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A Practical Guide, With Theoretical Underpinnings, for Creating Effective Virtual Reality Learning Environments

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Abstract

With the advent of open source virtual environments, the associated cost reductions, and the more flexible options, avatar-based virtual reality environments are within reach of educators. By using and repurposing readily available virtual environments, instructors can bring engaging, community-building, and immersive learning opportunities to students. Based on many years of academic research and development within this environment, the authors suggest educationally productive, research-supported ways to create learning environments that can motivate, engage, and educate participants. Instructors can develop virtual communities as centers for meetings, collaborations, and shared experiences, moving distance experiences beyond the limitations of engagement and collaboration in nonimmersive settings. The authors explain how instructors can develop useful learning interactions, pilot their learning environments, assess learners, and evaluate the environment. Specific experiences, images, and videos from the authors' work are shared as well as broader application that could suit multiple purposes in guiding an instructor's development and instructional efforts.

Keywords

virtual reality, learning, designing, assessing, curriculum, Second Life

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Introducing the Approach

Designing an effective virtual reality learning environment can be a rather simple process where one uses predesigned environments to host visitors, students, or other audiences through experiences that map to experiences in the present world or the present course. Instructors and developers can also design virtual reality environments that can serve as advanced simulations for activities that could not be completed easily (such as flight simulations) or that move into the fantastic and imaginary (as found in gaming applications). The potential complexity of virtual reality and the powerful and yet unrealized advantages of these environments is leading to a new field of study known as design-science-research (Schmeil, Eppler, & deFrietas, 2012). However, to move educators, communicators, researchers, and academicians into productive uses of these environments, this practical guide will focus on the artistically and developmentally simpler applications, thereby enabling instructors to move more quickly and independently toward piloting such environments. Education uses, theoretical perspectives, and applications of the various components of a productive virtual learning experience will be provided along with specific examples and video links from over 10 years of direct use of these environments in science-education teaching and from teaching others to become virtual reality developers and educators. The theoretical framework that explains why the elements of these virtual environments can produce desirable effects is embedded within relevant sections of the guidance and advice. The schematic in Figure 1 overviews key areas that will be addressed within this article: beginning with locating virtual islands to suit course needs and presenting what can be done within these islands; considering how to develop a rich platform of potential educational interactions; finding ways to integrate virtual components into face-to-face and other online experiences; and developing methods by which to assess virtual experiences to determine their educational value while also evaluating the productivity of the virtual environment itself.

Testing the Waters—Visiting Existing Islands

The first decision about creating or using a virtual reality learning environments involves deciding what island to use or acquire. Although virtual reality environments with avatar personifications have been used quite effectively when designing games for recreation and education (Squire & Jenkins, 2003), the education research on more open-ended, higher education-focused applications is less developed. Instructors who were early adapters of virtual environment, such as O'Connor (2010) or those interviewed by Wilde (2010), reported positive social, collaborative, and community supportive results. However, the requirement for instructors to conceive of their own environments and purposes

