Virtual worlds, or simulated 2D and 3D online environments (e.g., Second Life), have become an increasingly common software platform for education and training applications during the last decade (cf., Brown & Bell, 2004; Chou & Hart, 2012; Cremorne, 2009; deNoyelles & Kyeong-Ju Seo, 2012; Gerald & Antonacci, 2009; Jones, 2007; Kingston, 2011; Taylor, 2002). They hold the promise of opening new horizons for students and educators, but can also present unexpected barriers to access, especially for students who have disabilities (Folmer, Yuan, Carr, & Sapre, 2009; Forman, Baker, Pater, & Smith, 2012; Mancuso, Chlup, & McWhorter, 2010; Stendal, Molk-Danielsen, Munkvold, & Balandin, 2011). For the purposes of this discussion, a “virtual world” is defined as “a synchronous, persistent network of people, represented as avatars, facilitated by networked computers” (Bell, 2008, p. 2). Applying the definition of online accessibility from the World Wide Web, Web Accessibility Initiative (WAI—http://www.w3.org/WAI), “accessibility” refers to the degree to which people with disabilities can use the virtual world. More specifically, accessibility means that people with disabilities can perceive, understand, navigate, and interact with the virtual world, and that they can contribute to it. “Disability” in this context can be defined as any functional limitation (physical, sensory, or cognitive) that impedes a student’s ability to fully engage in the educational process, as compared to similar-age norms.

One common assumption about the educational uses of virtual worlds is that “immersion or “the subjective impression that one is participating in a comprehensive, realistic experience” (Dede, 2009, p. 69) can enhance the
learning experience. Researchers have also observed that virtual worlds offer possibilities for experiential learning, encouraging students to engage in problem-solving activities within a flexible environment that facilitates collaborative and constructivist learning (Cremorne, 2009). Educators have also been drawn to the potential that virtual worlds offer for distance learning, social interaction, and learner engagement (Chou & Hart, 2012). In these applications, the presence of avatars can enhance “engagement and learning beyond computer-mediated communication without such agents” (Jarmon, 2009). Researchers have also noted the capacity of virtual worlds to facilitate experiential learning (Jarmon, Traphagan, Mayrath, & Trivedi, 2009) via simulations, role-playing, and group work (Duncan, Miller & Jiang, 2012; Inman, Wright, & Hartman, 2010). Outputs like user-created content are also of particular interest. In many virtual world environments, including the relatively popular Second Life, students themselves become the creators of content, and mediate their own interaction and learning (Jarmon, 2009; Kingston, 2011). Although more recently there has been some disenchantment with the complexities of using virtual world environments, (deNoyelles & Kyeong-Ju Seo, 2012; Young, 2010), they remain popular educational tools. In this chapter, we will investigate a specific domain of user difficulties in virtual worlds, namely, accessibility issues, especially for students with disabilities. We will present key accessibility issues involved in the deployment of virtual environments for educational uses, focusing on popular fee-based (Second Life) and open source (OpenSim) platforms. These platforms were chosen because of the number of their concurrent users, the ability to create within them, and their use within the educational community.

It is important to note that we, the authors, are not end-users of the assistive technologies included in the chapter, but have consulted with end-users throughout the writing process via the BreakThru project (http://www.georgiabreakthru.org) on virtual mentoring, funded by the US National Science Foundation’s (NSF) Research in Disabilities Education.

Accessibility issues can make the uptake and use of virtual worlds in education a challenging concern, especially for institutions that have adopted full inclusion in their policies. But developers of virtual platforms, third-party software developers, teachers, students, and organizations based in virtual worlds continue to respond to these challenges, providing tools, guidance, mentorship, and promising practices to overcome difficulties and allow the platforms to live up to their potential as learning environments.
Accessibility Barriers

While virtual worlds offer unexploited potential for innovative educational practices, at this stage in their development they also present a range of potential barriers common to all users, as well as accessibility related ones that impact people with disabilities. General barriers, those common to all users, include issues such as:

- Reluctance to accept virtual worlds as a serious educational tool rather than a “gaming” environment;
- Potential technical problems for hardware, software, and Internet connections;
- Potential for distraction;
- Privacy issues for students;
- Legal issues;
- Development and maintenance costs;
- Authentication of individuals using the platforms.

In addition to these issues, accessibility is often a greater concern for people with disabilities (White, Baker, Pater, & Todd, 2011). Accessibility barriers inherent in many virtual worlds violate global demands for total “e-inclusion” and “eAccessibility,” which call for full inclusion of all users in information and communication technology (ICT), including users with disabilities (European Commission, 2012). Accessibility has not typically been a primary concern for most developers of virtual world platforms. Created environments typically rely heavily on visual stimuli and graphical user interfaces that assume relatively “normal” vision, eye-hand control, and dexterity (Folmer et al., 2009; Forman et al., 2012). Platform developers have placed some useful settings in many of the common virtual environments, such as customizable fonts, high- and low-contrast options, keyboard navigation, and sensitivity controls (Trewin, Laff, Cavender, & Hanson, 2008). Unfortunately, these basic user interface options are all that most virtual environments include. Additional technologies and design approaches (such as universally designed processes and interfaces) are needed to fully enable users with disabilities to access the entirety of virtual world interfaces.

Regardless of the platform, the level of accessibility provided is more limited by the time and resources available for the development of the environment than by any barriers inherent within the technology (Trewin et al., 2008). Ironically, the very richness that affords so many possibilities for inclusion,
participation, and dynamic interaction complicates the implementation of accessibility features, especially for those with sensory, dexterity, communication, and cognitive disabilities (Cremorne, 2009; Ellis & Kent, 2008; Forman et al., 2012). In many cases, “digital design is triggering disability when it could be a solution” (Ellis & Kent, 2008, p. 1). Particularly within educational settings, barriers to the delivery of content and interaction with instructors can limit the educational experience for students (Stendal et al., 2011).

