Chapter **5**

Instructional Simulations and Games

Overview
In this chapter you will learn to compare and contrast the qualities and learner interactions associated with simulations and games and how they influence creating, using, and managing them in instructional settings. We will first define, in broad terms, simulations, games, and simulations-games. We will then explore them deeper by comparing and contrasting the qualities commonly associated with each. This will be followed by a discussion of the most common learner interactions with each area. Next, we will describe the stages involved with creation of simulations and games, with the understanding that some of the steps taken are common with other digital media, and others are unique. We will conclude with a discussion of best practices for using and instructional simulations and games, including how to most effectively use them to assess learning outcomes.

Keywords: Play, Game, Simulation, Rules, Instructional Simulation-Game, Complex Problem Solving, Decision-Making, Experimentation

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Chapter Objectives
At the end of this chapter, you will be able to:
- Define instructional simulations, instructional games, and instructional simulation-games
- Compare and contrast the qualities commonly associated with instructional simulations and games
- Differentiate the common learner interactions associated with instructional simulations and games
- Describe the stages involved in the creation of instructional simulations and games
- Identify the advantages, disadvantages, and learning techniques that need special emphasis when using instructional simulations and games
- Assess the effectiveness of instructional simulations and games

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1. Defining the Terms: Instruction, Simulations, and Games

Several authors have proposed categories and created taxonomies for understanding and distinguishing the qualities instructional simulations and games. For example, Baptista, Coelho, and Carvalho (2015) listed seven game genres in their taxonomy of game categories as they applied to game-based learning and serious games: "Strategy, Role-Playing, Sports, Management Simulation, Adventure, Puzzle, and Quiz." The Wikipedia entry on Educational video games itself has 21 different subcategories ("Educational video games," n.d.). Similarly, multiple authors have attempted to create categories for instructional simulations. For example, Gredler (2004) described Experiential and Symbolic simulations; Alessi and Trollip (2001) described Physical, Iterative, Procedural, and Situational simulations; and Aldrich (2005) described Interactive Spreadsheet, Virtual Labs/Products, Branching Story, and Game-based Models. Rather than attempt to sort through each of these categories and create our own taxonomies, we instead focus on the common and distinguishing qualities and learner

interactions associated with instructional simulations and games and leave it to others to continue to sort through and create further taxonomies and categories.

As can been seen from the lists of categories above, the boundaries between simulations and games can, and often are, blurred. For instance, one of the game categories listed above is a "managerial simulation," and one of the simulation categories is "Game-based Models." In fact, in examining instructional simulations, you can almost always find game-based elements, and when examining instructional games, you can almost always find simulation elements. This might lead one to conclude that it is fruitless to try to differentiate between the two, and that *everything* is a simulation-game. From an absolutist perspective, that may be true, but we do not hold that position. Rather, we think it is useful to accept that while the lines are often blurred and grey areas are everywhere, it is still useful to differentiate among instructional simulations, games, and simulation-games based on the *preponderance* of qualities and interactions related to games or simulations. Figure 5.1 below visualized the intersecting categories of *instruction*, *simulations*, and *games*.
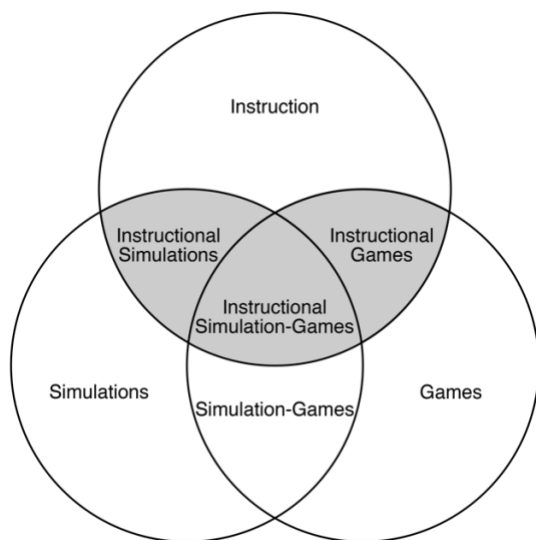

Figure 5.1 The Intersection of Digital Simulations, Games, and Instruction.

In regard to the terms *simulations* and *games*, there are many good definitions, with one of the better treatments offered by Sauvé, Renaud, and Kaufman (2007) after a systematic review of attempts at defining these terms. For the purposes of this chapter we will use the following relatively succinct definitions:

> **Game:** A series of activities carried out by cooperating or competing players, within a framework of rules, with pre-defined conditions for success.
>
> **Simulation:** A simplified version of reality, represented as a system with interdependent parts.
>
> **Simulation-Game**: The overlay of rules and conditions for success onto a simplified representation of reality.

In the conext of simulations and games, we consider *instruction*, as a term, to be generally understood, and we have chosen to it interchangeably with *learning.* For example, *instructional simulations* could be referred to instead as *learning simulations*. As mentioned above, it could

be argued that each of the instructional simulations treated in this chapter is in fact an *instructional simulation-game*. It is very rare to find a pure instructional simulation that does not employ *any* game elements. That said, for the remainder of the chapter we will use the terms *instructional simulation* and *instructional game* to describe most of the examples, based on the relative emphasis and focus on each area. We reserve the term *instructional simulation-game* for rare circumstances, where we feel there is an extraordinary balance between *simulation* and *game* elements.

2. **Aligning Instructional Goals**

It is critically important to know whether there is a match between the specific instructional product and the instructional goals of a simulation or game. Table 5.1 below lists suggested questions to ask to help determine if there is an alignment between with instructional goals. The questions are largely focused around determining if the instructional intent is matched by the learning outcomes.

Table 5.1: Determine if the Simulation or Game is Aligned with your Instructional Goals.