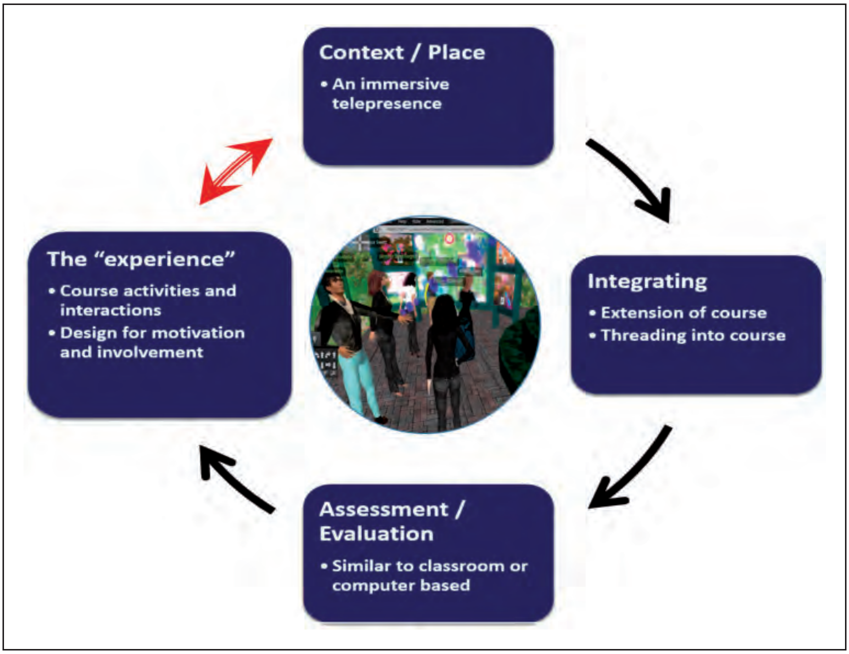

Figure 1. Key components of virtual learning design.

suggests that if they are just starting to explore possible applications, they might benefit by visiting well-developed, user-created virtual environment such as Second Life. Second Life is a platform that has been available since 2004 and that can be visited at no cost (www.secondlife.com). In Second Life, there are many useful and interesting islands that have been made available for public use. Note that although the other vendors mentioned later in this article have publically available island, their inventory is not as large. Visitors must be mindful though that Second Life is a public area similar to the Internet and should be cautious about places they visit and people they meet just as they would in any web-based forum. Many interesting institutions and government organizations created islands here, and some still remain. However, Second Life eventually removed the academic pricing and thereby making their virtual islands more costly to initiate. Concurrently, the open-source availability of many islands and artifacts resulted in new vendors coming to market with significantly reduced cost for island rental, the ability to download entire islands for local computer storage, and other virtual-development options (O'Connor, 2016). Thus, new and exciting possibilities became available to educators to piloting and rapid development. So, if one wants to quickly explore virtual environments to gain a perspective on possibilities or to bring students to test a virtual environment itself, an initial visit to Second Life would be helpful. Second Life also has useful introductory materials on using the environment for those acquiring their avatars.

Selecting a Virtual Environment

However, the primary focus for this article is to encourage the creation of personalized, immersive, virtual environments within the budget and skill level of educators who are more interested in using the community-building, flexible, geographic-reach features of these islands (O'Connor, 2016). Although many of the elegant islands available within Second Life were created by commissioning professional three-dimensional artists, today, premade and customizable buildings and islands allow instructors to have attractive environments for lessons and sessions almost immediately. Therefore, an initial question for educators becomes what should the island contain? What should it look like? And how can such an island be acquired even before an instructor has become particularly proficient in creating virtual environments?

Presently, it is possible to acquire entire populated islands for a monthly rental fee of $15 to $20, as currently available through Kitely; other vendors offer equivalent functionality and cost (http://unity3d.com/; http://www.dreamlandmetaverse.com/). To visit these Kitely islands or to create own islands, download a "viewer," such as Firestorm from http://www.firestormviewer.org/, and acquire an avatar at www.kitely.com. The document available at link https://docs.google.com/viewer?a=v&pid=sites&srcid=ZGVmYXVsdGRvbWFpbnx2aXJ0dWFscmVzb3VyY2VzZm9yZGV2ZWxvcGVyc3xneDo1MjZjZjQxNzViNjA0NzNk is a more depth guide about acquiring a viewer, visiting the authors' islands and working with avatars. Should users decide to acquire their own island, they are actually renting server space. Within this rented server space, users can acquire predesigned environments available with their initial rental or they can upload other options that are available for free online. Users can modify these islands in small ways—by changing colors and signs—or they can modify and even add buildings and terrains. Island can also be created *from scratch*. With the features available through open-source vendors such as Kitely, users can then actually download the islands and save them on their computer and then later upload these islands. Thus, one can have multiple and different virtual reality environments to suit different purposes. (Second Life does not allow this download and upload feature.) And, since instructors can keep these environments available even outside of class time, they can serve as meeting spaces for students even when the instructor is not present. Given that islands are readily available, what style and type of island can support particular educational purposes?

