Chapter 3
Authenticity in Immersive Design for Education

Jeffrey Jacobson

Abstract *Authenticity*, is a concept found in both media design and educational design, usually as a quality needed for success. Here, we develop a theory of authenticity for educational experiences with immersive media (VR, MR, MUVEs, etc.) to help educators and authors in this new field. In our framework, authenticity refers to the relationship between a *truth* and its *representation*, guided by a *purpose*. By truth, we refer to a fact, concept, or procedure, about something in the world or in the body of human knowledge, something we want to learn. To scaffold the learning process, students require a representation of the thing. It may be a written article (for concepts), an image (e.g., a photograph), or maybe an exemplar (an idealized example of a category). A representation or an experience is said to be authentic, when it successfully captures the fundamental truth of what we are learning. The immersive media have unique capabilities and just in the last few years have become available to the public on a large scale. Our theory is not a comprehensive style guide, but a practical way to look at one key dimension of good educational design.

Keywords Authenticity · Elegance · Pedagogy · Design · Immersive · VR

3.1 Introduction

In this chapter, we develop a theory of *authenticity* as an essential quality of educational experiences with immersive media (VR, MR, MUVEs, etc. see Chap. 1). We produced it to be an analytical tool for educators and designers, to help them build effective experiences for their students. It is not a comprehensive style guide for authoring, but illustrates a crucial dimension of good design. It will help with the lack of guiding theory in education in immersive media (Fowler, 2015).

J. Jacobson (✉)
CEO, EnterpriseVR, 333 Lamartine St., Jamaica Plain, MA 02130, USA
e-mail: jeff@enterprisevr.com

D. Liu et al. (eds.), *Virtual, Augmented, and Mixed Realities in Education*,
Smart Computing and Intelligence, DOI 10.1007/978-981-10-5490-7_3

In our framework, ***authenticity*** refers to the relationship between a *truth* and its *representation*, guided by a *purpose*. By *truth,* we refer to a fact, concept, or procedure, about something in the world or in the body of human knowledge, something we want to learn. To scaffold the learning process, students require a *representation* of the thing. It may be a written article (for concepts), an image (e.g., a photograph), or maybe an exemplar (an idealized example of a category).

A **representation** or an **experience** is said to be authentic, when it successfully captures the fundamental *truth* of what we are learning. For example:

> Suppose we create an animated 3D model of a bird design to help us to teach the flight dynamics of its species. In that case, the representation does not need to be highly detailed —a simple, flexible, 3D model will do, as long as its proportions are right (Fig. 3.1).
>
> However, the movement of that model must very accurately depict the movements of a real bird of that type. On the other hand, if the goal is to learn exactly what that bird looks like (feathers, beak, skin, etc.) then the representation must have a lot of physical detail, but its motion would not be relevant. It may not need to move at all (Fig. 3.2).

Importantly, authenticity is **not** realism. Usually, a representation is said to be more *realistic* the better it mimics the real thing in every way. Sometimes, that is what we need for authenticity, but more often, we do not need it.

In our discussion, we will call this the principle of *truth* (Sect. 3.3.1), that the relevant facts or ideas are represented in the virtual environment depicted by the immersive medium. However, we must understand the purpose of the learning experience to know which truth we are trying to represent (Sect. 3.3.1). Further, we strive for the right *level of detail* (Sect. 3.3.2), meaning that the representation shows what it needs to show, but without extraneous detail. Finally, the design should be *elegant* (Sect. 3.3.3), meaning that the different representations in the design fit together and function well.

Fig. 3.1 Artful model of a bird, low resolution, but well proportioned. Suitable for animation to demonstrate movement. http://clipart-library.com/clipart/XrcjKGXTR.htm

Fig. 3.2 High resolution drawing of a bird, suitable for study of detail. http://clipart-library.com/clipart/ATbr7BLRc.htm

But first, we will look at existing theories of learning in *educational* media, because the *purpose* comes from the learning objective and the pedagogies that help us get there. Specifically, immersive media is well suited to constructivist approaches, where students build their own learning experience within the learning environment as guided by the teacher (Duffy & Jonassen, 2013). Also, Winn's (2003) framework for learning in VR is an excellent tool to focus that approach. We will use both to guide our discussion.

Versions of the concept of *authenticity* is also found in writings throughout media design (Kronqvist, Jokinen, & Rousi, 2016), and in education (Strobel, Wang, Weber, & Dyehouse, 2013) (Herrington & Parker, 2013). We will explore those theories, describe our own frame with examples, and finally list the topics where immersive media are most likely to be useful (Sect. 3.6).