1) Overall, does the cost of the instructional simulation or game (both in terms of money and technical requirements to use) justify using it in an instructional setting? **(Instructional Value)**
2) What, if any, are the stated instructional goals of this simulation or game? **(Instructional Goals)**
3) Based on your observation, and in your own words, what are the goals of this simulation or game? **(Instructional Goals)**
4) Do the stated goals match with your observed goals? **(Instructional Goals)**
5) Are the instructional strategies used in the game accurate and current? Will they arouse motivation and interest? In your estimation, are they effective? **(Sound instructional strategies)**
6) What are the learners actually doing in the game? Evaluate the tasks and activities that they perform. Are they in alignment with the goals and objectives, stated or otherwise? **(Learner Activities)**
7) How are learner tasks and activities assessed by the game? Do they ensure retention of knowledge and skills? How are learners encouraged to reflect upon the content? **(Assessment and reflection)**
8) Evaluate the actual program's content and also, its screen layout (or interface design). What is effective and what is ineffective? Is it a high-fidelity or a low-fidelity simulation? (*Design evaluation*)

2. **Qualities of Instructional Games**

Artificial Rules are almost always present in instructional games. They are man-made and constrain the player to make the game experience challenging, as well as to limit and focus learner interactions. For example, the easiest way to score a goal in soccer would be to catch the ball, and then run it into the goal. If this happens the game is no longer soccer, which is precisely the point: the rules are what defines the game. These rules are what encourage *competition* and provide *challenge* both between and among players, as well as with the game environment itself.

Goals and Objectives can be set by both the game designer as well as the instructor (learning facilitator). These can be simple and short-term, complex and long-term, and everything in-between. At their best, instructional games have goals and objectives that are closely associated with the obstacles and challenges they face in the game, and that they must use

knowledge or skill (or both) to overcome them. Players can also set their own goals, but these may or may not be associated with the intended learning outcomes. For example, one of the authors observed middle school boys playing *The Oregon Trail* in a school library during a study hall. He watched as they conducted a contest among themselves where they took turns killing multiple buffalo, and then added up the total to see who won. And while the "winning" totals often topped 5,000 pounds, in the game they could only take 200 pounds back to their wagon, and the rest was wasted. And while technically they were playing a learning game, it was clear that the only learning that occurred was an improvement in their virtual hunting skills, as well as a disregard for the buffalo they killed.

Conditions for success are well-articulated and clear in instructional games, and they are in almost all cases directly tied to the goals and objectives embedded in the game. Most instructional games describe what is needed to *win* the game, although this is not always the case, as some games use individual or group achievement as the measure of success. In some cases, determining what it means to be successful in the game is itself one of the challenges. Instructors often create their own conditions for success, either in addition to, or as a substitute for those embedded in the game (eg. control your emotions, play nicely with each other, or write a story about your experience). For example, it might be useful, from a storytelling perspective, to purposefully perform badly in *The Oregon Trail*, so the player has something good to write about.

3. Qualities of Instructional Simulations

Representation of a System Found in Reality is often considered to be the first principle of simulations. The system can seek to simulate, imitate, reenact, or represent a particular activity, situation, or environment based upon the parameters of a real-world setting. All simulations are representational in nature. Simulation participants are given the opportunity to interact with a representation of a particular content area (e.g., trading stocks, dissecting a frog, predicting how glaciers will form) within a controlled environment. One of the primary goals of a simulation is to condense and summarize a set of actions within this virtual environment, allowing focus and emphasis on particular aspects of the system. This is so that individuals can effectively interact within what Pappo (1998) refers to as a "make-believe environment." For example, one could become a captain in History Globe's (2010) *The Jamestown Online Adventure* and make decisions that a Jamestown leader would need to confront. Through interactions within these representational environments, learners are able to develop their own mental model (Laird-Johnson, 2009) and corresponding skills within a safe environment without fear of coming to or causing harm.

In MarketWatch's (2010) *Virtual Stock Exchange*, novice learners can safely buy and sell a variety of stocks to experiment with various market trends. This experimentation within the simulation allows learners to see the outcomes of their choices. That is, if one makes the right decision in buying shares of a particular company at a good price based upon a particular set of criteria (e.g., determining a company's price-to-earnings ratio), she or he reaps the benefits of a higher sell price. Participants can apply their recently acquired stock market knowledge to future *Virtual Stock Exchange* transactions or better yet, apply this knowledge to the actual Dow Jones or NASDAQ stock exchanges. These action/consequence trials give learners insights into how this kind of activity would affect a real-world situation. Note that the intended consequences must be genuine and directly related to the actual simulated event and content. Experiencing the results of their actions can be quite effective for these learners. Simulation enables these learners to participate in a *learn by doing* environment (Kluge, 2007).

Focused Instruction is a property of instructional simulations whereby certain representational elements can be deliberately compromised to allow learners to focus on relevant aspects of the environment. For instance, an instructional simulation may only represent a portion of a real-world setting so that learners can concentrate on certain critical elements of the simulated environment. Or an instructional simulation may add components or details that are not present in the actual setting in order to enhance learners' knowledge. For example, in PhET Interactive Simulations' (2010), pH Scale simulation, learners observe and record the pH of various materials, such as drain cleaner, beer, milk, blood or other liquids. Learners can add or remove specific measurements of water to the existing liquid and observe the change in pH. This ability to focus on addition or subtraction of *particular* liquids enables learners to readily observe these changes in pH. By focusing on liquid pH and adding or subtracting water to the mixture, learners concentrate their attention on the changing pH.

This instructional focus and potential rearrangement of the actual setting enables learners to focus their attention on specific elements within the simulated world. This conscious instructional intent provides the best learning opportunity for simulation participants to perform initial actions and to respond to the consequences of these actions. Simulations often have the ability to turn on and turn off various features, making it more approachable for novices, yet scalable and appropriate for experts as those features are enabled. When designing an instructional simulation, one must consider the best learning opportunities for participants, as well as enhance their ability to transfer knowledge acquired from the simulation to real-world settings.