Figure 2. Informal presentation space and a later poster session.

Authors' Example

Over the years of the first author's work, different designs for formal education spaces have been tested; these will be reported herein. The second author has more recently joined in virtual design for learning and has been expanding the reach and applications within these environments. Experience has suggested that for the science education students, informal spaces seem to create a more open and collegial environment. In Figure 2, on the left, an online class was meeting for a presentation on the use of peer-reviewed badges in K-12 science classrooms. These students later created their own "posters" about their science lessons, returning to this space, as shown on the right, where the large poster boards were now populated with their slides. Students explained to their colleagues their educational designs within this open-air conference environment. As found effective by O'Connor and McQuigge (2014), these students were asked to vote on each other's presentations. The results of the voting generated peer-reviewed badges for colleagues. These students valued and enjoyed the shared academic experience with these colleagues even though they had never met face-to-face. See https://www.youtube.com/watch?v=4GvYDuiwvdE for a 4-minute segment of a videotaped poster presentation.

Other Environments

More formalized environments are readily available. For example, the images in Figure 3 were taken from a prepopulated island known as the Universal Campus available through Kitely. In these images, a more formalized spaces is shown on the top, with the left being an auditorium and the right being a classroom that is displaying a slide presentation with a photo in the background. At the bottom are recreational settings that are also available in the same Universal Campus islands. Pathways around the islands and transportation-guiding kiosks help new avatars find their location. Thus, if instructors begin with these

Figure 3. Prebuilt islands with a variety of meeting spaces.

environments, they can work within these formalized education-like settings or they can customize these settings to meet their needs.

Another useful application comes from customizing and modifying predesigned virtual classroom settings. By uploading images saved from the web, taken as photographs, or created in PowerPoint and saved as JPEGs, instructors can create a content-focused and unique environment. Since websites can be placed within the environment and videos, from platforms such as YouTube, can be streamed, instructors can easily customize an environment to have the concepts, information, web, and video resources that they might want to have continuously available in their actual or virtual learning environment. In Figure 4, the authors have customized a poster area for science education students. These important reminders can be available whenever students visit the virtual classroom. Marian Hospital, in the image to the right, is a repurposed, freely available building that now serves as facsimile of a sub-Saharan outpost hospital where a dermatologist, presenting from another state, addressed science teachers, and eventually will address their middle students, about healthcare issues and local diseases in the African environment.

Considering the Research on Simulations and Environments

Developing the background context and environment within which instructors will immerse their students, therefore, presents a number of options. Advanced

Figure 4. A customized virtual space with websites and video and a sub-Saharan healthcare facsimile.

applications such as flight training where Koglbauer (2015) found that students with virtual flight simulators learned specific multitasking activities more rapidly or a healthcare clinical trial where virtual simulations are intended to help patients control their psychotic states (Pot-Kolder, Veling, Geraets, & van der Gaag, 2016) have leveraged the ability to immerse the avatar visitor into a new experience for learning or development purposes. Urso and Fisher (2015) found that virtual reality is solving the challenge of finding clinical experiences for nursing students. The introduction of reality-simulating headsets such as the Oculus has even publications such as *The Wall Street Journal* (Nicas & Seetharaman, 2016) pondering how these devices that change the perception of human experience will affect our psychology. While examining community aspects of virtual environments, Martin (2014) posits a belief (heralded within recent research) that younger students from their prior virtual experiences will be more motivated to participate in virtual settings because of the "telepresence" they experience in virtual reality environments. Given the ability of virtual reality visitors to become immersed and engaged in such environments, instructors can select environments that already elicit learned behaviors and expectations, such as a classroom or laboratory setting, establishing a tone for serious work. Piaget (1950) noted that learners call on their previous mental schema as they are brought into situations. Having familiar environments can set a particular behavioral expectation. However, Schmeil et al. (2012) remind virtual educators to move beyond simply making three-dimensional displays of areas that could be developed in two-dimensional environments and fully explore the potential of immersive experiences.