3.2 Existing Concepts of Authenticity and Learning

Good design in educational media a broad topic, and achieving high quality is usually more art than science. This leads authors to employ (and create) frameworks of design advice, to point out the key issues and provide practical ways to develop solutions. These guides are usually specialized by topic, media type, and purpose, although some can be quite broad. Others have a particular theme or theoretical approach. In this section we will look at some of the existing theories of authenticity and learning.

Kronqvist et al. (2016) define authenticity as a function of the degree of presence, affordance, and control the environment provides to the user. William Winn (2003) describes learning in VR as an adaptive response to a challenging task or environment. The learner is *embedded* in the virtual environment while s/he is *embodied* there. Both approaches apply reasonably well to the other immersive media. We also reference *constructivism*, which posits that the learner constructs his or her own learning experience, within the learning environment. Constructivism is the most widely cited pedagogical approach in the historical literature on educational VR (Duffy & Jonassen, 2013).

Then, we look at two theories of authenticity in education, one by Strobel et al. (2013) and another by Herrington and Parker (2013). Both frameworks emphasize the search for a way to convey the fundamental or foundational truth of the topic to the student in way that is respectful of the material. They also contain much practical advice, specific to their fields. We are fortunate to have their work, because the idea of authenticity is widely cited in the education literatures, but often without adequate definition or theoretical foundation (Strobel et al., 2013).

Readers who wish to go deeper should look at Barab, Squire and Dueber (2000) and their work on authenticity as an emergent property of good practice in training. Donnelly (2014) provides a practical design guide for authenticity in architectural design.

3.2.1 Kronqvist's Authenticity in Virtual Environments

Kronvqvist et al. (2016) created a metric for measuring *authenticity* in virtual environments, when accessed through a VR-like interfaces (e.g. HMD, or big screen). They developed a post-test questionnaire to measure it, across several types of interfaces. Their goal is to give VR researchers a way to verify that their virtual environments are sound.

They define *an affordance* to be a quality of the virtual environment (VE), which is the degree to which representations of (objects and phenomena) in the VE provide the same affordances as the real thing. It allows user to perform their learning tasks much as they would in real life. This implies that we must know what the *purpose* of the simulation is, in order to define *which* affordances should be captured. (See Slater's *Plausibility Illusion*, Chap. 2). That makes Kronqvist's *affordance* similar to our own definition of authenticity. However, his definition of authenticity includes the sense of *presence* in the user (equivalent to Slater's *Place Illusion*, Chap. 2), but our definition does not.

3.2.2 Winn's Framework for Learning in Sensorially Immersive VR

Winn's approach (Winn, 2003) states how authentic learning can work in an immersive environment, even though he did not use the word, *authenticity*. While his focus was on VR, the principles apply well to the other immersive media. He proposes that optimal learning requires (quote):

> ***Embeddedness:*** *The mental and physical tasks a person performs cannot be defined without some reference to the environment. This does not imply that the environment defines cognition, but that some reference to the environment is required to describe it.*
>
> ***Embodiment****: The learner/actor's physical body is an essential part of the process, because everything we perceive must be mediated through our limited senses. We directly use our bodies to accomplish most tasks and the brain must be regarded as an organ of the body.*
>
> ***Dynamic Adaptation:*** *In a changing environment, we must continually adapt to the changing circumstances. It is also true that the environment changes in response to the person's actions. In this way the individual and his or her environment are evolving together, responding to each other.*

Embeddedness would certainly apply to many or most immersive learning environments, especially those with high authenticity. The **embodiment** clause requires an engaging physical environment, a good mixed reality, or a fully immersive virtual reality. In Slater's terms (Chap. 2) embeddedness requires what he calls *place illusion*, and dynamic adaptation requires what he calls *plausibility illusion*, as well as an instructional strategy. Slater's chapter also explores embodiment.

However, Winn's framework is only partial, with respect to the overall enterprise of educating and learning. For example, it does not address assessment, which should be hidden within the learning activities and the environment itself (Shute et al., Chap. 5; Dede, 2012) to avoid distraction from the learning task.

3.2.3 Constructivism in VR for Education

Ideally, learning as an active process, which the student constructs within the learning environment, to achieve the required goals, and complete the learning task, all under the teacher's supervision. This is the *constructivist* approach to learning theory, which is widely cited in the literature on educational immersive media. Describing it further is beyond the scope of this chapter, but we recommend (Duffy & Jonassen, 2013) for a good description. Also, Gardner and Sheaffer (Chap. 9) and Shute et al. (Chap. 5) discuss constructivism in their chapters.

