Chapter 10
Massively Multiplayer Online Roleplaying Games and Virtual Reality Combine for Learning

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Abstract The places where Virtual Reality (VR) can really make a difference in learning are those in which the VR can bring a truly unique experience to students. The simulated online world of games is an ideal way to take advantage of the capabilities of this new technology. Games provide a set of structures that not only scaffold learners in solving complex problems but also provide a great deal of freedom to explore personally interesting pathways. In particular, Massively Multiplayer Online Role Playing Games (MMOs) offer an environment that supports social learning and exploration around increasingly challenging problems. VR can greatly enhance MMOs through opportunities for more natural and expressive communication and collaboration as well as ways to visualize the complex information resulting from interactions in this space. When this approach is applied in an educational context, learners can be presented with challenging problems, requiring participation from multiple players around realistic scientific concepts. As this genre moves forward it can explore interesting hybrid approaches that combine VR with Augmented Reality (AR) and traditional displays to meet the needs of schools, teachers, and learners.

Keywords Games · Learning · Science education · Collaborative learning

10.1 Introduction

I was recently reading an announcement (Whitmore, 2016) about a new school that will have virtual reality (VR) as a central theme. In discussing the ways in which they would use VR, this description was offered:

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> Imagine this: Students enter the lab, strap on a virtual reality headset (just like the HTC Vive Andrew [one of the people at the school] had me put on during a demonstration), and **instead of playing video games, students will enter a fully immersive and scientifically accurate virtual reality chemistry lab.** *They will see their lab partner, and the two will discuss what they will do in the experiment, just as students would do in a traditional lab.*
>
> Let's lay out a simple experiment: Does adding salt affect the boiling point of water? The student would reach out with hand controllers, take a graduated cylinder, fill it with water, measure out the salt, light a Bunsen burner, add a thermometer, track the boiling point — *and then repeat the experiment without adding salt.*

As new technologies are introduced, they are often initially adapted to previous practices. Going back in time, the first films were simply movies of live plays. Later films explored cameras that moved around, went outside and shot on location. And today we see a diverse use of this medium. More recently, we saw the first wave of Massive Open Online Courses (MOOCs) broadcasting videos of lectures (Papano, 2012). This medium has also started to change, incorporating more features of the unique online environment and scale that they offer.

So this usage of VR is a predictable initial foray for the technology. Before we dream up new kinds of interactive experiences, we recreate existing practices in a new medium (see Dede's "Old Wine in New Bottles"). While the pathway to such experiments may allow for rapid development, boiling water in VR is unlikely to lead to great advances in 21st century learning. Rather than recreating 20th century laboratory practices to demonstrate known phenomena, we should be doing exactly what this passage passes over. Instead of having students replicate those prior practices, they should be playing video games.

10.2 Why Video Games?

Why should students be playing video games instead of conducting labs? That is actually a false dichotomy. They should be playing video games and conducting labs. Some of those labs should be in real life. If Bunsen burners are unavailable, then draw upon kitchen science. Experiments in virtual reality can permit working in domains that are difficult or impossible to recreate in the real world. Experiments can take place on long time scales like that of evolution, at microscopic levels in chemistry experiments, or on the inside of a nuclear reactor.

But those labs can also be embedded in or connected with games. A game world can provide context, identity, and purpose for conducting such investigations and make the experience more meaningful and (while it might seem counterintuitive) it can also make them more authentic. For many students, isolated labs have little meaning. Breeding peas to determine whether wrinkled or smooth is dominant (long after Mendel established this) might seem quite routine. But breeding plants to find the variety that will help cure a (fictional) illness in an online world can situate the activity in a more personally meaningful context.

While some look to games merely to "make" an activity fun, their real advantage comes in providing structure around activities that allow for freedom and autonomy, yet also provide enough boundaries to help guide learners. There are many definitions of games, some of which focus on narrative, identity, or the separation of play and reality. My definition has focused specifically on the structures of games. These five principles describe these structures or "gaminess" (Klopfer, 2015).