A typical barrier to accessibility for users with visual impairments, for example, is a lack of metadata, that is, embedded code such as names and descriptions of virtual objects. One study found that in the popular virtual platform of Second Life, at least 31% of objects lack a descriptive name (Folmer et al., 2009). Overall, users with low vision present a special challenge due to the highly visual nature of the medium. Audio cues are required to orient the user and to describe the environment. By supplementing visual effects with audio, the vision impaired user could potentially react with the same degree of precision as sighted users. Studies that presented the results of this approach suggest promising results for user navigation, but note that there is a significant learning curve for users who have not yet learned to associate objects with their sound cues (Trewin et al., 2008). Text cues and object labels can provide increased accessibility for both users with low vision and users who are deaf or hard of hearing. Provided that these labels are as meaningful as alternative text on a web browser, they are a valuable addition that increases accessibility for users with disabilities, while also increasing usability for all users. Taken together, these accommodations increase the flexibility of the software to provide access to both populations.

Researchers note a need for more creative solutions that can tackle challenges generated by highly graphical and multimedia rich environments (Cremorne, 2009; Stendal et al., 2011). Sophisticated interface elements, scripting, Cascading Style Sheets (CSS), dynamic updating (e.g., Ajax), embedded video and sound, Adobe Flash, and reliance on mouse interactions all push the limits of assistive technologies and existing accessibility guidelines (Gibson, 2007) in virtual worlds and kindred environments.

An alternative approach to generating “fixes” to accommodate users of these highly visual environments is that of Universal Design (UD). In the context of information, Universal Design, or as it is called in the European context “Design for All,” is aimed at ensuring that everyone can participate in the Knowledge-based Society. The European Union refers to this using the terms eInclusion and eAccessibility. A three-way approach is proposed: goods that
can be accessed by nearly all potential users without modification, or failing that, products that are easy to adapt according to different needs, or use standardized interfaces that can be accessed simply by using assistive technology. To this end, manufacturers and service providers, especially but not exclusively in the Information and Communication Technologies (ICT) domains, produce new technologies, products, services, and applications for everyone (Stephanidis & Akoumianakis, 2005).

The UD approach is slowly becoming integrated in virtual worlds and games designed for the general public, increasing accessibility for users with disabilities in the process. Various software platforms are at different stages of completion with regards to accessibility features, and the open source community has supplemented the software with alternative clients that provide expanded accessibility options, particularly for users with disabilities. Sections of the Second Life Wiki (http://wiki.secondlife.com), for example, are devoted to accessibility issues, tips, and resources (see Second Life Wiki, 2011a).

Examples of Disability Issues Evident in Two Virtual World Platforms used in Education

Virtual world platforms used in education share many accessibility issues common to multi-user virtual environments (MUVEs), although they also differ as to particulars. This section provides a summary of accessibility issues in two platforms currently used in educational settings: Second Life and OpenSim. Both platforms are built on similar foundations, but have different approaches to content development. While Second Life was developed by Linden Labs, who remain in control of a majority of the servers and environment, OpenSim is maintained and developed by the user community. Both virtual environments are designed for large groups of users, and content is typically developed using inworld tools. Second Life was chosen as an exemplum because it is the most commonly used virtual world platform internationally for online education (Dalgarno, Lee, Carlson, Gregory, & Tynan, 2011; Duncan et al., 2012) and is the most-cited platform in educational literature (deNoyelles & Kyeong-Ju Seo, 2012). OpenSim has been included in this review to provide an open-source option for readers, important for those users who cannot pay ongoing fees for propriety platforms, and for those educators who want more complete control over the virtual environment. OpenSim was chosen among open source platforms because it maintains a high percentage of educational users (Dalgarno et al., 2011) and shares a high level of compatibility with the Second Life client.
Robert L. Todd, Jessica Pater, and Paul M.A. Baker (Allison, Miller, Sturgeon, Nicole, & Perera, 2010), making it relatively easy to “port” virtual artifacts from one to the other.

**Second Life**

Second Life is currently the most popular virtual world platform used for education and entertainment (Dalgarno et al., 2011; Miesenberger, Ossmann, Archambault, Searle, & Holzinger, 2008; Warburton, 2009) in terms of number of users. It has been widely used by individuals with disabilities, who have given it mixed reviews. On the one hand, the platform has allowed some to be free of situations they cannot control in real life (Springer, 2009). For example, users can explore outer space with the NASA-sponsored MoonWorld (http://moonworld.cet.edu). Participation has also offered many benefits to users such as “[improving] spatial awareness, hand/eye coordination, and fine motor skills” (Springer, 2009, p. 42). On the other, the platform presents some accessibility issues that make it difficult for many users to participate.

![Figure 4.1 Moonworld: a Second Life learning tool for space exploration.](image)


Second Life has traditionally presented significant challenges to users with visual disabilities, especially blind users (Peters & Bell, 2007). Currently there is no set standard on providing metadata in virtual worlds, and therefore there is
little guidance for developers to address vision concerns. This can inhibit the interaction of users with low vision; they may not be able to perceive objects, relate to events, or even perform basic user functions without descriptive and informational tags. People using screen readers or other alternative methods to access Second Life often have difficulty moving about and interacting because objects in their virtual world are not defined. For this reason, many believe that virtual worlds, including Second Life, should be held to the same accessibility standards as the Web, including having alternative text for object and meta-information on behaviours (Miesenberger et al., 2008).