3.2.4 Strobel's Framework for Authenticity in Engineering Education

Strobel et al. (2013),[1] distills the idea of authenticity found in the literature on education for engineering. The consensus, there, is to bring the learner closer to the realities of the workplace, with principles, summarized here:

Context Authenticity: *Context resembles real-world context [....]*

Task Authenticity: *Activities of students resemble real-world activities [....]*

Impact Authenticity: *Student work is utilized in out-of school situations [....]*

Srobel proposes two more dimensions that come from the Applicative or Sociocultural Perspective:

Personal Authenticity: *projects are close to students' own life. (i.e. life-stories of their neighborhood, biodiversity in the forest nearby)*

Value Authenticity: *personal questions get answered or projects satisfy personal or community needs.*

They recommend that learning environments should have the above characteristics, and others not included in our summary.

3.2.5 Herrington's Framework for Authenticity

Herrington, Reeves and Oliver (2009, p. 17) propose a framework of authentic e-learning, summarized, here:

- *Provide authentic contexts that reflect the way the knowledge will be used in real life.*
- *Provide authentic activities.*
- *Provide access to expert performances and the modeling of processes.*
- *Provide multiple roles and perspectives.*
- *Support collaborative construction of knowledge.*
- *Promote reflection to enable abstractions to be formed.*
- *Promote articulation to enable tacit knowledge to be made explicit.*
- *Provide coaching and scaffolding by the teacher at critical times.*
- *Provide for authentic assessment of learning within the tasks.*

They recommend that learning environments have the above characteristics, and others not included in our summary.

[1]Strobel relies heavily on theories by Anderson, Billet, and Buxon, and cites them properly. We do not have the space to repeat those citations, here.

3.3 Our Framework for Authenticity in Educational Immersive Media

In this chapter, we develop our theory of *authenticity*, as a way to think about the design of immersive educational experiences. It is centered on the idea that for a simulation or representation to be authentic, it must capture the basic truth of what it represents. However, you also have to know what the instructional goal of the experience is, before you can decide what truths you want to represent.

Herrington et al. (2009), Herrington and Parker (2013), Strobel et al. (2013), Kronqvist et al. (2016) each place the same requirement on their definitions of authenticity. However, Kronqvist's definition of authenticity is broad, including *presence* for authenticity in immersive media, which we do not. Strobel's authenticity includes design advice for education in engineering, and Herrington's authenticity does the same for e-learning.

Our theory of authenticity is meant to be a helpful tool for designers and users of immersive educational experiences, but not a comprehensive guiding theory. Instead, we propose authenticity as **one dimension** of good design, one tool among several. The key components are:

- **Purpose**
- **Truth**
- **Elegance**
- **Continuity**

We will describe these, in turn, and how they work together. Then, we will discuss where authenticity resides and how to measure it.

3.3.1 Purpose and Truth

As with so many endeavors, it begins with the *purpose*, our learning goals, which drive everything else in the design. Generally, we want successful *transfer*, where the student learns something from the immersive media that s/he successfully applies elsewhere (Grotzer et al., 2015). The most straightforward examples are simulations, like this one:

> A good way to begin learning how to drive a car is to use a driving simulator. There, the student pilots a virtual automobile through increasingly challenging lessons. The virtual car must behave like a real one, and have realistic controls, to support the training. However, neither the virtual car nor the virtual environments has to look good. Even relatively crude models will do, as long as they are correctly proportioned and readable (Fig. 3.3).

This illustrates how *purpose* defines the next component of our framework, which we call the *truth*. That is the relationship between the real thing and its

Fig. 3.3 Driving simulator (Teen Driver Source, Children's Hospital of Philadelphia). http://www.teendriversource.org/images/drivingsimulator.jpg

simulation in the virtual environment. We want the simulation to capture or represent some fundamental truth about the real thing.

In our driving simulator example, the need to learn how to drive dictates which aspects of the car we want to simulate. If, instead, we wanted to teach the student how to decorate a car, we wouldn't care much about how the simulation behaves, only how it looks.

This applies to experiences, not just objects. For example:

Suppose the student is using a VR simulation to overcome a fear of public speaking. S/he sees herself in an auditorium room filled with automated human figures (*bots*). At the simplest level, she speaks for a set period of time, giving a short speech, while the virtual audience either sits in silence or responds in a positive or negative way. After each interval, the student provides feedback to the software indicating her level of discomfort and her desire to continue. Based on the curriculum built into the software, the student is progressively challenged with an increasingly difficult audience (Pertaub, Slater, & Barker, 2002) Fig. 3.4.