Virtual settings could also be used to challenge previous conceptions. Thus, instructors can select environments to have students segue into new ways of thinking and communicating. Having chosen an environment, then what types of activities are possible within these environments?

Understanding Virtual Features

When considering the procurement of a virtual environment, instructors will also want to know the basic exercises and activities that they can easily integrate. The complete pliability of a virtual reality environment allows instructors to easily (a) make or acquire the buildings and artifacts; they can even program virtual devices for interactivity; (b) determine who can or cannot visit islands that they own; (c) decide if they will let visitors make their own objects within their virtual holdings; and (d) design the programs, presentations, activities, meetings, and events that will occur inside these environments. Even avatar visitors have many ways to communicate, observe, and interact, and they can have independent activities, as summarized in the Table 1. The very ability of an avatar visitor to design the way he or she appears within the virtual space can bring richness and individual ownership to the experiences within these environments. Although beyond the scope of this article, Lee and Chen (2011) actually developed a methodology to determine if a virtual environment was attracting avatars, a key aspect with commercial applications. As will be addressed later in this article, instructors can integrate these various features, known as the *affordances* available with the technology, into a variety of basic activities that can launch authentic and engaging academic and intellectual communications.

Table 1. Activities Available to Avatars.

Avatar abilities	Possibilities
Audio and text is and	Multilevel communications; text chats can be exported
Snapshots and video	Built-in snapshot feature; video capture the virtual environment
Instant Message and storage	Extend communication beyond synchronous meetings
Walk, run, fly, teleport	Rapid movement to different locations, individually or collectively
Multiple experiences	Observe images, presentations, websites, streamed videos
Change appearance or clothing	Explore new ways to look and interact with others
Gestures, movements, “sits”	Communicate, interact, and move as if present in the environment
Building objects	Create objects in sandbox areas

Figure 5. Multiple ways to communicate; an impatient avatar gesture.

As shown in Figure 5, the left side illustrates how avatars can have varied and engaging interaction process within a virtual space, using a speech process where the avatar's lips move in sync with the words, and a companion text chat that can also be saved to document interchanges. The environment also has a full instant messaging and message storage system for enhancing communications. As shown on the right, avatars can also use built-in gestures and animations to communicate emotions, information, and ideas. This field is growing rapidly to allow even more realistic movements by avatars (Metz, 2016).

Designing Basic Learning Environments—And Integrating Into the Course

Although, ultimately, instructors should think about the learning environment holistically, starting from a knowledge of virtual reality environment choices and the possible activities, a logical next step is thinking about the community that can emerge from within this environment. Providing a telepresence, a sense of being immersed in a shared actual experience with others in the environment, is a powerful way to create community and engagement. Martin (2014) observed that the newer generation of students, sometimes called the *millennials*, are actually more motivated to participate given the immediacy of telepresence which can be found in virtual reality. And, Vesely, Bloom, and Sherlock (2007), note the challenge that all online instructors have when developing community, cautioning educators to find better ways to establish community given the need to competitively search for students today in higher education.

Therefore, developing ways to extend a virtual community to a variety of online learners is essential.

Also, when considering how to design both a learning environment and learning activities, instructors need not have the virtual learning environments serve as the entirety of a course. Whether instructors have an online environment, a blended environment, or even a face-to-face meeting which they want to extend their reach beyond the institution itself, they can consider the virtual elements as a component within the larger instructional environment (O'Connor, McDonald, & Ruggiero, 2015). So, what type of activities can readily be designed into virtual learning environments that can encourage both a community perspective and a productive educational setting?

Author Example Uses

To make this interplay of environment, community, and activities more concrete, first several actual applications are considered. Some of these might seem obvious and feasible if students were in the same geographic location. Facets of this might have been possible through a webinar or conference call. However, these students were dispersed across the country. And, an instructional goal was to provide for self-directed student-to-student interactions that went beyond instructor-led webinars or discussion board text postings. In this truly learner-centered virtual environment, these students also had the freedom and independence to visit the virtual islands before and after their explicit course assignments. They could work independently and in their collaborative teams within the course's virtual environment without the instructor's presence, allowing them to develop their work and practice any required presentations before the event began.