Moreover, the Second Life viewer was not designed to be compatible with any voice-output screen readers. These readers, such as JAWS (Freedom Scientific, 2012) or Window-Eyes (GW Micro, 2012) provide voice output for operating systems features, software applications, web browsers, and other normally visual elements of computer use. The lack of built-in compatibility with these readers means that they cannot effectively translate Second Life controls and environment objects into sound and speech. A few options exist to help minimize this problem. TextSL, created by the University of Nevada, is a text client that lets screen readers access Second Life. Unfortunately, at the time of writing JAWS was the only screen reader supported by TextSL. IBM has also developed a tool called the IBM Virtual Worlds Accessible User Interface (2011) to assist users with visual limitations. In addition to these, Virtual Helping Hands has developed the Virtual Guidedog (discussed later in this chapter), which uses an object to assist avatars of users with limited vision, hearing, or mobility. For users with low vision, Second Life also offers features to change the text size for the interface and chat.

In general, Second Life worked well for users who are deaf or hard of hearing, until voice features were introduced (Peters & Bell, 2007). Before 2007–2008, many users who were deaf or hard of hearing were pleased with Second Life because all conversations took place in text chat. Under these circumstances, people who were hard of hearing had the option to withhold information about their disability if they chose to do so. With the introduction of voice via microphone, if these individuals choose not to use the voice/listening features then they may feel forced to reveal the reason, therefore creating the potential for social and communication barriers (Carr, 2010). This presents a social/communication conundrum which these individuals claim mirrors real-life situations. Users who are deaf or hard of hearing and users with difficulty speaking have stated they sometimes claim that they lack the technical capacity to communicate in voice, as opposed to disclosing their disabilities.
Second Life also offers voice-recording capabilities to record inworld events, such as meetings and conferences. Voice chat is recorded to an audio file for later playback. While this feature helps users with low vision, it can create problems for users who are deaf or hard of hearing, as a growing number of Second Life events are now available only with voice recordings, not text. Second Life does not offer any transcription services. Users must provide transcriptions when preparing for events, or must outsource the service for a cost. For this purpose, Second Life recommends CastingWords (http://www.castingwords.com) or the Amazon Mechanical Turk (http://www.mturk.com).

Those who use sign language as a first language may face barriers to access similar to those with difficulty reading caused by slower written language skills. In effect, these individuals are forced to use a “second language” to communicate, since American Sign Language (ASL) is not supported by Second Life. These users often report a “lag” in textual communication, but few claim it is an insurmountable barrier (Carr, 2010). Frequent conversation partners tend to learn their reading/writing speed and accommodate them.

On the whole, users who are deaf or hard of hearing and users with difficulty speaking can generally participate in most activities in Second Life. Such users are distributed in skill level and engagement throughout the Second Life population, including some high-level builders and scriptwriters. Some engage with the Second Life disability community at large, while others choose not to. Despite these barriers, users who are hard of hearing still seem, as a whole, to be happy with the function and ability that Second Life offers (Carr, 2010).

Many Second Life users who have mobility limitations have expressed relative satisfaction with Second Life as well (Antonacci & Modaress, 2008). Some report that the platform opens doors, as those with limited mobility feel less constrained by functional limitations, since in Second Life, they can walk or even fly with ease. Some users with mobility impairments present themselves in Second Life using a wheelchair, while others do not. Other users switch back and forth between avatars using wheeled mobility aids and avatars that do not. Many users report the virtual world provides an opportunity to hide their mobility issues or present them to others in hopes of increasing disability awareness, with the power to choose which approach to take in specific situations. The reduced physical barriers are a positive point for those who have difficulty moving around in real life. Users can attend events or even travel to other countries that would have otherwise been difficult for them to reach (Antonacci & Modaress, 2008).
Even though Second Life is providing many opportunities for users with limited mobility, it is often difficult for those with severe dexterity limitations to manoeuvre their avatars. Simple functions such as walking or flying can be challenging. The viewer controls for camera and avatar motion in Second Life require precise, small click targets. However, using voice-to-text tools or alternative pointing devices, most users are able to participate to a certain degree in most functions in the world, and some are even able to participate in advanced functions like building or scripting. Second Life suggests many alternative input devices such as 3Dconnexion alternative mice, FrogPad (see http://www.frogpad.com), the Wacom tablet, the Kensington Expert Mouse, and so on (Second Life Wiki, 2011b) to assist users who have dexterity limitations.

Users with cognitive disabilities have not been addressed in literature to the same degree as other groups (Inman et al., 2010). However, in the limited research these users report increased feelings of inclusion since any delay due to cognitive issues could be perceived as multitasking between spatial, remote chat, and other activities in Second Life. Additionally, many users feel that the immersive qualities of virtual world environments allow them to focus their attention more effectively than they can on other computer tasks such as web browsing, which are discrete and asynchronous. Users with Asperger's Syndrome and autism often react positively to Second Life because it allows them to learn social skills that may otherwise be overwhelming or difficult to grasp in real life (Boulos, Heatherington, & Wheeler, 2007; Stendal et al., 2011).

Barriers for users with cognitive disabilities are typically a result of software complexity and difficulty learning virtual world skills. The learning curve for Second Life is already significant for users without cognitive disabilities, creating an even larger barrier for those with them. But experience has shown that these users can and do compensate, and given time they can become relatively proficient.