Experimentation with Natural Rules are generally associated with instructional simulations, and mimic those found in reality. Natural variables are mapped into the digital simulation, and often include physical characteristics like time, light, heat, and gravity, or in the case of social simulations, variables such as affection, desire, love, or hate. One of the attractive features of instructional simulations is the ability to experiment with these variables in a way that is not possible in a natural setting. This most often includes turning variables on or off, weakening or intensifying them, and ultimately observing and recording how the different parts of the system react to the changes.

4. Learner Interactions Associated with Instructional Simulations and Games

There are four basic learner interactions common to most instructional simulations and games: Decision-Making, Play and Experimentation, Complex Problem-Solving, and the Formation of Narrative. While simulations or games may emphasize these in different ways, they are most often found in both.

Decision-Making and choice (or the illusion of it) are necessary and fundamental in instructional simulations and games. *Agency* is the term most often used to describe the degree of control that a player has in determining the outcome of the simulation or game. At the outset, a learner can exercise ultimate agency by choosing to play or not to play. Assuming the player does engage, decisions and choices are embedded in the learning environment. Choices represent a state of heightened attention by the learner, so it is important to match learning events and outcomes with these choices. Further, more important choices should be paired with the more important learning objectives. In terms of choice and agency, when a game or simulation has very limited choice, it is referred to as being "on rails." Usually, there are still choices for the player to make, but those choices tend not to affect the progression of the game in any profound way. The creativity from the player, in a case of a game on rails, often centers around figuring out more efficient ways to progress. Perhaps the ultimate example of this would

be "speed runners," who keep video records of those who have moved through the game fastest.

A particularly notable game that artfully plays with notions of choice and agency (in that the player has *none)* is Super Press Space to Win. It is a postmodern commentary on choice itself, as well as what it means to be a "game," and represents the extreme-example of a game on rails (Crane, 2012). Perhaps on the other end of the spectrum would be the construction game *Minecraft*, which offers the player an endless, open-ended environment with virtually unlimited choice. In regard to learning more generally, Clark, Kirschner, and Sweller (2012) fully treated the notion of just how guided instruction should be, and how to determine the amount of control to give to the learner. They concluded that as the background knowledge and developmental level of the learner increased, the more control should be ceded to them (and vice versa). This conclusion is consistent with instructional simulations and games, where too much agency might be inappropriate for novice learners but could be appropriate for those with more experience.

Play and Experimentation are intimately connected as points of interactivity between the player(s) and the game or simulation. Both involve making choices, getting feedback from these choices, and reflecting about how this should influence future choices. Both games and simulations allow the player to "circle back" to these decision points for a redo of their original choices. In games this most often occurs by replaying a level or moving back to a designated saved game or checkpoint. In simulations this often occurs by changing variables in the system and restarting the simulation, either from the beginning, or from a designated stopping point in the middle.

This cycle of experimentation is fundamentally a learning cycle and was outlined by Betrus (2007) "Interactivity = Action + Feedback; Learning = Action + Feedback + Reflection." Above all else it is the learning that occurs in simulations and games that makes players *feel good* and *have fun*.

Intrinsic in this model is the notion that experimentation and play involve frequent *failure* by the leaner, and this is not just okay, but critical if the outcome is learning. *Failing forward* is now common parlance in many progressive learning environments, including NSF funded projects and STEM Learning Labs (UW Institute, 2014), and is embedded in the Next Generation Science Standards (NGSS, 2013).

Complex Problem-Solving goes beyond single decisions or simple interactions, and in most simulations and games the player is required to employ the skills they have learned in combination with each to progress in the simulation or game. This type of strategic planning should be the result of a natural progression from simple to complex. Game designers and educators both understand the fundamentals of what is often referred to as the *Goldilocks Principle,* and was well articulated by Lepper and Woolverton (2002):

> Games have an optimal level of challenge that is at the level of not being too hard or too easy, but just right (ie. The Goldilocks principle). A good game is in the Zone of Proximal Development (Vygotsky, 1978) or at the brink of other zones of ability, cognition, and emotion (Conati, 2002; Rieber, 1996). A game that is slightly more challenging than the learner's skill and knowledge may sustain interest by providing accomplishment while maintaining effort. Success breeds self-efficacy, which is highly correlated with interest in games and learning environments in general (Lepper & Woolverton, 2002). (as cited in

Ritterfeld, Cody, and Vorderer, 2009)

It could be argued that simulations, by their very nature, lend themselves to complex problem solving, and that this is not always the case with games. This may indeed be true, nonetheless *most* games, and virtually *all* simulations involve this strategic combination of knowledge and skill to solve complex problems. For this reason, effective *problem-based learning environments* will in most cases have a number of simulations and games embedded within them.

The Formation of Narrative occurs in both instructional simulations and games through the players' interaction with the digital environment. In general, games tend to lean toward a designer-constructed narrative, and simulations tend to lean toward user-constructed narrative. Yet these are just that: tendencies, and both simulations and games can have a wide range of narratives associated with them. That narrative can be explicitly laid out by the designer and revealed by the player. It can also be constructed by the player(s) through their interactions and choices, and it may or may not be related to what the designer intended. It can also be a "meta-narrative," where the players have a story that wraps around the simulation or game itself (a story *about* playing). In most cases the narrative includes a combination of all of these, although it is the player constructed narratives that they "own" that are generally processed more deeply and remembered more than the designer's explicit narrative (Betrus, 2007).

Also embedded in both instructional simulations and games, and intimately connected to the narrative, is that the player is quite often playing the role of somebody other than who they actually are in real life. In the case of instructional games, this is often superficial, as in the case of a *skin* that changes their appearance but does not influence gameplay or their choices for interactions (note: in some cases *skins* do influence gameplay). In some games, however, the choice of character will influence which interactions are available in the game. In the case of an instructional simulation, it is quite often the case that the role the player chooses strongly influences what abilities and interactions are available to choose from. Simulations are especially suited to narrowly focusing on a role and the choices associated with it. In both simulations and games, role play helps the players to take ownership of the narrative. As was mentioned earlier, it is critical in instructional simulations and games for the facilitator to manage the narrative of the game throughout the briefing, gameplay, and debriefing. MicroSim's *Inhospital* (Appendix B) is a good example of role play and taking ownership of the narrative.