This selection of meetings illustrated in Figure 6 was conducted across space and geography. The students and the instructor sharing this visual space within this enriched context felt as though they were working together, benefiting from the verisimilitude effect noted by Vanderbilt (2016).

- On the top left is a meeting where the Dean talked about developments within the college to students geographically dispersed. The questions and interactions that came forward were helpful for the students and for the college. See https://www.youtube.com/watch?v=BUo_vXpOhD0 for a video segment of this presentation.
- Students also presented poster sessions, explaining the science lessons they had developed. Later students and other visitors voted on the presentation on specified criteria. See https://www.youtube.com/watch?v=pvgXca-xf00 for video overview of this work.
- In another situation, on the bottom left, students were sharing a video and discussing activities of K-12 students during the workshop

Figure 6. Various meetings, presentations, and activities within virtual spaces.

represented by the video. See https://www.youtube.com/watch?v=hz1ld2AUTUQ to see an overview of this embedded video student activity.

- On the bottom right, students present a citizen science project within an entire pod that they customized with activities related to the project. See https://www.youtube.com/watch?v=VlXLPJcgEew for a portion of the student presentations.

General Application

Thus, instructors should start thinking about virtual learning possibilities by considering ways they would want students to interact, listen, share, and learn *if any physical environment where possible*. O'Connor et al. (2015) suggested that since instructors can now design with the fluidity and access available through e-communications that they should think expansively and plan with the freedom of no time or location constraints. Fogg, Carlson-Sabelli, Carlson, and Giddens (2013) in their study of a virtual nursing program propose that the instructor creates the social context, communication, and interactions that enable knowledge construction. Thus, the instructor should use these expanding possibilities—with environment development, an continuously available meeting space for students, and lack of geographic restrictions—and design for new instructional and pedagogical experiences. McManimon (2011) generalizes about how virtual environments when used with constructivist principles support pedagogically sound activities, such as situated learning, role-playing, cooperative or collaborative learning, problem-based learning, and creative learning. So, instructors should consider who they would want to bring to this environment and with whom they would like their students to interact and converse if any such meetings were possible. Even without knowing how to create advanced images or artifacts, instructors can bring in pictures, slide presentations, videos, and resources to take a predesigned environment and customize it to have the look-and-feel of the important aspects of the content (as is shown in left image of Figure 4). When planning for virtual events, begin from the larger perspective and then determine what elements would be logical and feasible for an initial start. Consider the following notes and activities.

Prepratory Note: Loop Interactions

Extend any of the activities suggested here by bringing them back into the larger class environment, by having virtual conversations extended into discussion boards, shared PowerPoint summaries, or further studies and reports. Since virtual interactions can be open-ended and student-led, and not simply instructor dominated, and since virtual interactions can take place in breakout groups, they can often amplify and extend the learning, collaboration, or interactions by having events, activities, and discussions brought back to the larger class or course experience by these *looping* techniques.

Ice Breakers and Community Building

Begin initial work by having class and team meetings in the virtual space, posing icebreaker questions to encourage students to know each other or seeding open-ended inquiries which teams could review and report on—within the virtual environment, in online forums, or face-to-face. Students can be sent on solo or team-based scavenger hunts, learning how to use the environment and have fun finding the island's features. These initial interactions can start creating a classroom community and can provide instructors with an understanding of various student proficiencies with virtual environments for later groupings and peer supports.

External Speakers

Bring in external speakers, content experts, and panelists, populating the room with images relevant to the content (as in the left side of Figure 4) and conducting interactive sessions with the audio speech abilities and through the text chat possibilities. Consider extending discussions into later online areas or post-meeting debriefings. Take snapshots or video recordings—both easily accomplished within the virtual setting—to preserve and extend the discussions begun. See https://www.youtube.com/watch?v=SGEaeZCKRSA for a guest speaker explaining about a technology project in K12.