- Interesting Decisions—This is Sid Meier's (the creator of Civilization) hallmark of game design. Good games are defined by the choices that players make. Deciding between heads and tails is not interesting, but making decisions that are informed by previous experiences and insights often is.
- Consequences to Decisions—There needs to be some set of consequences to the outcomes of the player's decisions. Those outcomes can be positive or negative, providing feedback to the player as to how those decisions are valued in the context of the game.
- Clearly Defined Goals—The game should provide a set of constraints and opportunities so that the player either knows a priori, or can easily discover what they are trying to accomplish. In good games, the player can choose between multiple different goals and can pursue them in a way that they see fit. For example, a player may choose to accumulate the most wealth, conquer the world, or broker peace.
- Visible Measurable Feedback—The player needs to know how they are doing. Ideally, they get this kind of feedback along multiple dimensions. This is not just a single measurement of score, but might include level of achievement, health, or gear that they have collected. This feedback may reflect "stealth assessments" that are a part of the game (see Shute in this volume).
- Underlying model or systems—There should be a coherent set of rules that define an underlying system. In digital games this might take the form of a simulation or set of simulations. But it can also be a comprehensive set of rules that define the mechanics of a non-digital system (Fig. 10.1).

There are many ways that these principles can be manifest in games. They could be provided through structured narratives, quest structures or other game systems and mechanics. Many great games embody many or all of these structural principles. These could be strategy games like Civilization, battle arenas like League of Legends, or Massively Multiplayer Online Role Playing Games (MMOs) like World of Warcraft. The latter is a particularly good example.

World of Warcraft (WoW) is a game set in a fictional world occupied by two warring factions consisting of fantasy races like elves, dwarves, orcs and even humans. Players choose a faction, race and class that specifies their roles, like a magical cleric or a hunter. They are then given a series of tasks to complete in the world by numerous non-player characters (NPCs) that inhabit the world. These tasks (or quests, as they are known) might be about collecting a certain number of items from a dangerous place in the world, or killing a terrible beast that has been attacking your folk. Players attempt to complete these tasks, granting them new

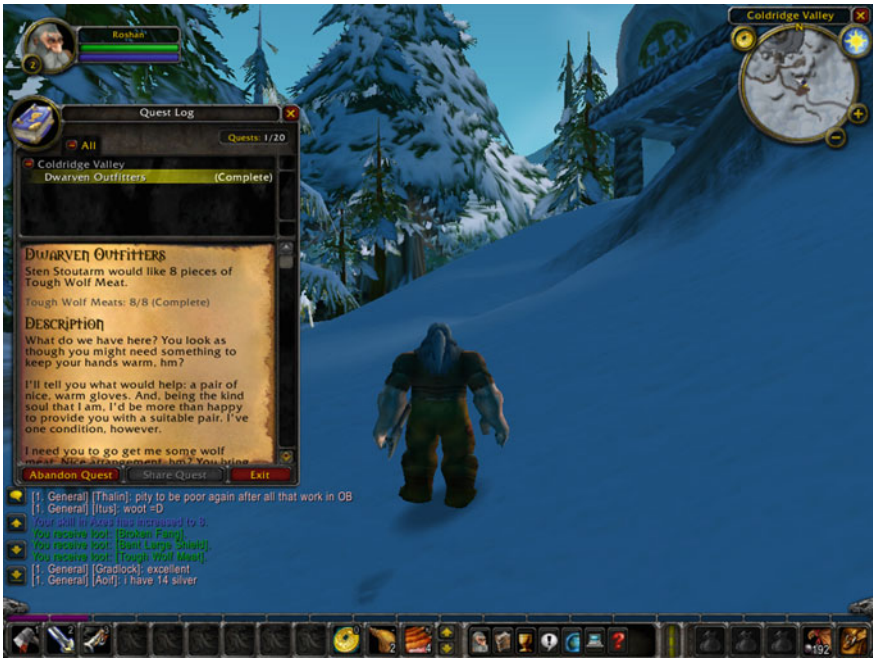

Fig. 10.1 World of Warcraft quest from http://www.mobygames.com/images/shots/l/91220-world-of-warcraft-windows-screenshot-the-quest-log-shows-you.png

skills and items. But they do so in a context that includes many other real players who inhabit the world. Most of those players are on the same side and are there to help. There are some quests that can only be completed by working with others. Such "dungeons" require collaboration with small groups. As players gain more experience they are challenged to collaborate in large groups (dozens of people) through "raids." Thus, the game exemplifies gaminess in the following ways:

