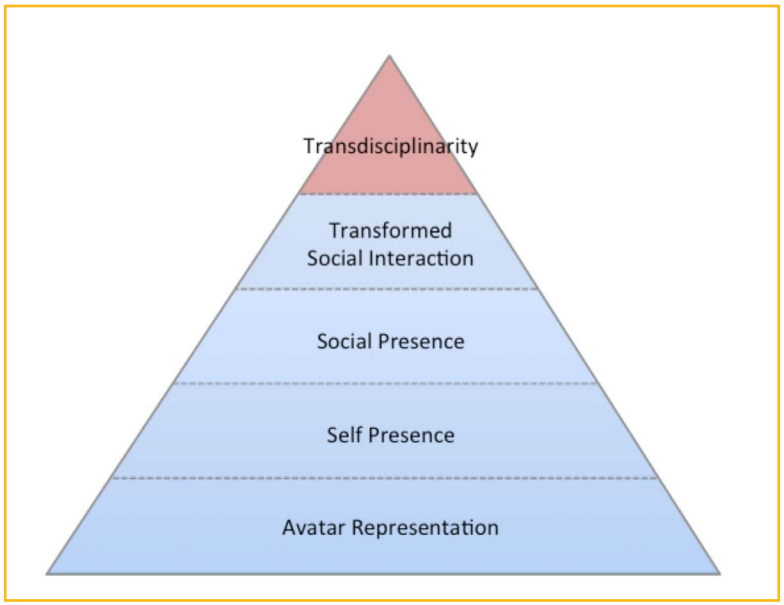

Figure 1. Virtual self-actualization and transdisciplinarity.

with leadership contributions among groups whose members became empowered as community activists operating within and beyond the virtual and physical environments.[40]

Virtual Self-Actualization and Transdisciplinarity was proposed by Truman and applied to the use of avatars in a collaborative virtual environment as a similar phenomenon to Benjamin Bloom's Hierarchy of Needs based on a theory of motivation.[40] The initial level refers to how users choose to represent their 'self' with an avatar. The reflection of 'self' raises consciousness of identity, appearance, and behavior, including communication and dialogue. Through group engagement, and especially through collaboration using avatars, social presence leads to attachment of avatar(s) and group(s). Transformed social interaction (TSI) forms the basis of theory and research led by the Virtual Human Interaction Lab at Stanford University where findings have shown that avatar use qualitatively changes the nature of social interaction. TSI provides a strategic means of communicating in a virtual environment using avatars.[41] Conscious awareness of the power of avatar use, its relationship to 'self', and the use of dialogue was found to associate with transdisciplinarity.[40]

Application to global health programs

Worldwide, the breadth of virtual simulation's application to training has included a multitude of uses in a number of collaborative projects. Virtual simulation platforms allow for the creation and/or replication of a variety of international settings, in addition to more traditional settings, for the purposes of training in global or public health issues (Figures 2 and 3). Creutzfeldt et al.[17] demonstrated that the use of virtual simulations increased self-efficacy in cardiopulmonary resuscitation for an international group of students from Sweden and the United States.[17]

Veltman et al. created a shared teaching tool between nursing schools in the United States and New Zealand, and while they decided against using the tool for a shared student experience, their use of the virtual environment in developing their teaching tool was successful.[42] In offering continuous professional development opportunities, Melus Palazon et al.[43] delivered a program where virtual presentations using Second Life® were provided for primary healthcare providers (n = 76) for nine locations in the Aragonese Health Service, providing an interactive environment and eliminating the need to travel.

Figure 2. Urban public health setting.

Figure 3. Global health training site.

In the public health realm, Schoonheim[44] used a virtual reality platform for public health distance education for developing nations. Though most of these studies tended to be small pilots, with limited outcomes data at this time, they demonstrated the potential and flexibility of virtual simulation in many aspects of healthcare education.