Student Interaction

Require student to meet about content topics or possible collaborations relative to course goals, objectives, and requirements. Even without the instructor being present, attendance can be taken by having students submit snapshots as they report back on their meetings or on discussion outcomes through means such as word processing reports, slide presentations, and video reports. Similar to the perseverance and social motivation noted by Vezina, IsaBelle, Fournier, Dufresne, and Doucet (2004), by meeting within virtual environments, students take more ownership and responsibility since the telepresence of an avatar brings about the social presence demands that would be found in an actual face-to-face meeting.

Interdisciplinary Activities

Plan for interdisciplinary and across course connections thereby moving students and faculty toward the 21st-century skills and requirements. Since instructors are not hamstrung by room assignment and meeting place designations, having an environment where classes can meet for the conferences, discussions, and joint projects makes a more expansive learning environment possible. Instructors may find, as did Umoren, Stadler, Gasior, Al-Sheikhly, Truman, and Lowe (2014) where the interpersonal intricacies of the actual healthcare scenarios could be studied internationally through virtual environments, that these extensions can expand their instructional boundaries.

Social or Educational Extensions

Structure the social, professional, and performance interactions so they can also integrate external measures and activities. For example, viewers of a presentation or poster session could vote for peer-reviewed badges on the virtual presentations that were made. Interactions need not always be formal or structured to be useful for encouraging learning and online community. As shown in the left side of Figure 7, students can meet for social purposes as well. Such multimodal technology interactions can cement a community and extend the learning through the attention paid to these additional social aspects.

Role-Playing

Take advantage of the ability to have students assembled across geography within a virtual environment to simulate the experience and cultures that they

Figure 7. Social interactions and shared building.

are studying. Based on the content area, role-playing in areas such as social work, hospital admissions, or preservice practice teaching can give students opportunities to practice important social and behavioral actions within the safety of an educational setting. Pot-Kolder et al. (2016) show how even the National Institute of Health is looking into ways to simulate experiences of psychotic patients to help in their recovery. Although instructors may not have the funds or experience to develop custom simulations, by using different freely available settings, such as a shopping center for marketing class, they may be able be able to generate practice sessions in these environments.

Shared Problem Solving

Find ways to bring students together to solve problems either related to the content area or even to solve community shared problems within the virtual space. Organizations often seek ways to bond community members through such shared problem solving. Students could be sent on team-based scavenger hunts to find locations in the virtual island—snapshots could be taken to document findings. Since virtual building is possible, in areas where instructors designate that building be allowed, students could work together to test their virtual building skills and to develop virtual artifacts, as seen in the right side of Figure 7.

The Skies the Limit

Needless to say, there is no limit to what instructors can do or require within a virtual environment. Since instructors make the rules for what can transpire within the educational learning space, imagination and practicality are truly the only limits. In the next section, examples that challenge instructors to think beyond copying the world today can bring the learning to a new level.

Designing for Motivation and Involvement

Designing an environment that becomes intrinsically motivational, and not simply have students join because of *required* participation, can further students learning. And ensuring that ALL students are participating is an absolute instructional requirement. Consider that the most well-known applications of immersive virtual environments have come from the gaming industry. In those situations, getting the audience motivated to join and then stay involved brings significant financial rewards, as noted by Morris (2016) from Fortune magazine in reporting that the video gaming industry brings in more revenue than the movie entertainment business. Although instructors have the advantage of being able to require participation, designing for motivation can enhance the learning experience. However, Parks (2012) warns educators not to oversimplify the ways to build motivation in virtual settings, and Frost, Matta, and MacIvor (2015) found that the gamification (bringing in game-like attributes) aspects designed into a learning management system lacked the voluntary and compelling aspect that could have improved motivation to participate. It seems that younger participants may have expectations for the type of interactions they may be used to from gaming settings. Although an instructor may not have the engagement found by Dunleavy, Dede, and Mitchell (2009), where students became so involved in their GPS game that they lost perspective of their true physical location, through thoughtful application of motivational principles, and instructor can enhance the students willingness to participate and stay interested. As Moneta and Csikszentmihalyi (1996) pointed out, achieving the proper balance between challenge and potential for participation can cause significant immersion in the problem study itself and a more natural flow to engagement and participation. So can problem solving become part of the motivational process?