5. Creating Instructional Simulations and Games
Chapter 3 provides a thorough treatment of the common techniques and processes used to create digital media. As with other media, you will be expected to follow a development model and to create design documents, including especially storyboards, that will help you move from initial concept to prototype to finished product. A typical instructional simulation or game development team will include at least one person to take on each of the following roles:
1) Instructional Content Specialist
2) Instructional Designer
3) Game Designer
4) Artist
5) Programmer
6) Level Designer
7) Sound Engineer
8) Game Tester

Depending on the scale of the production, job responsibilities can be consolidated into fewer people, ultimately with the possibility of one person "doing everything." This is often the case for student-projects or very small-scale instructional simulations or games. Perhaps the most famous example of this is Swedish game designer Markus Persson (aka Notch), who created *Minecraft* on his own (Appendix F).

The first step in the creation of an instructional simulation or game is to decide on a concept for the game. If the game is to be funded, or needs to have a production budget approved, the first step is typically the development of a concept document, or *pitch document.* Once presented and approved, development essentially proceeds through a series or progressively more detailed iterations, as the game moves through various workable stages (see Chapter 3 for details on various iterative design models). The attention to detail given to any of these iterative stages varies considerably with formality, size, and impact of the project.

One of the more common mistakes made by instructional designers seeking to create instructional simulations and games is the lack of understanding of the fundamental structure common to all simulations and games. Any instructional game or simulation should combine interactions into relatively short, achievable chunks that start simple, and become more complex as the game progresses. In game-development circles these are commonly referred to "convexities" (Bura, 2008). While this term may seem technical, it really is just another way of describing the grouping of interactions, whereby there are defined starting and ending points, with any number of ways to get from the start to the end (Figure 5.3). The relative shape of the convexity is closely related to the amount of choice that the player has. Typically, instructional simulations have bigger, broader convexities than instructional games. A *pure* simulation simply might be one giant convexity, consisting of the full set of interactions available, with the player carving their own, unique path and setting their own goals (by creating their own goals and achieving them they are creating their own smaller, personalized convexities within the game).
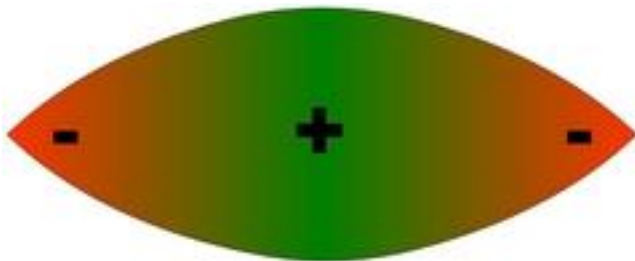

Figure 5.3 **Convexity of available choices during a challenge (Bura, 2008)**

These chunks of content are then ordered in any number of ways, usually by including simple interactions and smaller chunks early in the game, and then layering on complexity and increasing the size of the chunks later in the game. For instructional designers, the concepts of *chaining* and *shaping* found in cognitive information processing models can be used as close analogues to these increasingly complex convexities. Betrus (1996) described a similar arrangement of groupings in his "Chainsaw Model of Video Game Story Structure" (figure 5.4).
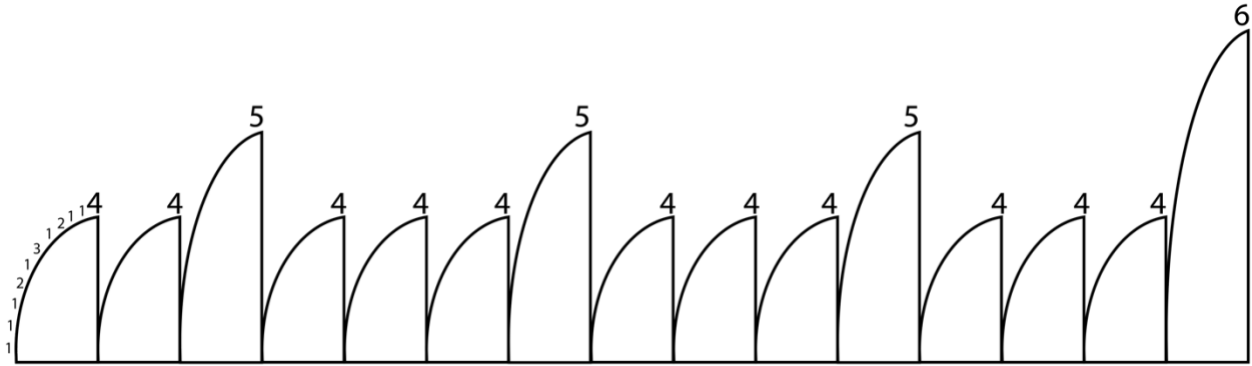
Figure 5.4 **The "Chainsaw" model of Video Game Story Structure (Betrus, 1996)**

The higher the number represented in the figure, the lower the frequency, the higher the difficulty, and correspondingly the higher the emotional impact. It is implied that similar sequences and frequencies of ones, twos, and threes would be included in each of the other spikes (convexities). Without the points of closure (achieved at 4, 5, and 6), contingency plans build up in the player's mind, and the piling on of choices can prove overwhelming. Game designers have understood for quite some time that providing smaller chunks of content allows for closure, whereby contingencies can be released, players can reflect upon their actions, and then move on with a relatively clean slate (although certainly some information is carried forward throughout the simulation or game).