- Interesting Decisions—The game offers players a variety of choices, beginning with their faction, race and class. As their characters level up, players need to continually make decisions about their specialization. While the world isn't truly "open" it has many places to explore and players need to choose where to go and what quests to take on. In battle, players choose from the array of abilities and weapons on hand to accomplish the task.
- Consequences to decisions—Succeeding in a quest leads to rewards. These include money, items and experience that can be used to level up. The more interesting consequences come from the choices about how to increase and specialize abilities. One can be a generalist, but at the cost of not being really great at anything. Or one can specialize in one domain, but be at a loss when another set of skills is needed.
- Clearly defined goals—For some players, WoW is about leveling up as quickly as possible. For others it is about obtaining some particularly rare item that can

be worn around. For still others it is about showing leadership within a group with whom one is collaborating. This diverse array of goals makes the game interesting to a range of players.

- Visible measurable feedback—On the way to accomplishing different sets of goals, Wow provides many levels of feedback. Players have wealth, items, experience, achievements, and reputation, to name just a few. Different players can choose to value these in ways that are personally meaningful and relate to their goals.
- Underlying model or system—WoW consists of many related systems. There are systems of weapons and spells. There are also systems that govern where and how often particular items are found. Discovering and debating the rules of those systems becomes an important thread in online discussions where players discuss their theories.

10.2.1 Educational Video Games—The Story of Radix

Many attempts have been made over the years to combine video games and learning. In some cases that means applying the superficial components of games like scoring or shooting to an otherwise mundane learning activity. The game Math Blaster exemplifies this kind of gamification. Math problems appear in the sky and the player needs to shoot down the right answer. There is no connection between the game play and the learning. The problems floating in the sky could just as well be vocabulary words.

Compare that game to The Logical Journey of the Zoombinis (Hancock & Osterweil, 1996), another long-lived educational math/logic game. But in this game the player never actually sees math problems. Instead, they solve mathematically modeled problems that are situated in a world inhabited by lovable creatures the player is trying to save (Fig. 10.2).

There have also been attempts at using commercial video games directly in the classroom. One such attempt (Steinkeuhler & Duncan, 2009) centered on WoW. In particular, it focused on the ways in which scientific discourse was incorporated into online discussion about the game. Players craft theories about how the systems work within the game and then collect and analyze data to test those theories. It might be about where the highest probability location for a particular item is, or the right sequence of spells to take down an enemy. Another topic was how players should best work together to accomplish complex tasks. Steinkuehler and Duncan found that many players used some fairly sophisticated theories and engaged in many levels of scientific discourse.

Players also invest a tremendous amount in their characters, developing them over months or years. At one point in time the most secure login system that I used was for my WoW character. It was more secure than my login for my bank, as I knew my character was nearly irreplaceable. That investment in the character immerses the player in the world in a deep and rich way. When that character