A possible "problem" that could motivate learners toward greater participation and community can come from differences within the students in the class itself. Wood (2010) notes the value of virtual environments as an educational platform since student populations now have an increasing number of millennials, those born around the turn of the century, who have often played computer games. However, Wood's also warns that instructors need to move to being learner centered to use these environments correctly. Using the terms coined by Prensky (2001) of digital natives (who would be the millennials) and digital immigrants, Jones, Harmon, and O'Grady-Jones (2005) even posit that the digital natives tend more toward experiential thinking then do their more reflective digital immigrant colleagues. Although these learner and student designations can hardly define a cohesive and consistent psychological or sociological grouping, instructors will be challenged by those who will find the virtual environment quite understandable and those who the literature cites will have a large learning curve before becoming comfortable in these environments (De Leon, 2011). An instructor's goal, regardless of which category they feel they belong to, is to get everyone reasonably comfortable within an immersive environment. As instructors will see in the next section, a Vygotsky-like approach was used to create some initial problem-solving challenges that create situations where the more-knowledgeable students helped their less capable virtual colleagues leading to a great motivation to participate by all members through group problem solving.

Author's Startup Approach

Over the past 10 years of bringing new students into virtual environment, the first author has developed and refined her techniques—the following approach has worked well. As a startup assignment, the students are required to go through the basics of getting set up with a viewer and an avatar and then making Snapshot postings (within the online course) of several locations within the virtual setting. Therefore, the students having basic skills with access, navigation, and mobility has been documented and assessed—*before* they come into the first class meeting.

Then, benefiting from the social-network learning, as noted by Vygotsky (1978), the instructor assigns initial teams were students more comfortable with virtual environments can work with those less comfortable. These teams are then sent to different parts of the virtual island with a startup icebreaker task were these teams explain their professional background and their initial thinking about the course content area. One team member, designated as the "documenter," takes snapshots, assembles the teams' thoughts, and creates a PowerPoint summary of the meeting which then gets posted within the online course. All students are asked to return to the online course and comment on the other teams' posting. As the instructor, the author is now able to have students share competencies and skills as they solve the joint problem of learning how to navigate and communicate within the virtual environment and hopefully increase their commitment to the course by working with colleagues to codevelop a common expectation about the course purpose. The first author has often seen students develop strong, collegial, and supportive relationships from this initial, albeit often awkward, experience of a virtually networked class.

Assessing and Evaluating

As in any learning environment, assessing what the learners actually gained from the experience must be central to understanding the effectiveness of the instruction. Although some studies, such as that by Jones and Devers (2014) who studied branching scenarios in specific social-work simulation, propose a program specific way to study learning effectiveness, a cohesive assessment theory particular to virtual environments has yet to emerge. As educators have been reminded by Wiggins and McTighe (2005), working "backwards" from the desired performance or understanding to hopefully be gained by the student, instructors should consider the competencies needed to achieve the performance that would designate the work product as a success. Thus, since most of the applications suggested here involve interpersonal and communication interactions, instructors should plan for the ways they might observe, document, extend, and evaluate such participation if this were a face-to-face environment. Having these interactions captured within a computer-based environment allows instructors to store text, snapshots, and video about transactions observed (See https://www.youtube.com/watch?v=VlXLPJcgEew for a video of a poster presentation that could be later evaluated to determine if it demonstrated the required competencies). Interactions not observed by the instructor can be documented through similar snapshots, text capturing and storing, and even video capture. The relative newness of using video environments suggests that it is important to evaluate the effectiveness of the virtual environment itself. Table 2 summarizes ways instructors can capture assessment data. Following is an amplification demonstrating several applications.