In addition to all of the populations we have described here, there are users who have perceptual difficulties in media-rich environments such as Second Life. These difficulties include vertigo from perception/movement in a virtual environment, seizures caused by flashing or moving objects, and migraines caused by moving or flashing objects, even the rate at which the monitor refreshes. In general, accessibility for these users has not been widely discussed. These conditions are often more incapacitating in the virtual world than in the physical one, and thus are not recognized as disabilities as easily as more common limitations. Because these issues can create adverse, difficult-to-tolerate symptoms, they often result in the recreational user abandoning
the virtual experience rather than seeking accommodations. Most users in this category who persist have an idiosyncratic way of adjusting viewer settings and their built environment that works for them specifically. An example is a user with perceptual limitations who creates default settings on Second Life so that visual images appear in a high-contrast colour scheme of black and yellow. This appears unattractive to most viewers, but allows this individual to navigate Second Life for hours at a time without headaches and related adverse symptoms.

Individuals with learning disabilities are another population that faces challenges in Second Life, but may also reap rewards. The platform’s interface sometimes creates initial barriers to usage as it requires learning control and communication commands unique to Second Life. But given proper training and time to learn the system, students generally report success (Moon, Todd, Morton, & Ivey, 2012). Limited research has been conducted into the levels of impact these platforms have on the learning processes of those who do not fall into the normal student paradigm (Inman et al., 2010), but studies do indicate certain advantages. The dynamic nature of the platform allows for enrichment of the learning experience that is not possible with a traditional textbook or standard course management system. Because the artifacts created are most often persistent, students who need more time with learning objects have the ability to revisit them and take the time needed for mastery. Also, Second Life is a very collaborative and social tool, which lends itself to greater peer interaction and potential mentoring that can give students with learning disabilities another kind of assistance.

Despite numerous accessibility issues, Second Life remains a promising tool for users from various disability communities to interact in ways that would otherwise be impossible or very difficult. Second Life is also slowly adapting and providing alternative access tools as they are needed by the user community. The high number of active users with a range of specialized needs has raised some awareness of accessibility issues, both with the Linden developers and with users at large. The growing movement for usability and accessibility standards for virtual worlds within the World Wide Web Consortium and other bodies holds promise for improved experiences for users with disabilities (Moon et al., 2012). Once such standards are in place, it is hoped that virtual worlds like Second Life will become more accessible and follow more closely the precepts of Universal Design.
OpenSim

OpenSimulator ("OpenSim") is an open source, community-developed virtual environment with basic features roughly equivalent to Second Life. However, the implementation of the software differs significantly. Second Life is a service; hosts purchase space from Linden Labs and sculpt a virtual world within the confines of the Second Life grid. OpenSim more closely resembles traditional software in that the goal is for individual users to create their own metaverse or shared virtual space where the end-user experiences a virtually enhanced physical reality and a physically persistent virtual space (Smart, Casico, & Paffendorf, 2007). The creators can choose to link these worlds to others or create a “walled garden” (Rogers, 2009) only invited participants can enter. World builders download the package from the OpenSim website and install it on private hardware.

Since OpenSim is based on the same protocol as Second Life, it suffers from many of the same accessibility limitations. The standard Second Life client does not become any more accessible when connecting to an OpenSim server than the Second Life grid. There are alternative browser clients for viewing both Second Life and OpenSim, such as Radegast (http://www.radegast.org) that make accessibility a higher priority. Unfortunately, OpenSim does not always mesh perfectly with these clients, and may require added effort on the part of developers if they are to be used. While largely similar to Second Life, the “plug-in” expandability of OpenSim and its community-driven development frequently makes compatibility an issue.

OpenSim’s largest drawback is not directly related to accessibility, but rather development. While an open source community potentially allows a very large pool of developers, the actual OpenSim community is relatively young, and thus small. The software is currently in alpha release, and not yet feature-complete. Community plugins have vastly expanded the project since its inception, but they almost universally focus on basic features rather than accessibility. In short, there is very little support for users with disabilities in the OpenSim community. This forces them to fall back on the same alternative clients and assistive technology that enable access to Second Life, while also requiring a far larger investment in time and code for those who choose to launch an OpenSim world.

Because of the strict controls within the Second Life platform, many have begun exploring how OpenSim could be used independently. Xplanet is an example of how independent researchers are making their findings more contextual and accessible (Dague, 2008).
Figure 4.2 is an example of how free and accessible content (xplanet.sourceforge.net) can be used to create an interactive 3-D learning tool inworld. Different layers can be used to analyze not only different attributes of the Earth but also other planetary bodies. These layers include historical, weather, and geological events (like volcano and earthquake activity) and other data.

OpenSim, because of the nature of the extensible platform, can be offered to individuals under the age of 18. The Teen Grid of Second Life was open only to individuals between the ages of 13 and 18, and was closed recently due to economic pressures within the company (Harrison, 2010). Because of the extensibility between objects created within these two platforms, many of these educators have moved to the OpenSim platform.

### Assistive Technology Tools for Accessing Virtual Worlds

A number of assistive technologies can be utilized to make virtual worlds more accessible to users with disabilities. While most virtual world platforms are relatively inaccessible “out of the box,” third-party clients and standard assistive technology (AT) hardware can allow users to access many more features than would otherwise be possible.
Accessing a virtual world environment can be a difficult task for any new user, and a daunting or nearly impossible feat for users with functional limitations. A person with limited dexterity might have trouble just turning on a computer, and virtual world use can be a demanding endeavour. Users have to see the environment in which they are involved, chat privately or with a group at the same time, hear audio prompts/music/talks, get bearings for the lay of the land, be able to navigate to a specific destination, store and retrieve files for sharing, research objects for possible purchase, and many other tasks that for the most part require vision, hearing, cognitive, and dexterity functions. We have provided information on types of AT that can enhance computer usage and, by extension, virtual worlds in education. These examples must remain broad in order to cover the range of AT involved, but specific instances of this AT, along with purchase information, prices, and so on, can be found on the assistivetech.net website. The site is free to use and provides searchable indices of thousands of products that may be of assistance to virtual world students and educators.