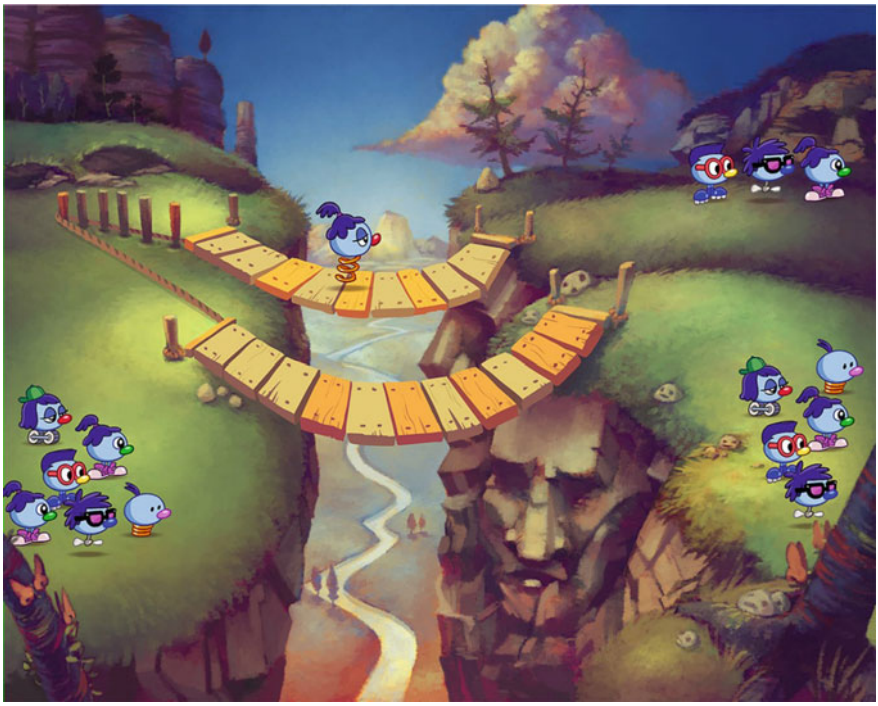

Fig. 10.2 The Logical Journey of the Zoombinis (https://external-wiki.terc.edu/display/ZOOM) showing a puzzle in which players must get all of the characters across the bridges based on an unknown logical rule

investment is combined with the social investment that players make—connecting to other players with whom they collaborate—it makes for a truly immersive experience.

Building on this idea, we (Clarke-Midura, Rosenheck, Haas, & Klopfer, 2013) created an educational MMO, Radix, about mathematics and biology. Radix is an MMO set on an earthlike planet in a Renaissance-like era of knowledge. Players take on the role of a novice in an underground society trying to use knowledge to make the world a better place. The quests that players take on relate to core content in either science or mathematics in one of several topic areas. For example, there is a quest line in mathematics that requires players to use geometry to reconstruct broken down buildings. Players are given tools that help them compute and construct the shapes that they need. Another quest line involves understanding human body systems. The player takes on the role of a physician who must isolate the system that is malfunctioning based on the symptoms patients present with. The challenge is to make these activities authentic, as discussed in Jacobson's chapter, even in a fantasy world.

Within each of these areas the quests get more challenging as the player progresses. A first challenge might simply be about understanding the underlying tool.

The next quest might be about applying the tool in a basic way. Each subsequent quest makes the challenge more difficult. Failure along the way results in another opportunity to complete the quest.

Radix was designed in such a way that those failures, as well as the successes, are informative. Many of the quests were built on principles of Experiment Centered Design (XCD) (Conrad, Clark-Midura, & Klopfer, 2014), a variant of Evidence Centered Design (Mislevy, Almond, & Lucas, 2003), which is also used in designing Stealth Assessments (see Shute in this volume). In XCD learners are challenged to conduct experiments. Each experiment provides results. Based on those results players can take further action, which might include further experiments. By interpreting these data we can deduce what students do and do not understand. For example, if a player is challenged to get "true breeding" (plants that breed to create plants with identical characteristics) medicinal plants, they would conduct a series of genetics experiments. If they breed two plants and get a mixture of offspring we can understand a lot based on what they do next—do they breed the offspring, go back and find new parent plants, or simply breed them again? This methodology gives the players a lot of choice and agency, but still allows us to better understand the model of the system that they have in their heads. In turn, the game can provide feedback to the students or their teachers based on these outcomes (Fig. 10.3).