Table 5.2 The "Chainsaw" Model of Video Game Story Structure Applied to the Oregon Trail

Level	1	2	3	4	5	6
Interaction	Resources are depleted, time passes	Trade for or discover equipment. Get lost & lose time	People get sick. Change pace or rations	Hunt animals. Trade for goods. Ford River	Outfit Wagon. Arrive at Fort/Town.	Arrive at Oregon
How often does this occur?	Continually, virtually all the time	Very frequently	Frequently	Occasionally	Seldom	Very rarely, usually only once per game
Emotional Impact of the Event	Low	Low-Moderate	Moderate	High	Very High	Extreme

Without understanding or appreciating this basic structure, instructional designers creating instructional simulations and games can end up providing interactions that are either too "flat" or too "hard," because the relative frequency and placement of interactions is unnatural to the players. While perhaps not explicitly understood by game players, they nonetheless implicitly expect from their experiences with other games that the instructional simulation or game will move from simple to complex, providing appropriate challenge along the way. Making it too easy removes this challenge and makes it "boring," while making it too hard can push the player away from playing altogether. Instructional Simulation and Game design involves a delicate balance between these extremes, and an appreciation of the fundamental structure of games is important in achieving it.

Some other considerations for your instructional simulation or game include keeping a **design document** during development that includes:
1) Design Sketches (graphical representations of the art assets in your game)
2) Sketches of your interface designs
3) Core interactions available in the game
4) How your scenarios (convexities) are arranged (eg. linear vs. non-linear)
5) A list of interactive elements available in each scenario
6) Your instructional Goals and Objectives associated with the game, as well as with each scenario.
7) Lists of media elements needed in your game, including any needed
    a) Storyboards for various screens
    b) Scripts for any spoken or written components, including especially instructions for players, or advice from embedded tutors.
    c) Music and Sound assets
    d) Art assets
    e) Textual assets
8) A production flowchart and anticipated timeline for major milestones

Finally, when the project is over, a **production document** should be produced that clearly describes the creation process as it actually happened, including all major milestones, obstacles overcome, and compromises made. In regard to the instructional efficacy of the project, it is important that each of the following also be included in this document:
1) A description of the subject matter and content (e.g., 5th grade Math tutorial, 7th grade Science simulation or 12th Computer Science game).
2) A description of target audience and their learning characteristics (e.g., 11th grade Biology students).
3) A description of learning task and corresponding goals (e.g., balance of powers in US government).
4) A description of how your instructional simulation fits into an overall course of study and strategies to integrate your simulation into an overall course of study (if applicable).
5) The *type* of instructional simulation that was developed (i.e., decision-making, data-driven, modeling, and/or scenario-based)
6) *Rationale*: An explanation on how your project incorporates the principles and concepts of instructional simulations.

6. Advantages and Disadvantages of using Instructional Simulations and Games

The primary <u>advantages</u> associated with using instructional simulations and games, many of which were outlined by Betrus and Botturi (2010):
1) **Increased Motivation**. Students who are having fun and are engaged tend to find the learning experience meaningful and memorable.
2) **Complex Understanding**. Complex processes--especially relationships among systems and system components--can be well reflected in games.
3) **Reflective Learning**. Learners are given the chance to experiment within a safe play space and to reflect upon the outcomes of the decision they make.
4) **Feedback and Self-Regulation**. Through experimentation and feedback, players learn to refine their choices and to control their actions with the game space.
5) **Transfer to Real-World Settings**. The overall rationale is to enable learners to directly transfer their recently acquired knowledge to an actual setting. When a learner successfully

completes assigned activities and successfully applies this information to a real-world setting, the intent of the simulation has been met.

6) **Learner Buy-In.** Adams, et al. (2008a) observed "the student's interaction with the simulation is directed by the student's own questioning" (p. 397). By interacting with an instructional simulation or game, learners essentially "own" the event and are internally motivated to complete the assigned tasks and activities. It is a big incentive if learners are directly interacting, making decisions, and then observing the impact of their decisions. Participating and exploring in instructional simulations and games enables learners to become a stakeholder in their learning process and there will be no need for an extrinsic incentive to complete the assigned project. However, it is essential to give learners an appropriate range of choices in order to own this learning process and to be in control.

7) **Higher-Order Thinking Skills.** One of the essential characteristics of instructional simulations and games is the capability to successfully teach learners' higher-order thinking skills. By representing real-world activities in a simulated setting, learners are to experiment, discover, role model, and perform other similar activities in order to acquire knowledge about the higher-order thinking skill, concept and/or principle.

8) **Safety** is an important factor to consider when designing instruction. Simulations, in particular, are often conducted in a Lab Setting**.** It is advantageous to create simulations within a laboratory-like setting. Within this "lab" environment, simulation designers can create a safe learning environment while at the same time managing this environment to maximize its instructional effectiveness (Cannon-Bowers & Bowers, 2008; Gordon & Buckley, 2009). Simulation learners can perform seemingly dangerous activities (e.g., removing hazardous waste) within a secure simulated learning environment. Each of these learners can perform, interact and complete the assigned tasks within their respective "lab" and then, hopefully perform, interact and complete similar tasks within an equivalent real-world setting. Lab settings can be quite cost efficient as well. Learning to perform a task by trial and error is preferable in a simulation rather than training in a real-life situation. A lab-like environment enables designers to control and manage discrete variables within the environment. Designers should consciously maximize certain aspects of a simulated event or topic to make it as instructionally effective as possible for their learners.

9) **Simulations Encourage Learning by Doing.** Simulations naturally encourage learners to interact with the selected topic area. Though possible, a strictly linear-based simulation where learners use the simulation as a "page-turner" is virtually unheard of. On the contrary, a bona fide simulation will ask its participants to directly interact with content and provide learners with a variety of activity choices. This explicit contact with the topic area and corresponding activities can facilitate highly effective learning experiences for simulation learners. This interactive approach ensures that learners draw upon a rich experience with the expectation of applying the experience to a similar, real-world setting (Moreno & Mayer, 2007).

10) **Learning by Doing.** Simulations and games naturally encourage learners to interact with the selected topic area. Though possible, a strictly linear-based experience, where learners are essentially "page-turners," is virtually unheard of (Moreno & Mayer, 2007). On the contrary, a well-designed experience will ask its participants to directly interact with content and provide them with a variety of activity choices. This explicit contact with the topic area and corresponding activities can facilitate highly effective learning experiences. This interactive approach ensures that learners draw upon a rich experience with the expectation of applying the experience to a similar, real-world setting.