A person with limited dexterity will have trouble using the full attributes and applications of a mouse and keyboard. He or she might have trouble gripping and moving a mouse, pushing the buttons, and rolling a small navigation wheel. He or she might also have difficulty in typing on, reaching for, and fully utilizing a standard keyboard. Many variations of mice and keyboards exist to accommodate a user’s dexterity needs, along with certain accommodations that negate the need for a keyboard and mouse altogether. Such items include:

- Track and ball mouse
- Optical mouse
- Wireless mouse and keyboard
- Joystick
- Ergonomic mouse and keyboard
- Glove mouse or movement sensor
- Head pointer/mouse
- Adjustable keyboard/mouse tray
- Voice activation/prompt software

A person with low vision must be alerted when his or her environment changes, other users are trying to access them, events are starting, and when there are objects for possible retrieval and sampling. Users without disabilities rely heavily on their vision to navigate them through virtual environments. It is challenging to replicate all of the prompts, cues, and changes that a person with average eyesight will perceive so that a user with low vision can have comparable
functionality. However, AT attempts to deliver these prompts and cues through other sensory outlets. The visual accommodations for a virtual world experience include:

- “Thin” browser clients like Radegast and Metabolt
- Screen magnifiers
- Keyboard magnifiers
- Larger keyboard
- Text-to-speech software or screen readers
- Larger screen/display
- Low-glare screen filter
- Braille keyboard
- High contrast text displayer
- MaxVoice
- Virtual Guidedog (“Max”)

Virtual world users who are deaf or hard of hearing have less difficulty, as much of the virtual environments can be navigated with no audio. However, in educational environments, teacher’s lectures and class discussions are often provided via audio, a critical component of the user experience. Further, audio can provide interesting and informative cues, such as environmental noise, such as waves crashing when near a beach, music being played by a band, or an individual avatar broadcasting a playlist. A user might attend concerts, dances, lectures, and the arts while in the virtual world. For these occasions, assistive technology might include:

- Sound amplifier
- Words-to-text software
- Environment sounds to text

The learning curve for virtual world navigation is relatively steep for all users. If users with learning or cognitive disabilities must access a virtual world, they might require further assistance and guidance. Such users might benefit from clear and comprehensive step-by-step instructions. The following outlets can provide support:

- Chat rooms, blogs, and technical support
- Easy and thorough instructions for accessing the virtual world

Overall, there are many accommodations that virtual world users might need in order to fully function and participate in a virtual learning environment.
Many users with disabilities will already have assistive technology that they use to effectively operate their own computer, while others will need more accommodations to utilize a virtual world setting. These needs tend to be very individual, and require specific tools and combinations of tools. See the “Examples of Virtual World Tools and Assistive Technologies in Practice” section later in this chapter, for examples of AT integration by users. In addition, there are two wikis that may be of assistance in helping students and teachers find the best combinations of AT and software tools to address educational needs. These are the ATWiki (http://atwiki.assistivetech.net) and the Second Life Wiki, especially the core article on Second Life Accessibility (Second Life Wiki, 2011a). In these, users share solutions to problems of interest, and since they are public wikis, all stakeholders may comment on and expand the articles. In general, reference to Universal Design for Learning (see the section on “Accessibility Barriers”) can help guide students and educators to make effective choices in AT and other tools.

Accessible Second Life and OpenSim Projects and Tools

The Second Life client provided by Linden Labs makes very little effort to provide accessible solutions to students. Likewise, OpenSim is based on the same basic software, and is in such an early phase of development that the volunteer developer community is more concerned with core functionality than accessibility. Luckily, there are a few projects in development that allow users to access these worlds using alternative clients with a stronger focus on accessibility for users with disabilities.

IBM AbilityLab Virtual Worlds Accessible User Interface

IBM is developing an alternative client for Second Life that is specifically tailored to users with blindness and low vision. Unlike the normal Second Life client, the IBM Virtual Worlds Accessible User Interface (IBM, 2011) de-emphasizes the visual nature of the world in favour of pure information. Sighted users may use the program, but the virtual world is not rendered pictorially. Instead, it is rendered in pure text that is accessible to industry standard screen readers such as JAWS. This is a major step forward compared to the base client, which is inaccessible to these software packages.

The interface is a Web 2.0 application run from within a web browser. It requires foreknowledge from sighted users with whom the interface user is interacting. Sighted users must equip an annotation item in the virtual world that allows them to select objects in the world to describe to non-sighted users.
The interface picks up cues from these objects that are then rendered as text descriptions within the browser window. It also allows users to record voice descriptions and transmit them to non-sighted users. These descriptions are contributed to a database of annotations that the interface user may access to learn about the world.

**Accessible Online 3D Virtual Learning Platform**

This is a collaborative project by the University of South Australia (UniSA), Flinders University, University of Sydney, Edith Cowan University, RMIT University, Monash University, and University of Sheffield (UK), conducted in consultation with accessibility specialists, legal advisors, and human rights representatives (http://www.communitywebs.org/3dvle). It builds upon multidisciplinary approaches for the creation of an accessible 3D virtual world environment in Second Life and OpenSim to demonstrate the pedagogical benefits of an immersive, flexible, inquiry-based approach to online learning. The project focuses on 3D affordances to enhance experiential learning for undergraduate and graduate students. Simulation experiences are created that parallel problem solving in real-world environments. Developers employ techniques from simulation games to enhance learning and retention. Online teaching experiences seek to promote cooperation and knowledge sharing between students. The project’s developers also hope to address the critical goal of assembling online learning and teaching standards for virtual worlds in education.