Over time players unlock more capabilities in their characters and discover new parts of the world. They can also collaborate with peers and classmates on different

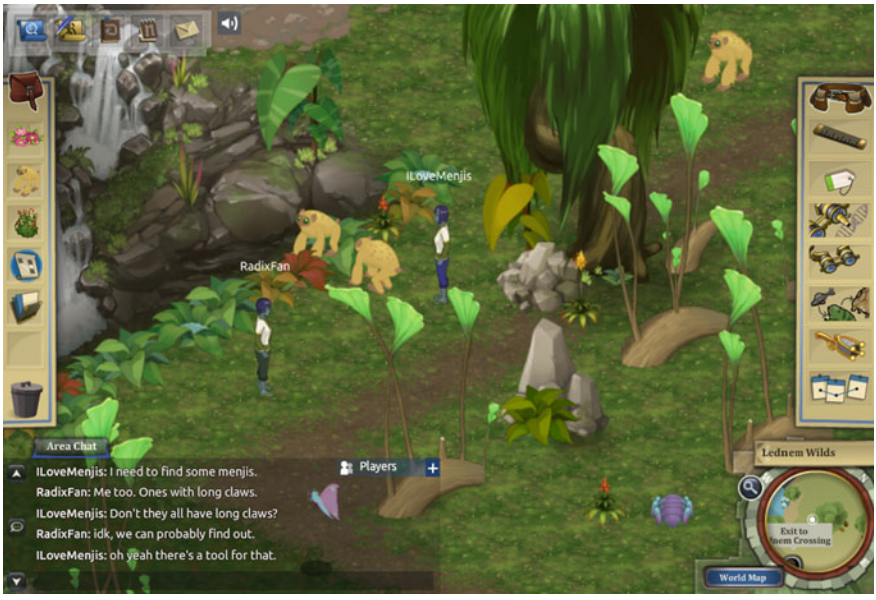

Fig. 10.3 Radix, an educational Massively Multiplayer Online Roleplaying Game (http://radixendeavor.org)

tasks, sharing data and knowledge to make the tasks more tractable. This form of collaboration, however, only scratches the surface of what is possible in these spaces.

10.3 VR + MMO + Learning

There is a huge potential for MMOs in VR. While some aspects of MMOs are adequately handled in 2D, or even better handled in this way, there are some aspects that can greatly benefit from this technology. Some early attempts already exist (see Looking Glass, 2016) and others are on the way (https://orbusvr.com). While Minecraft isn't an MMO, it shares some common facets, and it, too, has a VR version.

There are several reasons why MMOs in particular stand to gain a lot from VR implementations.

- **Immersion**—The most obvious reason is immersion, which I will interpret here as "investment." Part of the success of MMOs is immersion (similar to narrative immersion). There is the immersion in the character, social interactions and the world itself. Really being invested in a character means being invested in the world. VR can make the player a part of that world. A player becomes more invested in the fate of the world, the assets that they must protect or seize to accomplish their goals, if they feel that world is real. A player in a VR version of a game like Radix can benefit from the immersion in the character, interactions and the world, which are enhanced by removal of other distractions and a deeply connected first person perspective. See the world as if the player and the character are one can change the perspective of that player (see Slater in this volume).
- **Presence**—Presence is also fairly obvious and what I see as feeling like you are really in the virtual world. Complex tasks within WoW are notoriously challenging and require real time understanding of a multitude of data and factors. Screens of knowledgeable players (Fig. 10.4) contain dozens or hundreds of buttons, meters and heads up displays to keep them apprised of the situation. Bringing the player into the world allows them to experience and visualize that information in entirely new ways. Displays can be embedded in the world, or better yet, the ability to focus and perceive elements within the 3D space can be used to directly convey information for the player. The best representations and interfaces will need to be designed for these worlds to take advantage of the increased 3D perception, and situational awareness. For example in a game like Radix, rather than having detailed tools broken out into a zoomed in view in another panel, the tool could be used in context directly in the virtual world.
- **Collaboration**—The biggest possible contribution of VR to MMOs has to be around collaboration and social interaction (discussed in Kraemer's chapter). What really makes MMOs interesting and unique are the Massive and