The primary disadvantages associated with using games were also largely described by Betrus and Botturi (2010):

1) **Subversion of Rules**. In competitive situations, players may employ strategies that ignore the learning outcomes in favor of winning tactics.
2) **Games Take Time**. The increased time associated with preparing and delivering a game may not seem to be an option for some instructors.
3) **Loss of Control**. Instructors may not always have complete control over which parts of the game the students find meaningful and memorable.
4) **Traditional Learning May Now Seem Dull**. Traditional learning, during which students receive less feedback and have fewer choices, may be more difficult for them after playing a game.
5) **Learners May Be Accustomed to Professional Game Media**. With modest game budgets, expertise, and tools, some instructors may not be able to provide games of the same quality that learners are used to playing at home.
6) **Overkill** is a problem in some situations. That is, if one is considering a topic where learners do not necessarily need to interact with or take ownership of the content area, it does not involve higher-order thinking skills, and the tasks or activities do not need to be performed in a lab setting, then an instructional simulation or game is not recommended.
7) **Cost Prohibitive**. Though instructionally effective, the development of an instructional simulation or game can be extremely time consuming and costly. If the instructional goals of the topic area do not match aforementioned benefits of an instructional simulation or game, consider other specific digital media options described in this book. For example, tutorials are relatively easy and inexpensive to produce and could prove more cost-effective and even more instructionally effective for certain learning outcomes. Two case studies Appendix G (Radiation Safety Training) and Appendix H (Designing an Instructional Card Game) are presented as mini case studies that describe real instances of creating instructional simulations and games.

7. Assessment Techniques Associated with Using Instructional Simulations and Games
As with other activities, the use of instructional goals, objectives, and assessments within and alongside the *simulation*, *game*, and *simulation* environments are what makes them *instructional.* Betrus and Botturi (2010) noted that special emphasis should be placed on both the Briefing (before play starts) and the Debriefing (after play ends) to facilitate appropriate learning outcomes. Heinich, Molenda, and Russell (1993) further emphasized the importance of the debriefing:

> During either the hurly-burly or the determined concentration of intense involvement in simulations and games, there is little opportunity to intellectualize or verbalize what one is learning or failing to learn from the activity. The overlay of emotion inherent in these activities militates against cognitive awareness. Because conscious awareness of the main instructional points may be very low during play, it is doubly important to plan for a thorough discussion, or *debriefing*, after play." (Heinich, Molenda, & Russell, 1993)

Yet without proper guided preparation and reflection, it is quite possible that learners could "get through" the game or simulation using the wrong technique or by making improper choices, and in fact never learn appropriately. "Just getting by" is a natural human behavior and is not unique to simulations and games. The frequency of people who have never learned to touch-type and continue to use the "hunt-and-peck" method of typing is a good example of how people can initially learn the wrong technique, and settle because it is "good-enough," even when there is another technique that is demonstrably better. In the case of typing, the average typing speed is between 27 and 37 WPM for 2 finger typers, and between 40 and 60 WPM for touch typers (Gecawich, 2017). Unfortunately, as with other instruction, one of the most common errors is to

short-change guided reflection, and trust that the learners arrive on their own at the correct learning outcomes. The idea that learning takes care of itself when using instructional simulations and games is perhaps the biggest fallacy held by instructors, and this attitude should be avoided at all costs.

Proper reflection, on the other hand, can transform an otherwise mediocre experience into a profound learning experience. Another effective tactic for encouraging metacognition and reflection--especially in longer simulations and games--is to embed feedback from content experts throughout gameplay. These "mini-debriefings" offer information from a different perspective, provides an expert view, and guides learners through the simulation or a *particular* aspect (often a difficult or tricky part) of the simulation.

Special attention should be paid to the debriefing, and it should progress through the use of these four basic questions.

1) **How do you feel?** It is important that this is the *first* question asked to the players, as simulations and games produce strong emotions, both positive and negative. Without letting the players vent these feelings, their minds can get stuck in a negative feedback loop, where they perseverate on the things that went badly for them. By sharing their feelings, they often find that others have similar feelings, and they are not alone, which is comforting and puts them at ease, and ready to talk about:

2) **What happened in the game that made you feel this way?** This is a natural progression from the first question, and the idea is to cover what were perceived to be the major things (in the players' minds) that happened in the game. There can be both of pride and frustration with what happened (often both). Often how the players dealt with the things that happened to them involved them overcoming barriers or moving past obstacles. This is most often achieved by learning, so the debriefing moves through this second stage, players will naturally talk about what they learned from the interactions in the game. To tease this out, ask the players:

3) **Based on what happened during the game, what did you learn**? You should encourage them to be as specific and detailed as they can, as this is where the significant learning outcomes are met. Recording of the details can happen in any number of ways, and additional detail and reflection can occur as a task or assignment given to the players to complete on their own. Finally, after the players have fully discussed what they have learned, you can ask the question:

4) **Based on what you learned, what, if any, changes are you going to make outside of the game?** This is a tricky question if asked out of order, but if asked through the previous progression, the players should be able to think about how what they learned would be useful to them in other areas. If the debriefing is for an instructional simulation or instructional simulation, the answer to this question might be quite obvious (I will use it in the real setting when I do the real thing).

To further facilitate reflection, instructional simulations and games often embed within them data capture, which is recorded and available to players after the game is over. This can be particularly useful after highly stressful or challenging interactions, as players often don't remember negative events clearly. Other tools that are helpful include players logging information in a game journal, or facilitators taking notes about what happened during gameplay. In some cases, video of the session is also recorded, and is available during the debriefing.