One of the most mature forms of virtual world global collaborative education is the Pan American Health Organization's (PAHO) "Leaders in International Health Program." This program has had participants from over 30 countries address a variety of public health issues, with training occurring in a mostly virtual setting. As part of a collaborative effort, the participants have developed projects based on priority health issues in their nations, and these projects were implemented by relevant ministries, as well as other entities, in their respective countries/subregions.[45,46]

In the MENA region, the use of virtual simulation in healthcare education has been largely limited to technical training, mostly for surgical residents[47 – 49] and nurses,[50] and leaders in the Gulf Cooperation Council (GCC) region are exploring the potential of virtual reality to replace the use of cadavers.[51] Since virtual simulation is a growing field through which training and continuous professional developmental activities could be offered in an engaging setting, we should further explore its potential in this region.

Virtual worlds for interprofessional collaboration

Given the affordances of virtual worlds, it is not surprising that there are numerous examples of interprofessional networks of collaborators that are supported through virtual environments. Some of these networks are based in the United States or Europe, while others are international. Bilateral and multilateral institutional partnerships have been formed through connections made through virtual conferences and round-table meetings and supported through ongoing interactions around research and training activities in virtual environments (see Case Studies).

The use of virtual simulation as a platform to develop interprofessional competencies,[21] such as communication and interpersonal skills,[52 – 54] underscores the role of technology to enable interprofessional education.[55 – 57] The use of technology is particularly helpful in bringing together geographically separated students from

Case study 1: Virtual Islands for Better Education (VIBE)[1]

In 2011, the United States based group, Virtual Islands for Better Education (VIBE), was created as a result of a collaboration among various schools and educators under the leadership of Stephen Gasior and was originally named Biological Objects for Science Education. The primary goal of the group was to develop educational activities in a more controlled hosting environment than the commercial grid Second Life®. The initial founders included college educators working at separate institutions. This group was geographically dispersed but had become connected in virtual environment group participation and in collaborating on designing and assessing student projects. Through collaboration with ScienceSim, another science education grid, and the unique opportunity to interact with the Intel group's engineers and programmers, VIBE developed expertise in hosting Open Simulator grids, as well as in activity design.

VIBE uses virtual world grids for regular meetings and uses Second Life® and OpenSimulator grids as a professional networking platform with other groups. Meeting as avatars in a personal setting is much preferable to asynchronous or even other synchronous methods involving a group of people. The outcomes of this collaboration, including a partnership with Wizardry and Steamworks,[58] a European consulting group, have been to build a network of grids providing learning opportunities for students in primary, secondary, and tertiary education and to create a strong, supportive network of educators.

[1] (https://sites.google.com/site/virtualislandsbettereducation/)

Case study 2: Biome

In 2008, Carolyn Lowe created Biome, a science education region, in order to use virtual environments for teaching ecology and biological classification to undergraduate, pre-service teachers, as well as for teaching online graduate level courses in science education. The region was used both as a source of content and as a classroom setting. Students were able to study the ecology and classification of living things in a forest and in a coral reef. In addition, graduate students built environments to teach content in their own science areas, such as a group-created Mars habitat with the necessary life- and social-support systems, and a volcano in which the Earth science content could be easily taught. In a paper, Lowe summarizes the strategies used in her study.[59]

Through virtual groups created by this project, conversation and collaboration occurred within a global community of science educators. Working with other educators, it was possible to attend and present at conferences, both in virtual and face-to-face formats, and perform research on the effectiveness of using virtual environments for learning. While the courses utilizing Biome for education ranged from undergraduate courses in biology for future elementary teachers to graduate level seminars, it also was possible to consider the utility of the virtual environment for science education.

Surveys of graduate students in online science education courses showed a preference of using virtual worlds for collaboration and discussion over other types of synchronous and asynchronous interaction.[60,61] The majority of those surveyed indicated that virtual worlds were more comfortable, interactive, and personal than the other venues. They preferred the benefits of choosing an appearance, sitting comfortably in a beautiful setting, and interacting through text and voice-chat in real time over other modes of communication, including emails, discussion forums, and video conferencing. Both educators and students tended to prefer text chat, or typing, rather than using voice, with those who are not likely to contribute vocally being more willing to share using text. In addition, the students would often review the chat logs or written copies of the typed chats for material they may have missed or wanted to further study from the class period. These and other findings of utility in tertiary science education led to the development of Biome4Kids, a virtual world learning environment for elementary and secondary science education. Both Biome and Biome4Kids are now offered on the VIBE OpenSim platform, in which there is more opportunity for expansion into new areas of science education.