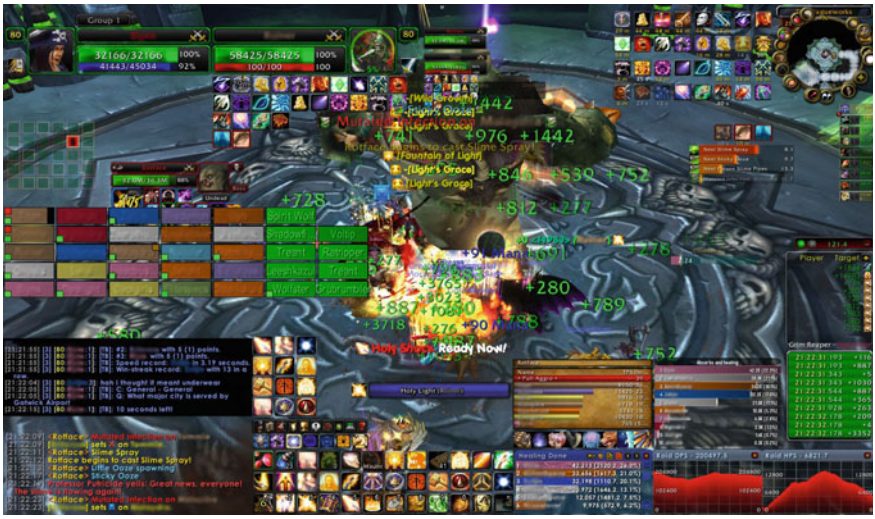

Fig. 10.4 World of Warcraft raid interface showing the kind of displays and information players use. https://noggenfoggerblog.files.wordpress.com/2013/06/raidui1.png

Multiplayer parts. Sometimes that interaction is simply around two players who run into each other in some part of the world, exchanging ideas or helping each other on a task in which they are both involved. I've been continuously surprised and elated by the friendly help I receive from other players who just are passing by. In most cases the game is designed such that tasks become easier when players collaborate, encouraging this behavior. For example, players might be collecting unique samples of some flowers in the world. When two players encounter each other they might share some of the samples that they have each found.

Other times the collaboration is a lot more intense; every player in a group numbering dozens must coordinate their efforts down to a fraction of a second to take down "the boss," an opposing powerful NPC. In these cases information must flow through multiple channels, including not only the meters and displays shown above, but also audio and chat channels. In a game like Radix, this could be mean a biologist finding the genetic weakness of invading monsters, while a chemist creates substances that could attack those weaknesses.

But VR has the potential to make collaboration and social interaction much more productive and natural. This is why Facebook, the massive social network, purchased Oculus, one of the first producers of VR consumer hardware. They see VR as the next frontier for social interactions. Recent announcements (Lee, 2016) have started to give indications of what this will look like. Players might need to hold two sides of a lens to reflect light in the proper direction to activate a secret entrance, or simultaneously cleave a DNA segment to edit genes.

While the typical Facebook interaction might be different than the kind of social interaction that makes up an MMO, many of the same principles will apply. It should be easy to see and understand the actions and expressions of your peers in the virtual space. It should be natural to interact with shared objects. It should be obvious what people are doing and where they are headed. These same traits are useful in an MMO.

In fact, the next generation of social interactions in MMOs may look quite a bit different than the ones in current games. We may see more interpersonal and expressive interactions enabled by higher bandwidth, greater graphics fidelity, new controllers and VR headsets. MMOs might try to blur the lines between the game and the network of people working in the game so that other kinds of social interactions are supported, keeping players in the game world longer.

Getting back to the initial story on VR in schools, VR does show the promise of supporting greater collaboration around shared artifacts. Those could be test tubes filled with salt water for conducting a traditional lab. But a much more exciting opportunity is that those could be test tubes filled with alien DNA for analysis, or used to collect and analyze chemicals from a toxic waste site. These scenarios not only involve substances and scenarios that are unobtainable in real life, they can also be situated in a context that provides a rationale and in which the learner can immerse themselves. They can become something beyond a student in a class doing a lab, perhaps a scientist, adventurer, or pioneer (as illustrated in Dede's chapter). This is important for helping students develop an identity.