Summary

Simulations and games, if used properly, can be very powerful learning tools. When creating games, it is important to understand the fundamental structure that (almost) all games have, as it is this structure that provides feedback, motivation, and narrative. Every time we play a simulation or game, there is a story to be told after. As such, it is important that when facilitating a simulation or game that you move the learners through a coherent briefing that frames their interactions with the game, a structured play session where their interactions are monitored, and a thoughtful debriefing that allows them to reflect on their experience. If these things are not done, or not done well, the story of the game can be drastically different than what was intended. The underlying story for all simulation and game play in instructional settings should be a story about *students' learning.* So long as the focus and value is placed on learning, simulations and games can yield powerful and profound outcomes. You will find a listing of all simulations and games that we refer to in this chapter in Appendix A. You will note that they cover a wide range of topics, including, but not limited to: Nursing, Education, Biology, Physics, Business, History, Political Science, Geography, Aviation, and Mathematics**.**

Reflection Questions
1) What are the differences and similarities between simulations, games, and simulation-games?
2) What are some common learner interactions associated with simulations and games?
3) What are the stages involved in the creation of instructional simulations and games?
4) What are some advantages and disadvantages of using instructional simulations and games?
5) Why is it important to ensure that the simulation or game matches with your instructional goals?
6) In your experience, when have simulations or games worked well to help you learn? What made those experiences special?

Appendix A
Games mentioned in this chapter:

1) The Oregon Trail https://classicreload.com/oregon-trail.html

2) Jamestown Online Adventure http://www.historyglobe.com/flash.html

3) MarketWatch Virtual Stock Exchange https://www.marketwatch.com/game

4) (phET) pH Scale https://phet.colorado.edu/en/simulation/ph-scale

5) Super Press Space to Win Adventure RPG 2009
   http://www.notdoppler.com/superpressspacetowinactionrpg2009.php

6) Minecraft https://education.minecraft.net/

7) (phET) Greenhouse Effect https://phet.colorado.edu/en/simulation/greenhouse

8) (phET) Froguts http://www.froguts.com/

9) Lemonade Stand Game http://www.lemonadestandgame.com/

10) The Many Hats of an Instructional Designer

   i) Paper Based Game: https://www.thegamecrafter.com/games/the-many-hats-of-an-instructional-designer

   ii) Online Digital Game: https://www2.potsdam.edu/betrusak/manyhats/manyhats.html

Appendix B
Featured Instructional Simulation: **MicroSim Inhospital**

Image 5.1: Laerdal's (2010) MicroSim Inhospital

Scenario: In this simulation, learners respond to a patient within an emergency room setting. The learner plays the role of the emergency room physician. The virtual patient has a medical condition or conditions. The learner is expected to make a diagnosis according to the patient's condition and subsequent issues.

Learner activities: The learner must make several critical decisions based on the patient's medical condition, with each decision alterning the patient's condition. It either improves or worsens the patient's health. Learners must apply and synthesize their existing medical knowledge as a health care professional. After the completion of this simulation, learners reflect upon how the decisions they made affected the patient.

Image 5.2: RealLives (2010)

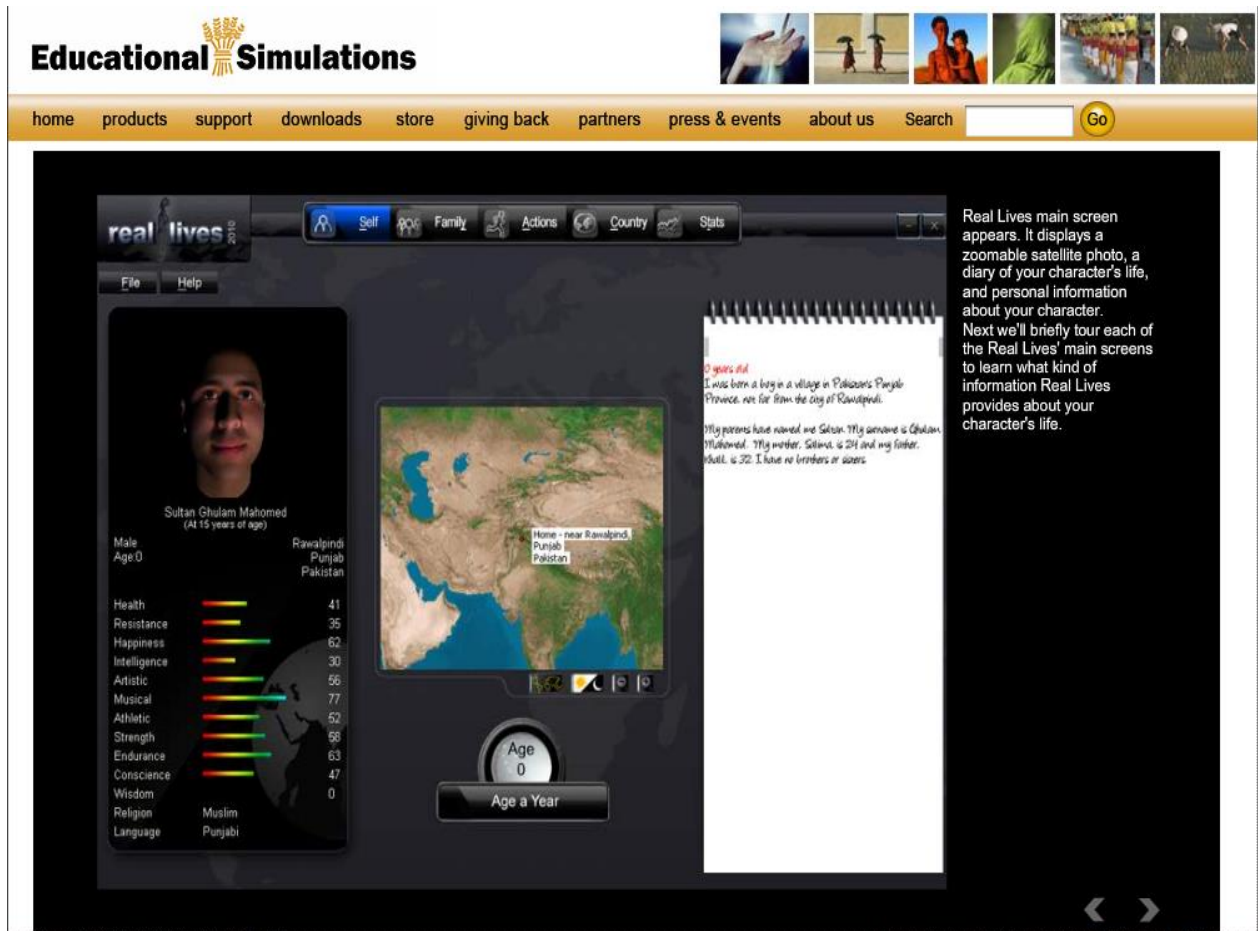Website: http://reallivesworld.com (note: RealLives was updated in 2017)