In this case, the bots only need to be recognizably human, capable of expressing emotion through simple facial expressions or even body language, alone. This requires that their motions be authentic in terms of what they convey, but the actual appearance of their bodies can be quite simple. In the physical world, puppeteers use this to great effect (Engler & Fijan, 1997).

Fig. 3.4 Two audience reaction scenarios presented by a VR trainer for public speaking (Pertaub et al., 2002). https://publicspeaking.tech/wp-content/uploads/2016/11/Pertuab_etal_PublicSpeakingAnxiety.jpg

The learning experience is effective if it induces the required feelings of discomfort, and provides the student with the opportunity to overcome it. It is *authentic* if it is well focused on the lesson, and only the lesson, in an elegant way. The *truth* in the above example is that public speaking won't hurt you, the *representation* is the audience and its reactions, and the *purpose* is to overcome one's fear of speaking.

See Kraemer (Chap. 4) for a deeper exploration of how students can learn from virtual social immersion with sophisticated bots and avatars. In Sect. 3.4, we will discuss where authenticity resides, and how to measure it, but first, we will complete the description of our framework.

3.3.2 Level of Detail

In every media, the author chooses which *level of detail* is most appropriate for his or her purpose. S/he may present a large number of details in order to convey complex information, create a mood, build an argument, or for other reasons. For example, a scientific visualization may require complex forms to represent the data fairly. On the other hand, certain traditional Japanese paintings convey a great deal of information with just a few clean lines. Also, a high level of detail is not the same thing as realism. Many representations that are not realistic have a lot of detail in them, while some realistic depictions don't need much detail.

Usually, an element will belong in the design, because:

- It conveys something about the topic to be learned. (For example, if the topic is chemistry, we might see models of molecules.)
- It makes the experience more aesthetically pleasing, even if the author is not explicitly making art.
- It helps the experience function.

For example, a student might be using a mixed reality program to examine (representations of) different species of frog. The command s/he uses to switch from one representation to another doesn't represent anything, but it is essential for the process.

Here is an example that illustrates some of these themes:

The Virtual Ancient Egyptian temple (Gillam & Jacobson, 2015, Chaps. 3 & 7) (Fig. 3.5) was built to be a symbolic representation of a late period cult temple. Our virtual temple had the minimum architectural features required to properly house a representative sample of Egyptian ceremonies and public events. The temple also contains hieroglyphics and artwork on the walls, arranged in the correct order, saying the right things, to typify an ancient Egyptian temple.

The virtual temple (minimally) embodies the key characteristics of late period Egyptian cult temples, but not a particular one. It is an *exemplar,* an idealized model used to describe a category of things (Barsalou, 1992). Had we faithfully simulated one particular, real, temple, its idiosyncratic features would have misled our readers into thinking they were universal. Instead, a less realistic, idealized, temple is paradoxically a better exemplar.

However, we did add some naturalistic lighting and material effects, just to make the space more comfortable and readable. We also (unrealistically) enlarged the hieroglyphics to make them readable in the computer displays available at the time.

Level of detail can refer **to action and motion,** as well as the appearance of things. Japanese anime' often has only the most important elements in the scene moving, an example of minimalism in movement. In immersive media, especially VR, one must be careful to present enough motion in the virtual environment so it feels true to the things it depicts. But do not use so much motion that the user become disoriented, distracted, or annoyed.

Fig. 3.5 The Hypostyle Hall of the Virtual Egyptian Temple (Gillam & Jacobson, 2015). http://publicvr.org/images/HypostylePromoShot.jpg

3.3.3 Elegance

When the learner's experience is *elegant,* we mean that is achieves its purpose artfully, with the right level of detail. The experience is well integrated with its environment, well-coordinated with other instructional materials, internally consistent, sensitive to its audience, and consistent with it purpose. The narrative design must fit well within in the larger curriculum. (Dede (Chap. 8) and Schneider (Chap. 12) both discuss what stages of the student's learning process are more likely to benefit from immersive media and those that are not.)

For example, the authenticity of any historical or archaeological digital simulation partly depends on how well it fits with other materials and media that describe the same thing.

In immersive media, the user's physical or pseudo-physical location in the virtual environment is a critical part of the narrative and usually is the foundation of how they interact with it. (See Winn's *embeddedness*, above).

In the mixed reality that Gardner and Sheaffer describe in Chap. 9, some of the students are in a physical space, while others are in a MUVE, but the two spaces are connected through a kind of portal wall. This allows the students "in" the MUVE to participate in the classroom activities sufficiently, so they apparently learn just as well as the students who are there, physically.