10.4 Innovation on the Horizon

So why aren't we seeing educational VR MMOs yet? There are a number of reasons. They require a lot of time and money to create, which means that before anyone can be successful in that space there are a few innovations that need to be worked out. One set of challenges involves the barriers that any MMO might face, which include the massive domain of content to be authored, which require authoring tools, which could be made accessible to individual content creators. Other VR specific challenges include:

- Interfaces—The existing set of interfaces for managing information and interactions within MMOs have been designed for relatively small flat screens. Yes, those can simply be ported to VR, but then there won't be a big advantage for VR. Instead, new interfaces that can both be situated in 3D space and that can display information in novel ways need to be created. People's abilities to focus on elements in the world and to perceive the relationship between information and objects will change in VR, and that can lead to exciting new visualizations.
- Controls—MMOs are notoriously complex and often require the use of the whole keyboard for navigation, use of abilities, and control of displays. Using a

keyboard with an opaque VR display adds new challenges to using this kind of control scheme. New VR controllers for navigating in 3D space and performing complex operations are starting to emerge. These controls need to be adapted to the space of MMOs to support the kinds of interactions they need.

- Settings/Context—Many MMOs are set in space or Tolkienesque lands inhabited by mythical creatures. But VR opens up the opportunity to situate these games in other kinds of places. They could be real societies, historical sites, or scientific microcosms. Being immersed in these kinds of spaces in VR becomes an exciting opportunity.
- Pacing—Playing an MMO is often a serious time commitment. Some MMOs have sought to break this time constraint by chunking play into smaller pieces. Being immersed in VR, particular when considering school context, likely needs to further advance this work of breaking play into smaller, manageable chunks of time.
- Collaboration—As mentioned above, this is perhaps the biggest and most exciting challenge for MMOs. What are the new forms of collaboration that can be fostered through VR in terms of social interactions and shared objects? Can players communicate with a nod of their head or wave of their hand? And can they interact with the same warp drive motor to try to repair it? This will make for rich game play and educational experiences. There may also be in-game and out-of-game collaboration opening up a range of mixed reality experiences. Perhaps one player is in VR, and the other is in the real world, feeding them live data through a mobile device that is incorporated in the game or simply using a flat display to provide a different perspective on the world.

10.5 Next Generation VR MMO for Learning

So what might a next-generation MMO for learning look like? I might start with a premise something like that of Radix, being part of a group trying to use science and math to make the world a better place. But perhaps it is set in the near future, in a world created through mapping and filming of actual cities. Ideally, this might be created via an openly shared mapping database that could be used for many VR applications, thus reducing the cost and barrier to entry for creating rich VR spaces for learning.

Given the current context, the problems to be solved might be based on real issues like fighting emerging diseases, breeding crops to cope with global climate change, or tracing the source of air pollution hundreds of miles away. Players might specialize in different domains like genetics, air quality, or data analysis. In the VR world, they can become that character, and take on that unique identity.

In one scenario, perhaps players need to manage an emerging disease in the southern United States (think something similar to Zika). They need to assemble a team consisting of someone who is role-playing a doctor, another who is a DNA expert, another who is an entomologist, and one who is a mechanical engineer,

along with several others. They need to build a trap to collect mosquitoes for analysis and must collaborate to assemble the pieces and build the machine. They use specialized controllers to move the parts around, often requiring two people to lift together, and haptic feedback indicates when the pieces are in place.

Meanwhile, another team is collecting blood samples and analyzing them. Instead of using the traditional analysis tools, they can shrink down into the bloodstream and examine cells and molecules as they whiz by. One player needs to keep an eye on what is coming down the bloodstream and communicate to make sure the players don't get washed away.

Yet another team is in command central on traditional computers, monitoring the situation and advising the other players in real time. Flat displays might still be useful in the context of such activities as displaying maps, text, images and allowing seamless access to real world information such as laboratory equipment, documents, and peers.

The game might even include some Augmented Reality, relaying real time information to players' phones throughout the week. Augmented Reality (AR) can mean many different things. There is tabletop AR, as one might see through a specialized phone app showing a 3D model that pops out of a book, room scale AR, as seen on platforms such as Hololens, and landscape scale AR, which has been popularized in Pokémon Go. Landscape scale AR has quite a history in education (e.g. Dunleavy, Dede, & Mitchell, 2009; Klopfer, 2008; Squire & Jan, 2007). In much of this work, AR is used to add an interesting but fictional layer onto the real space, such as a school yard or nature center of museum, in which players are exploring. Also, in these experiences players work on teams to solve complex problems. The AR nature of the experience allows them to rely quite a bit on reality for communication using familiar devices like phones or face-to-face communication to work together.