**Radegast Metaverse Client**

Radegast (http://www.radegast.org) is a lightweight, feature-rich non-graphical client, ideal for situations where a full 3D rendering client is not a feasible option, for instance while running the software on low-performance computers. It provides connection to Second Life and OpenSim-based virtual worlds.

Radegast supports a full array of Second Life communications features, including group and inventory management, friend lists, and many others. It includes a Bundled Speech plugin with text-to-speech and speech-to-text capabilities and adheres to standard accessibility APIs. Accessibility enhancements are currently only supported on Windows.

**Virtual Guidedog**

Max, the Virtual Guidedog (http://www.virtualguidedog.com) is popular among users with low vision. For those who are able to use graphical pointing devices, the Virtual Guidedog allows them to integrate this ability with some screen reading...
capacity. The dog is a set of scripts that have a variety of functions, such as printing the names of nearby objects or avatars into chat, or going to objects and avatars on command. This functionality is limited to instances where Second Life builders have provided the necessary object information. The Guidedog screen reader is a plugin that runs on top of the standard Second Life viewer. Ordinary screen readers are unable to access Second Life chat windows, but the Guidedog’s can. However, the screen reader does not know how to access many advanced features in the viewer, so the user needs to be able to use a mouse-like device to access full functionality. Some Second Life functions are accessible via keyboard shortcuts as well, but the number is by no means complete.

Figure 4.3 Max, the Virtual Guide Dog from Virtual Helping Hands. Reprinted with permission from Virtual Helping Hands.

Voice-to-Text Programs

Second Life is, at best, semi-accessible with voice-to-text programs (V2T) and there is a steep learning curve for learning how to use them because the user must have the ability to customize software. In addition, both Second Life and
V2T software tend to be memory-intensive, meaning that the user has to have a high-end computer. Overall, it is most useful for text chat and limited navigation, with an appropriate pointing device to augment navigation, building, and other 3D functions. Second Life is not compatible with “Say What You See” functions that allow advanced control of menus and other interface elements because the client does not have standard window classes. It would be possible to develop a client that does so, but one does not exist at this time.

Typical tools used for V2T in Second Life are Dragon NaturallySpeaking (Second Life Wiki, 2011b) and Dragon Dictate (2012). Many Dragon users have to rely on older versions of the software that have the Mouse Grid Command, and use the professional edition with extensive macro recordings. It may be possible for someone to record a package of Dragon macros for distribution, but this has also not been widely implemented. It is workable to both script and build in Second Life and OpenSim using V2T, although some functions require a pointing device. Many V2T Second Life users rely upon a “Dragon” guide published on the Second Life Wiki (2011b) and on mutual support to achieve their goals.

**Space Navigator 3D Mouse and Other Control Devices**

Some users with repetitive strain issues use the Space Navigator (3Dconnexion, 2011), a 3D mouse specifically designed for Second Life. This 3D device allows users with very limited dexterity to perform all essential control functions in many virtual world platforms, including Second Life. Other choices for those with severe dexterity limitations include “frogpads,” trackballs, head-mounted pointers, or a range of other common AT devices that act as mouse substitutes.

**OpenSim Voice–to-Text**

OpenSim allows the use of any Voice over IP (VoIP) system, and the integration of users who are on the VoIP system and not in the virtual world into conversations. This means that if a VoIP system were to have a usable voice-to-text transcription feature as an extension, it could be used with an OpenSim platform. However, as on the rest of the Web, automated voice-to-text is not particularly advanced in producing legible text, and more research is indicated for practical use.

**Live Transcription Service**

Most Second Life events held in voice use voice-to-text transcribers to provide a summary of what is being spoken. The service operates as it typically does in webinars and online conferences.
Examples of Virtual World Tools and Assistive Technologies in Practice

Combinations of assistive technology and promising practices are countless, but students and teachers within the BreakThru project have provided real-world examples of their use. Each of these students uses Second Life to communicate with his or her mentors and fellow students, forming virtual communities of support to help overcome challenges in science, technology, engineering, and mathematics (STEM) courses in secondary and post-secondary programs.

One student who is blind uses a text-to-speech software product (JAWS) in combination with the Radegast Metaverse Client to render Second Life visual data into an audible format. He employs a Braille keyboard to input data, along with speech recognition software. Within Second Life, he prefers to use a microphone for speaking and receiving information from other users, avoiding text chat whenever possible. Another student who has a dexterity limitation uses a joystick as an alternative “mouse” along with an ergonomic, large-key keyboard. She supplements these tools with voice recognition software as necessary. Within Second Life, she relies heavily on voice interaction, and asserts her preference to communicate with others via voice whenever she is expected to provide input. Unlike the blind student, she does not have a preference for voice over chat for receiving information, however. A third student, who has Asperger’s Syndrome and a medical condition that causes headaches from eyestrain, uses different accommodations. She alternates between using of the Second Life browser and the Radegast client. When using the Second Life browser, she uses its inherent tools to change the colour and contrast of her view to decrease eyestrain. Within the Radegast, she relies more heavily on text views with light graphical display. Unlike the students above, she does not use the microphone to speak and requests text chat only from users within the world. She explains that this accommodation allows her extra time to formulate appropriate responses, avoiding the awkward pauses and vocal mistakes that she tends to make in speech communication. Additionally, she uses a low-glare screen filter whenever she is online.