Consider some of these expanded and applied assessment ideas given here. Instructors should use what is appropriate to their learning environment and create assessment measurements of their own too:

- **Analytics** (built-in measures of participation; data displayed with graphs is often used to make the numbers meaningful) can be added within virtual environments to determine what avatars come to the locations, how long they stayed, and even what areas they visited—there are many ways to implement these types of virtual-world monitors and newer ways of measurement are emerging rapidly.
- **Observation, Snapshot taking, and videotaping** can allow instructors to monitor and observe the participants much like in "real world" setting if they were in a meeting area or classroom with the individuals. The videotaping allows preservation of the interactions and presentations that occurred within a virtual space as they can see this video (see https://www.youtube.com/watch?v=aToCEUtg024) that shares part of a teacher presentation of an effective citizen-detective science lesson. Being mindful that the participants are coming in from across geography can let instructors appreciate the value of this format. Instructors can use these storage features to as a way to take attendance, learn about behaviors and outcomes, and evaluate materials that are delivered or presented
- **Classic assessment of projects and interactions**, since a virtual space can be used much like any meeting place, assessment guidelines and rubrics could be

Table 2. Ways for Documenting Virtual Reality Learning and Interactions.

Overview of ways to monitor virtual performance		
Activity	Gathered with students present	Can be conducted later
Observations or videotaping or snapshots	Document and store as many interactions as possible	Participants can share or upload snapshots taken
Building activities	Can be observed building	Artifacts left for later review
Interactions and text chats	Interactions can be viewed; store texts chats for examination later	Text and audio files can be saved and examined later
Presentations or role-playing	Reports, presentations, interactions with artifacts, scenarios and role-play	Participants videotape themselves and submit later
External quizzing	NA	Participants take quizzes after leaving the virtual environment
External reports	NA	Participants make reports—snapshots could be included
Surveys	Survey tools are available within the virtual environment	Surveys taken after participants leave the environment
Avatar trackers	Trackers document time when avatars enter a space	Trackers data analyzed for visited and persistence at these points

developed and made available to clarify expectations and to establish evaluation criteria; consider this 3-minute video (see https://www.youtube.com/watch?feature=endscreen&v=hz1ld2AUTUQ&NR=1) of a session where student in groups viewed videos as a way of evaluating different classroom science teaching practices;

- **Badging** is an emerging area where the participants themselves conduct peer evaluations (O'Connor & McQuigge, 2014). Since virtual worlds can display websites it is possible to display the work of members, clients, and other participants and have peers specify their "votes" and thus contribute to a peer-ranking system.

Instructors can and should develop rich assessments and evaluations that are attuned to unique instructional possibilities available within virtual reality learning environments.

Assembling the Components . . . Then Getting Started

With the availability of affordable, predesigned virtual reality environments, instructors can readily use these immersive, communication environments as a way to bring students together over distance and geography in rich interactive ways. With a minimum of virtual-development effort, they could have student interactions, presentations, and discussions and they could also invite outside speakers and visitors to join in their learning efforts. By learning some basic artifact-modification approaches, they can further customize the virtual environment to create a more personal and content-focused look-and-feel to their environment. Instructors can even set up the environment so students can return later and so that students can work independently of the instructor. The learners can benefit from the flexibility of meeting and from the natural community sense of engagement created by a telepresence. Furthermore, instructors can assess student learning within this environment through observations, snapshots, and videotaping as well as the usual documents and reports that they might require in any interactive or collaborative assignment. The visual and text examples, the various video links, and the support documents embedded in the earlier sections of this document can expedite their journey to piloting these environments in their own educational settings.

In closing, although Gregory et al. (2015) highlight the need for schools to provide support to instructors who use virtual reality environments, these authors purport that virtual learning environments can be developed effectively and independently by instructors who start with pilot studies with reasonable and achievable initial goals. The built-in evaluation tools inherent in computer-based interactions will allow instructors to continue their growth as they experience and document their virtual learning efforts.

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