An elegant design should also exhibit *continuity* in its use of detail and other factors. We do not expect a written document to have too many different fonts. We do not expect a movie to speed up or slow down during the presentation, nor do we expect the picture quality to change abruptly. That is why most works of most media usually have a similar level of detail throughout; but there can be exceptions, if skillfully handled. For example, there may be some moment or object in the representation that is rendered at a deliberately higher or lower level of detail, specifically to focus attention, create a mood, or convey information.

Two excellent examples of elegance in authentic design are the mixed realities of Johnson-Glenberg (Chap. 11) and Schneider (Chap. 12). In both cases, they add just enough virtualized information for a profound impact, exploiting the advantages of mixed reality (MR). They take it a step further by designing unique and tangible interfaces that embody the information the student must learn and the action s/he must take to do so.

Elegance is not *minimalism*. The idea behind minimalism is to use as few elements as absolutely possible to achieve the purpose in the simplest way. This is a valid design choice, but an elegant design does not have to be so strict. It may contain more elements than necessary for aesthetic or functional reasons.

Suppose you want to show medical students what it is like to be in a hospital operating room during a surgery. An example of the type is shown in Fig. 3.6 (Kapralos, Moussa, & Dubrowski, 2014).

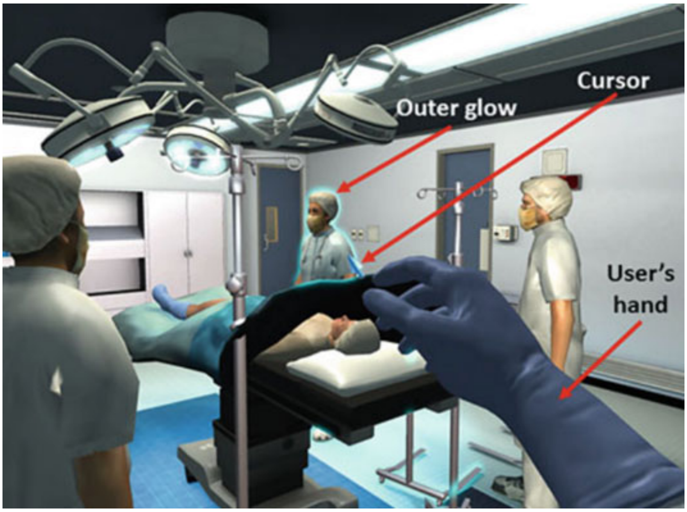

Fig. 3.6 VR simulation of a hospital operating room with user interaction (Kapralos et al., 2014)

> Suppose further that the student could take on the role of a nurse or doctor. If the goal of the simulation is to teach operating room procedure, then it must accurately show those procedures. That would require only a moderate level of detail in the models, the virtual people, and how they move.
>
> However, *additional* details might create a more comfortable experience and help the user focus. For example, the simulated people, the patient, the doctor, and staff, should all look a little different, which is more information for the system to implement. But if everyone in the room were identical, it would be distractingly strange.

Another aspect of *elegance*, is that the student should have a seamless and comfortable experience. Ideally, nothing should distract them, like motion sickness, which happens in VR, if it is not handled properly. See Richards (Chap. 6). Also, Shute et al.'s stealth assessment methods (Chap. 5) would be very useful, because they afford a way to test the student's knowledge, but without interrupting their experience in the virtual environment—an elegant solution.

3.4 Where Does Authenticity Reside and How Do We Measure It?

Authenticity resides in both the system (the virtual environment and its interface) and within the mind of the user. Simply put, if the builder of the virtual environment has created a representation that expresses the learning objective (a truth) successfully, then the student will perceive that truth and be able to interact with the representation productively.

Ideally, the ultimate test would be whether the student could demonstrate knowledge transfer, from the learning experience to a genuine situation in real life. However, the history of educational innovation is littered with examples of students learning despite technology or regardless of it. Additional measures are needed to determine the value and authenticity of the virtual environment.

Fortunately, there are many test instruments available for educational media and immersive media that should be directly useful. But we cannot propose a generic measure for authenticity, based on our theory alone. To evaluate some learning experience for authenticity, we'd also have to know it's base media (VR, MR, or MUVE), it's topic, and much more about its structure. What we can do is discuss basic approaches.

One way to measure authenticity would be to embed measures integral to the virtual environment and the experience, itself. We would be interested in whether the student perceives the truths we want the representations to convey. Shute's *stealth assessment* techniques could be quite useful here (Chap. 5). Slater (Chap. 2) does something similar in his tests for *presence*.