These are only three examples of the myriad accommodations possible for people with disabilities using virtual worlds. Each user is unique, and will require an individual solution. But understanding the breadth of possible resources and tools customizes solutions and therefore makes them more practical and effective in the educational environment.
Second Life Communities

With over 1 million monthly users (singularityu, 2011) on the Second Life platform, there are a variety of different communities that allow for greater collective sharing of best practices and solutions to give every user a way to maximize community connections. We have included several active communities that support people with disabilities. These often bridge the divide between the virtual and “real” worlds, and provide critical information and assistance to students with disabilities and teachers new to the platform.

Virtual Helping Hands

Virtual Helping Hands (http://www.virtualhelpinghands.org) is a non-profit organization that aids individuals with disabilities through coordination of virtual and non-virtual resources. Their primary goal is to make virtual worlds as accessible as possible to these users. They provide assistance and resources, and help to develop new technologies to remove barriers to accessibility. They manage four separate projects, including the Virtual Guidedog and SecondAbility Mentors.

Virtual Ability, Inc.

Virtual Ability, Inc. (http://www.virtualability.org) is a Second Life community with strong links to other virtual world non-profit organizations. They seek to “enable people with a wide range of disabilities by providing a supporting environment for them to enter and thrive in online virtual worlds” (Virtual Ability, Inc., 2014, para. 2). To that end, they have undertaken a project alongside ADL Company, an award-winning producer of education programs in leadership, management, and healthcare to develop AVESS: the Amputee Virtual Environment Support Space. Through AVESS, Virtual Ability, Inc. circulates best practices for delivering online services to military amputees and their families. The group has constructed demonstration environments in Second Life to test best practices, with the eventual product being controlled by the US Army on private servers.

Virtual Ability, Inc. also maintains close links to other Second Life resources and provides a list of their partnerships on their website. Affiliated projects include the Health Info Island in the Alliance Library System’s Information Archipelago, the Health Support Coalition, and the Accessibility Center.
Virtual Worlds and Learning Opportunities

Education via virtual worlds or other immersive 3D environments is not a new concept and has been explored since the early 1990s. Current platforms now provide for the ability to scale these types of educational projects from small pilots to larger initiatives. The declining cost of the enabling technologies, as well as a greater push for experiential and problem-based learning within educational practice contribute to the current environment that is favourable for these types of applications.

Assuming that adequate provisions are made for accommodating the needs of users with functional limitations, virtual worlds like Second Life and OpenSim offer a highly customizable platform for collaboration, simulation, and experimentation. Aside from documented benefits for students in certain disciplines—most notably languages, architecture, and traditional sciences (biology, chemistry, physics)—and for distance education students (Clarke, 2011), virtual worlds allow for the opportunity to manipulate the context and environment of an educational set of interactions.

From a curriculum-planning standpoint, virtual worlds can be deployed tactically in several different ways. From the perspective of the learner they offer a variety of methods to alter the context or presentation of the individual. For instance, in the case of individuals with communication limitations, the various communication modes available (text and voice), allow for the composition of a message in such a way that the hearer/observer, could be unaware of the disability of the “speaker.” This enables the communicator to focus on content and intent rather than being distracted due to concerns about what the “hearer” might map onto him or her based on instantaneous word-by-word communication. Several examples in application have been implemented, including many involving individuals with Asperger’s Syndrome or Autism Spectrum Disorder (ASD). Research indicates that virtual world text options provides many of these users with the opportunity to engage and participate with classmates in a relatively stress-free context (Gorini, Gaggioli, Vigna, & Riva, 2008; Parsons et al., 2000). In a very different example at Georgia College (Smith, 2012), Second Life has been used to supplement Spanish language classes by having English speakers interact with native Spanish speakers. Project personnel have noted that the virtual environment provides affordances for language learning that would not have been possible in person, eliminating geographical barriers between native speakers and allowing for voice and gestural nuances to enhance the learning process.
From the standpoint of the teacher or facilitators, these environments open up the opportunity to mentor students or learners in a manner that might be more cost-effective, convenient, or in some cases, practical. It allows for the opportunity to build teams of cross-cultural individuals or people with variable capabilities in non-geographically limited ways. For instance, while Second Life has been used to run model United Nations simulations (majenh, 2009), it would also be an ideal space to experiment with a similar venue focused on students with disabilities. Another recent initiative using Second Life for learning purposes is EmployAble (http://www.cds.hawaii.edu/employable), a model virtual reality employment orientation and support centre using Second Life as a platform to provide training, networking, mentoring, and employment resources for people with disabilities and connecting them with potential employers, developed by the Center on Disability Studies at the University of Hawaii.

Below we have listed some of the more important potential outcomes that educators could see from the use of virtual worlds in the learning process.

**Individualization**

Customizable user-generated content is one of the most critical functions offered through virtual worlds. On platforms like Second Life, relatively novice users have the ability to create unique and dynamic “inworld” artifacts. These virtual objects can be marked and tagged with metadata that allow for richer interactions and greater personalization. The creation and manipulation of these objects is something that is almost impossible in the real world. For people with disabilities, this could mean many different things. The primary benefit is that multiple learning styles can be accommodated and supported simultaneously. Objects can be made more prominent and certain data can be incorporated if attention needs to be called to a certain piece (Standen, Brown, & Cromby, 2001). Different pathways of knowledge acquisition can be represented in the same space so that the simulation or lesson supports individualized learning needs for unlimited numbers of students. This is important when taking into consideration the vast array of different learning and psychological disabilities, and how they have different impacts on the way students learn.