Case study 3: Euroversity

The utility of virtual worlds for language learning at a distance and in real-time has been explored through collaborations in both the LANCELOT (**LAN**guage learning with **CE**rtified **L**ive **O**nline **T**eachers) and AVALON (**A**ccess to **V**irtual and **A**ction **L**earning live **ON**line) projects. LANCELOT utilized a virtual classroom, whereas AVALON used a virtual world. The AVALON project focused on the use of virtual worlds for language education and consisted of a community of education experts and language teaching practitioners with the goal of providing resources and guidelines for teaching in virtual worlds, as well as providing course scenarios for use in virtual environments.

In 2011, these and other projects became part of a new initiative called Euroversity,[62] a three year-project co-funded by the European Union Lifelong Learning Programme. Euroversity comprises a network of 18 partners from ten European countries (the United Kingdom, France, Italy, the Netherlands, Norway, Sweden, Austria, Portugal, Cyprus, Germany). Members of this network have had significant experience with the use of 2D/3D virtual worlds in learning and teaching contexts. They wish to apply the experiences of the network to the design and construction of new courses within virtual worlds in their own contexts. The aims of the project are to bring together experienced and inexperienced users, to expand users of online 2D/3D virtual environments, to create a community resource outlining a good practice framework, and to build an experiential video data bank that will outlive the project's duration.

local, regional, or international health profession campuses. Through in-person or remote courses, healthcare professionals across a wide spectrum, including physicians, nurses, pharmacists and others, can be trained in virtual environments, using strategies that require participants to collaborate in virtual interprofessional teams.

Although there is an emphasis on competencies in interprofessional teamwork and communication in health education curricula, these aspects of training often are limited due to geography and scheduling challenges. Looking just within Qatar, there is a dearth of collaborative interprofessional educational activities, although the need exists with the country's medical school, nursing school, several pharmacy programs, and school of Health Sciences that offer training in a number of health professions. Virtual simulation could provide the platform for interprofessional and interdisciplinary activities at all levels of training, easing the burden of scheduling, location and, for higher fidelity simulations, cost.[21]

Limitations to virtual world use for education and collaboration

Since there is little data about the possible use of virtual simulation in healthcare education in the region, further research should be done about the familiarity and potential areas of interest in order to develop successful programs.

Planning, developing, and testing interactive scenarios will require a significant investment of time. Maintenance of the curricula and the environment also will require ongoing time and resources. Teachers who plan to use this platform will need training and will require the expertise of trained

IT personnel who can help design the interactive environments and help troubleshoot. Implementation is less likely to succeed if there is a faculty culture preferring hands-on experiences, if accreditation standards require real life patients, or if there is the absence of IT infrastructure to support the use of virtual environments, such as broadband internet.

Participant learners in these environments require training and must develop a comfort level in functioning as an avatar in this highly interactive 'artificial-real' setting. Privacy of data, security concerns, and cultural acceptability of avatar interactions would require further study. These concerns have been raised as potential limiting factors in the Cloud Computing setting in the MENA region,[63] although the use of virtual simulation in other first responder settings in the region[64] is encouraging.

Take Home Points

1. Virtual simulation environments enable the creation of user specific platforms that allow for interactive and immersive learning
2. Virtual simulation environments transcend geographical and time barriers allowing collaborative, international educational partnerships
3. Virtual simulation environments are conducive to interprofessional education and team building

Conclusion

The use of virtual environments in health professional education enables collaboration and can foster team-building. Virtual environments have been instrumental in the growth and sustainability of international networks of educators and, when feasible, should be utilized as a tool for the development of international partnerships. Though the use of virtual simulation is currently limited in the region, there is potential for a variety of collaborative healthcare educational activities, especially in the realm of interprofessional education and team building. Additional studies need to be done to further investigate the feasibility and potential limitations of such projects.

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