One could also measure how authentic the immersive learning environment is, outside of its educational mission, using something like the instrument in Kronqvist et al. (2016). However, he also measures *presence*, which our definition of authenticity does not include. We treat presence (Slater, Chap. 2) as a different dimension of immersive design, which exists alongside authenticity.

Finally, one could examine an educational immersive experience, and see how well each element works and how well they all work together. Hopefully, they will perform their key functions and represent the key facts in an elegant way, so the student can focus on the learning task. In the case of virtual objects, we expect them to behave like the real thing. Kronqvist et al. (2016) call these *affordances*.

3.5 Handling Uncertainty

Immersive media always use 3D models for objects and (in VR and MUVEs) the environment itself. That creates difficulty for the author, when s/he needs to express uncertainty or competing ideas about what things should look like. People tend believe what they see, so they often look uncritically at immersive representations. Usually, the author and the user, both want as much detail as possible in the simulation, but to depict what *is* known, one often must complete the picture with elements are partly speculation. Otherwise, the virtual environment won't be useable. Examples:

> Imagine a simulation of a crucial historical event, like the battle of Gettysburg in the US Civil war (Fig. 3.7). We know the basic clothing the soldiers wore, their weapons, the terrain, and much about the battle itself. But there are many gaps in our understanding. *Exactly*, how many soldiers were here or there? How much of the fight was in the town, and how much was outside of it?
>
> If the simulation is to show individual soldiers, at any level of detail, the author must show them moving about the battlefield. Without any other knowledge, the viewer cannot tell how much of that comes from established historical fact verses the artist's need to complete the environment. But without a complete environment, the immersive medium can't function.
>
> Another example: what happens when one attempts to simulate a building that is known to be a fully enclosed space, but the character and placement of an entire wall is not known? The author has no choice but to put something in there, which amounts to an educated guess, because leaving a gap would be worse.

A corollary problem is how to handle competing theories of how something should be represented.

> For example, an archaeologist may discover evidence of what appears to be a single building. While assembling the known elements, s/he may discover that some of the archaeological evidence conflicts with other clues. Or the total evidence does not make sense when used together in one building. A possible explanation is that the observed evidence comes from more than one building. They may have existed in the same location, but at different time periods.
>
> One strategy for the instructor would be to represent each competing theory its own 3D model, and let the students explore them. Sometimes, the competing models can be overlaid to occupy the same space, for easier comparison.

Fig. 3.7 Simulation of the battle of Gettysburg. Not from an immersive application, but illustrative. http://www.scourgeofwar.com/index.shtml

There are many visual techniques an immersive media designer could use to indicate uncertainty in parts of the virtual environment. S/he could indicate uncertain elements with a particular color, or lack of color, or lack of detail. S/he could use labels or symbols to explain the prominence of each virtual object. Many creative solutions are possible, but they'll have to be handled skillfully to preserve the system's *elegance.*

3.6 When to Use Immersive Media in Education

Like any other toolset, immersive media is good for teaching some topics and less effective for others. That begs the question: when is immersive media useful in industry and/or society? The gross outlines are fairly straightforward, from 60 years of experimentation with VR and other immersive media. However, the details are only just now being worked out, as the medium is adopted by society, generally. While the fundamentals of the technology have not changed, new applications are invented every day on a massive scale, because of a drastic drop in cost in just the last few years. (See Richards, Chap. 6). This will lead to both a steady evolution of the technology and occasional breakthroughs.

We list many good uses of immersive media, below, although it could never be an exhaustive accounting. Pantelidis (2010) also provides a good summary.

3.6.1 Training in Real Life Tasks

Many activities in real life do not employ immersive media, but immersive media could be used for training in those pursuits. These are usually activities that require *procedural* knowledge. Major examples are:

- Simulators of aircraft and other big dangerous machines. In fact, it was the military Aerospace industry that invented modern VR and they have a long track record of Success in training Airline pilots and military aviators.
- Military training has a long and productive history with VR and more recently MR.
- Medical training, through simulation, has been a huge area of research and development for years. Entirely physical props, mixed realities, and full VR are all being studied.
- Basically, learning how to do anything dangerous like firefighting, first responder to disasters, and So on.

Training is the oldest and most studied use for Virtual Reality, and the literature on it is vast.

3.6.2 Learning Topics Usually Taught in School

Many pursuits require knowledge about things, usually facts and concepts, such as history or physics. This is called *declarative* knowledge, which encompasses most of what one learns in school. Here are a few topics that require learning a large amount of declarative knowledge:

- Cultural history and heritage, where ancient monuments, events, and even whole societies can be simulated, interactively (Gillam & Jacobson, 2015).
  Bandt points out that aboriginal peoples Australia identified certain rock formations as having spirits and magical properties. Most of those formations have unique acoustical properties, so an immersive acoustical simulation of such as site would be informative. See http://www.sounddesign.unimelb.edu.au/site/NationPaper/NationPaper.html
- Astronomy, where students can explore the solar system, or reason about observable movements of objects in the sky (Vosniadou & Brewer, 1992).
- Physics, where students can see and interact with a variety of simulations (Shute & Ventura, 2013).