In this case, blending in AR might mean that players can get updates on situations they are monitoring, and their own city might be a part of the problem/solution as well. So as they come to and from school, or go about their after school chores, they can be pushed new information based on their location and scan areas for problems/solutions using a simulated heads up display on their phone. This borrows from the genre of Alternate Reality Games that blend game play and the players' lives (McGonigal, 2008). Perhaps in this scenario players are combating an outbreak of a disease in the virtual world, but they can pick up virtual medical supplies at any of thousands of medical facilities geotagged across the country. Or perhaps players need to pick up certain elements only found in particular regions of the world and then share them within the game.

The teacher could also interact in a variety of ways. They could drop in through VR to experience what many of the students are doing, teleporting from one location to another. Many teachers might find it too difficult to immerse themselves in VR because doing so means losing sight of the whole class. A more likely scenario might be a single display on a flat screen. It will allow teachers to track what their students are doing in real time, allowing them to see who is struggling and who is succeeding and to offer students real-time assistance.

10.6 The Reality of School

Conducting an activity like the one described above in most schools would provide a significant challenge. For one, if they have VR capabilities, it might be on a single workstation for demonstration, or with relatively simple devices like Google Cardboard, which don't allow for highly interactive environments. It will be some time before schools have the technical capabilities and resources to conduct these activities. That means emphasizing one design principle—differential experiences on different devices. The kinds of hybrid activities in which some are in VR and others are on traditional displays can create immersive experiences that still draw upon the unique advantages of VR without trivializing the unique aspects of VR.

But there are more fundamental changes to both school and games that need to happen to facilitate this activity, as discussed in Richards' chapter.

First, the activity needs to be pervasive. If it is just a matter of short experiences in the computer lab, then these experiences will have little impact on student learning. The activity itself can be pervasive through mobile extensions and explicit connection to the curriculum. Students can monitor the scenario, communicate, and perhaps even launch automated exploration through mobile devices. This allows them to be immersed in the experience even when they aren't in VR.

Second, the activity needs to be persistent throughout the year, or at least a longer period of time. It will take some setup to make the activity work, and that investment in time can be justified by maintaining the activity over a longer period of time. Additionally, this persistence allows students to develop and explore their identity within the virtual space, investing the time and resources to specialize their characters and make them unique. This is the investment we see in commercial MMOs, and we should see similar investment in educational MMOs.

Finally, school needs to change some. These kinds of activities are great for getting students to take new perspectives, develop identities, learn how to collaborate around complex tasks, and challenge misconceptions. But it doesn't compress a lot of factual learning into a short period of time. Leading scholars and educators agree that that the kinds of learning promoted in this sort of experience is the kind of learning that we need to be offering students today. We just need to align that perspective with what actually goes on in school.

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Author Biography

Eric Klopfer is Professor and Director of MIT's Scheller Teacher Education Program and The Education Arcade. His research focuses on the development and use of computer games and simulations for building understanding of science, technology, engineering and mathematics. The games that he works on are designed to build understanding of scientific practices and concepts as well as critical knowledge, using both mobile and web-delivered game platforms. Klopfer's work on simulations focuses on students' understanding complex systems through critical thinking and connecting computer programming with scientific practice and real-world issues. He is the co-author of the books Adventures in Modeling, The More We Know, and the upcoming Resonant Games, as well as author of Augmented Learning. His lab has produced software that includes the UbiqBio line of mobile biology games, the Massively Multiplayer game, and The Radix Endeavor, as well as platforms like StarLogo TNG for modeling complex systems, Taleblazer for creating augmented realities, and Gameblox for making games online. His work also includes a series of Massive Open Online Courses known as edTechX, which cover educational technology and games. His work has been funded by federal agencies including NIH, NSF, and the Department of Education, as well as the Gates Foundation, the Hewlett Foundation, and the Tata Trusts. Klopfer is also the co-founder and past President of the non-profit Learning Games Network (http://www.learninggamesnetwork.org).