**Mediated Consequences**

The capability of creating user content as well as real-time collaboration with many different people and objects can be both challenging and exciting. Because of the dynamic environment, the learner has the ability to experiment with educational applications and objects, the presentation of self as a learner or member
of the community, and the construction of self-produced content. If the same kinds of experimentation were to take place in the “real” world, the learner could suffer potentially humiliating or dangerous consequences (Cromby, Standen, & Brown, 1996). These consequences can be mediated or negated through the use of virtual environments and, by doing so, can build confidence and self-empowerment within the learner. These types of mediated “playgrounds” are rare within the everyday space of the classroom and have potential for positive outcomes, especially for students with various types of psychological disabilities (Gorini et al., 2008).

**Access to Mentors**

Because of geographic distances or the lack of integration with formal disability-focused communities, many learners with disabilities do not have the opportunity to meet and form relationships with peers who share the same health or social experiences. Within the health field, virtual worlds and other online communities have been used successfully to create community within specific sectors of the population. “E-mentors” formed within these communities can play a significant role by providing a consistent presence online, acting as a catalyst for a majority of the communication and action within the environment, and promoting relationships between other participants (Cantrell, Fischer, Bouzaher, & Bers, 2011). Applications within the disability field have proven successful in programs like the BreakThru project that connect students with disabilities and mentors via a virtual world in an effort to increase student confidence and participation in science, technology, engineering, and mathematics (STEM) classes. While online communities have served these purposes for many years, virtual worlds allow for a more interactive, individualized, and immersive experience for both the learner and the mentor.

**Future Directions and Conclusion**

Virtual worlds hold the promise to be exciting and powerful tools for teachers and students, allowing modes of interaction, expression, and creation never before possible in the classroom. As a relatively new form of ICT, it is to be expected that available platforms and tools are subject to rapid change, and so generalizations can be difficult. But it is still fair to say that in their current incarnations, virtual worlds as a whole do not make the most effective use of potential affordances for all users, in keeping with global demands for e-inclusion and eAccessibility. There is still considerable work that must be done to popular platforms such as Second Life and OpenSim before they provide a fully
welcoming environment for all users, especially those with disabilities. In this chapter we have indicated many of those weaknesses, and it is hoped increased awareness of such barriers will lead to more inclusive tools in upcoming virtual world builds. Virtual world users and researchers can assist developers by providing ongoing feedback of their needs, illustrating accessibility problems, and suggesting solutions.

In the meantime, it is the responsibility of all stakeholders in virtual education to work toward more accessible virtual world environments. Third-party software developers have provided exciting and effective tools to help students accommodate their needs. Students themselves continue to discover ways to use the affordances of their platforms, such as peer support through the virtual world itself, to solve problems and achieve educational goals. Teachers have contributed markedly to the process by sharing their teaching techniques, promising practices, and published research on virtual world education. Parents and student associates continue to be advocates and provide peer support for students working to overcome obstacles.

Fortunately, the nature of virtual world platforms creates affordances for this intercommunication. Users are able to meet, communicate, and share promising practices and information on assistive technologies. This requires basic access to the platform in question, but once it has been achieved, the virtual world can be a source of assistance in improving accessibility.

Specific examples of empowering communities include Second Life’s Virtual Ability, Inc. and Virtual Helping Hands, explored previously. Each functions as a node within the virtual world to share information on improved access for all users. Members and guests can interact freely within their island spaces on Second Life to help guide users throughout the process of accommodation, sharing online artifacts, and enabling scripts, such as the Virtual Guidedog, directly. In addition, they are typical of inclusive nodes within the platform in that they each have websites that provide guidance and communication portals to knowledgeable members. These websites can assist users who have not yet managed to gain sufficient access within the Second Life platform to seek solutions inworld. These communities, and many others like them, hold the promise of peer-generated solutions to many access issues and therefore more complete inclusion of students within virtual world educational settings.

Furthermore, many of the assistive technology tools discussed have user communities with a history of peer assistance, including website, email, discussion boards, and inworld guidance (see the BreakThru website, for example). Tool developers and users take advantage of common social media sites such
as Facebook and Twitter to reach potential users and communicate solutions. Examples include the developers of the Virtual Guidedog and the Radegast Metaverse Client. It is typical of users and developers to employ a range of “new media” tools to disseminate information, adding further access possibilities to users who have not yet achieved fluent communication within the platform.

The virtual world platforms themselves, depending on the underlying technical constraints, can handle a myriad of different (accessible) activities to support learning and encourage enhanced user engagement. The most popular additions include layering modelling, simulations, gaming, and real-time sensor integration into the learning construct developed inworld or within the platform. These “additions” allow for further social integration and educational immersion of the content. As we discussed throughout this chapter, the ability to further enhance the experience with user-generated content allows users to personalize the environment, and therefore can engender feelings of belonging and acceptance.

Accessible experiential learning encourages students to engage in problem-solving activities within a flexible environment that can facilitate collaborative and constructivist learning. Coupled with the potential virtual worlds capacity for distance learning, social interaction, and learner engagement, virtual worlds open entirely new approaches and possibilities for more inclusive communities of learning.

Acknowledgements

The authors wish to express their thanks to the staff and students of the National Science Foundation—Research in Disabilities Education “BreakThru” project (award 1027655) for their assistance in providing first-hand information on accommodations for students with disabilities in virtual worlds.

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doi:10.15215/aupress/9781771991339.01