- Simulations of social situations, investigations, laboratories, and a much else using MUVEs (Dede, Chap. 8), (Kraemer, Chap. 4), and (Gardner & Sheaffer, Chap. 9).

Of the immersive media, MUVEs are most widely used and studied in education, and probably have the most uses. See Klopfer (Chap. 10) and Dede (Chap. 8).

3.6.3 Clinical Psychology

Years of productive research have gone into using VR for diagnosis and treatment of things like PTSD in adults, ADHD in children, and treatment of phobias.

> For example, most PTSD and phobia treatments center on gradual exposure to what the user fears, while keeping him/her physically safe. That helps them overcome their aversion, and work through their cognitive dissonance around similar situations (Fig. 3.8) (Rizzo, 2016).

A great deal of literature is available; we recommend a search on the work of Dr. Albert Rizzo (2016).

Fig. 3.8 Gradual exposure therapy to cure post-traumatic stress disorder (PTSD) (Rizzo, 2016). https://c1.staticflickr.com/8/7609/16983316895_5e8decce03_b.jpg

3.6.4 Training for Direct Use in Industry

There are many industries where immersive media are directly useful, and students will need training to use them well.

- When Mixed Reality reveals something not otherwise seen:
  - Internal anatomy during surgery or diagnosis.
  - Subsystems in existing buildings.
  - Internals of complex machinery during maintenance.
  - Threat factors in dangerous situations. For example Augmented Reality glasses could be used to see areas of dangerous radiation inside a nuclear power plant.
- When virtual reality can be used for collaborative or remote work:
  - Users can collaborate at a distance as they engineer some complex object via an immersive MUVE.
  - Collaborators coming inside a digital dome or CAVE for a design review of some artifact. This is more useful for structures one wants to be inside, such as a building (Jacobson 2011, 2013).
  - Orthoscopic surgery offers a kind of VR as the interface for the surgeon trainee.
  - An operator can use a VR-like interface to control a robot carrying out any number of types of missions.
- Building community and other social uses:
  - Entertainment, such as World of Warcraft and similar games with millions of users and complex social dynamics.
  - Remote meetings and socializing, as with Second Life, AltspaceVR and VR Chat.
  - Immersive news reporting can give the audience a much more powerful view of some faraway situation. Immersive film is being used to great effect here.
- Other uses:
  - First responders, security people and the military can use VR to learn the layout of a terrain before going there, physically.

3.6.5 When Not to Use Immersive Media

Usually, one should not use immersive media when some other media will do just as well or better. For example when one needs to understand the exterior of an object, a 3-D model visible on a computer monitor is adequate. Or when the information is abstract, such as budgets, data, music, and poetry. One could use abstract visualization to make three-dimensional visualizations, but then you have the problem of elements in the graph covering up (occluding) each other from the user's point of view. It should only be done for a specific reason that arises from the data itself. Last but not least, the expense and barriers to access to VR and MR remain significant for most k-12 schools, although that is changing (Richards, Chap. 6).

3.7 Conclusion

We live in an exciting and productive time. The mass availability of decent quality immersive media tools has led to an explosion of creativity across many industries, education not least (Richards, Chap. 1). The social learning process will require a great deal of trial and error, just as it does with individuals. And with each experiment, it is important that practitioners in education learn the right lessons. For some direct design advice, hard won through experience, see Johnson-Glenberg (Chap. 11) and Dede et al. (Chap. 8).

Guiding theory has an important role to play. Experimental science can provide the foundation for these theories, but practical advice must also be developed from experience. In this chapter, we developed a theory of authenticity in educational immersive media, as a means to understand this key feature of good design. It is not a comprehensive framework, but a dimension of design that touches all aspects of an immersive education. In future articles, we will look at practical applications.

References

Barab, S. A., Squire, K. D., & Dueber, W. (2000). A co-evolutionary model for supporting the emergence of authenticity. *Educational Technology Research and Development, 48*(2), 37–62.

Barsalou, L. W. (1992). *Cognitive Psychology*. Hillsdale, NJ: Lawrence Erlbaum Associates, Inc. 0-8058-0691-1 (hard) 0-8058-0691-0 (pbk) of research on educational communications and technology (pp. 723–734). New York: Springer.

Dede, C. (2012, May). Interweaving assessments into immersive authentic simulations: Design strategies for diagnostic and instructional insights. In *Invitational Research Symposium on Technology Enhanced Assessments*.

Donnelly, P. (2014). Let's get real: Authenticity in design. *WorkDesign Magazine* (Oct 10th, 2104). https://workdesign.com/2014/10/lets-get-real-authenticity-design/.

Duffy, T. M., & Jonassen, D. H. (Eds.). (2013). *Constructivism and the technology of instruction: A conversation*. London: Routledge.

Engler, L., & Fijan, C. (1997). *Making puppets come alive: How to learn and teach hand puppetry*. Courier Corporation.

Fowler, C. (2015). Virtual reality and learning: Where is the pedagogy? *British Journal of Educational Technology, 46*(2), 412–422.

Gillam, R., & Jacobson, J. (Eds.). (2015). *The Egyptian Oracle Project: Ancient ceremony in augmented reality*. London: Bloomsbury Publishing.

Grotzer, T. A., Powell, M. M., Derbiszewska, K. M., Courter, C. J., Kamarainen, A. M., Metcalf, S. J., et al. (2015). Turning transfer inside out: The affordances of virtual worlds and mobile

devices in real world contexts for teaching about causality across time and distance in ecosystems. *Technology, Knowledge and Learning, 20*(1), 43–69.
Herrington, J., Reeves, T. C., & Oliver, R. (2009). *A practical guide to authentic e-learning*. London: Routledge.
Herrington, J., & Parker, J. (2013). Emerging technologies as cognitive tools for authentic learning. *British Journal of Educational Technology, 44*(4), 607–615.
Jacobson, J. (2011). Digital dome versus desktop display in an educational game: Gates of Horus. *International Journal of Gaming and Computer-Mediated Simulations (IJGCMS), Special issue on educational applications*, Spring, IGI Global.
Jacobson, J. (2013). Digital dome versus desktop display; Learning outcome assessments by domain experts. *International Journal of Virtual and Personal Learning Environments*, Fall, IGI Global.
Kapralos, B., Moussa, F., & Dubrowski, A. (2014). An overview of virtual simulation and serious gaming for surgical education and training. In *Technologies of inclusive well-being* (pp. 289–306). Berlin: Springer.
Kronqvist, A., Jokinen, J., & Rousi, R. (2016). Evaluating the authenticity of virtual environments. *Advances in Human-Computer Interaction, 2016,* 3.
Pantelidis, V. S. (2010). Reasons to use virtual reality in education and training courses and a model to determine when to use virtual reality. *Themes in Science and Technology Education, 2*(1–2), 59–70.
Pertaub, D. P., Slater, M., & Barker, C. (2002). An experiment on public speaking anxiety in response to three different types of virtual audience presence-teleoperators and virtual. *Environments, 11*(1), 68–78.
Rizzo, A. (2016). BRAVEMIND: Advancing the Virtual Iraq/Afghanistan PTSD Exposure Therapy for MST. University of Southern California Los Angeles. http://www.dtic.mil/docs/citations/ADA636987.
Shute, V., & Ventura, M. (2013). *Stealth assessment: Measuring and supporting learning in video games*. Cambridge: MIT Press.
Strobel, J., Wang, J., Weber, N. R., & Dyehouse, M. (2013). The role of authenticity in design-based learning environments: The case of engineering education. *Computers & Education, 64,* 143–152.
Vosniadou, S., & Brewer, W. F. (1992). Mental models of the earth: A study of conceptual change in childhood. *Cognitive Psychology, 24*(4), 535–585.

Author Biography

Dr. Jacobson has investigated fully immersive virtual reality (VR) as a learning medium for two decades, developing the technology and conducting experimental research. His early technical work in affordable free software is widely cited in the literature. His experimental trials on VR verses desktop displays were one of the few successful media comparison studies ever conducted. His later work (NSF and NEH funded) is highly regarded among scholars of cultural history and heritage. He has given hundreds of talks and demonstrations at top universities, academic conferences, and industrial conventions. Today, Dr. Jacobson is a co-founder and leader BostonVR, the fifth largest VR meet-up group in the world. He is currently consulting with educators and professionals in several industries, including university graduate studies, architectural design, large-vehicle piloting, and virtual reality display design. All this work is described in his many scientific publications and two books. Dr. Jacobson has served as a project reviewer for the National Science Foundation, NOAA, NASA, and many academic publishers. He is currently the CEO of EnterpriseVR (http://enterprisevr.com), his consulting firm.