Scenario: By participating in this simulation, learners are randomly given an identity of an individual living in the 21st century. These characters and corresponding characteristics are based on current world statistics. A learner lives the life of the character based on these statistics and his/her corresponding actions.

Learner Activities: On the main screen, learners view key information about their assigned character including their character's picture and a current assessment on several characteristics related to the character (examples include health, religion, and happiness). The learner's actions and decisions change this current assessment. A learner can make several life decisions, such as enrolling in a college, starting a business, seeking a new romance, or managing a household budget. Major life events (birth of a sibling, moving to another town, etc.) are recorded in the character's diary. Learners also can view a satellite map of their home and assess political, public health, and societal information related to their region and country.
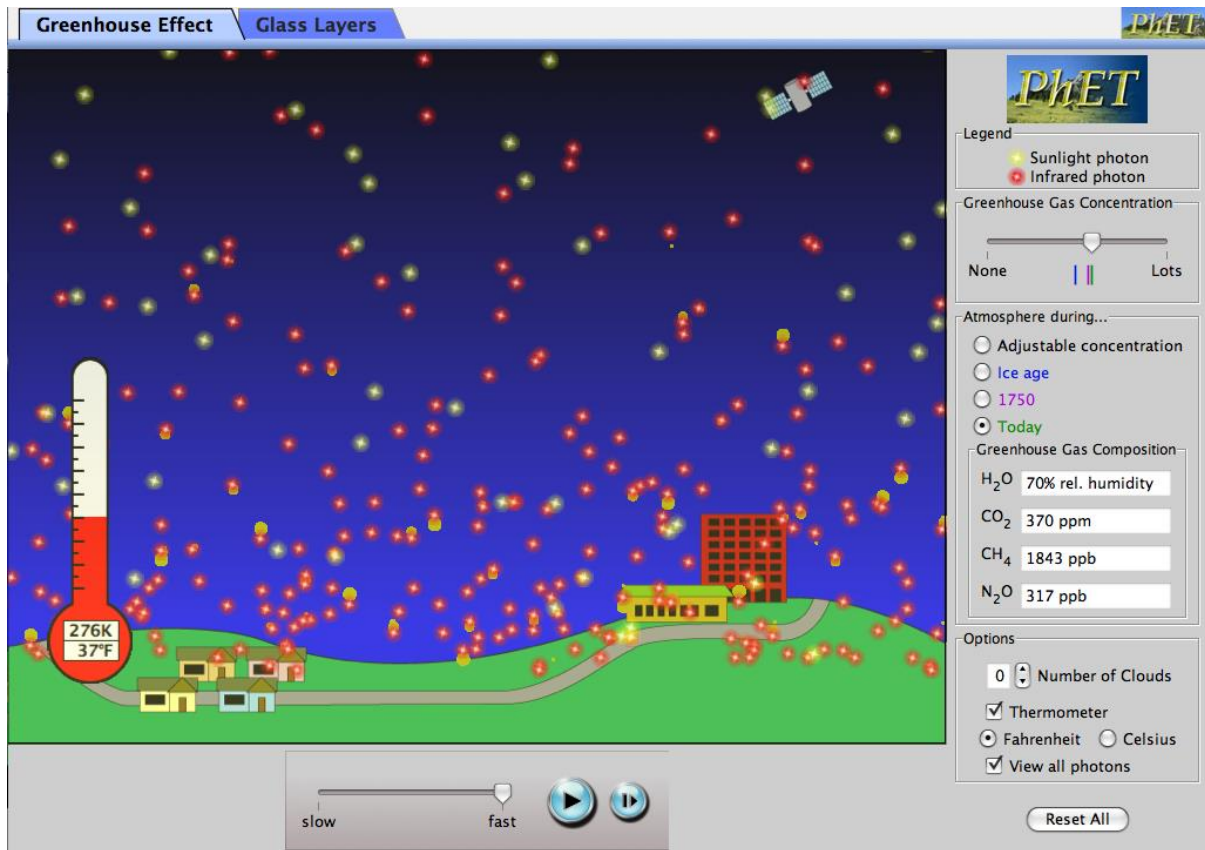
Image 53: PhET's (2010) Greenhouse Effect

Website: https://phet.colorado.edu/en/simulation/greenhouse

Scenario: In this simulation learners experiment with factors that influence the Earth's climate and greenhouse gases. The intent is to model the increased or decreased amount of sunlight photons and infrared photons and observe the temperate change based on three time periods: ice age, 1750 or today's climate. The learner plays the role of the climate scientist observing the effects of these greenhouse gases in these three time periods.

Learner Activities: Learners can select a few options within this simulation. After selecting the time period, learners adjust the amount of greenhouse gases, add clouds or add panes of glass. After making selections, learners observe the number of photons (sunlight and infrared) and the Earth's temperate. Within an Earth Science curriculum, relevant questions the simulation poses include:
- Describe the effects of the temperature, sunlight, and infrared photons as the concentration of greenhouse gases is increased or decreased. 2)
- What happens when clouds or panes of glass are present or absent?
- Distinguish the differences between two time periods

By answering these questions and observing their actions in this simulation, learners become quite knowledgeable about climate change and global warming.

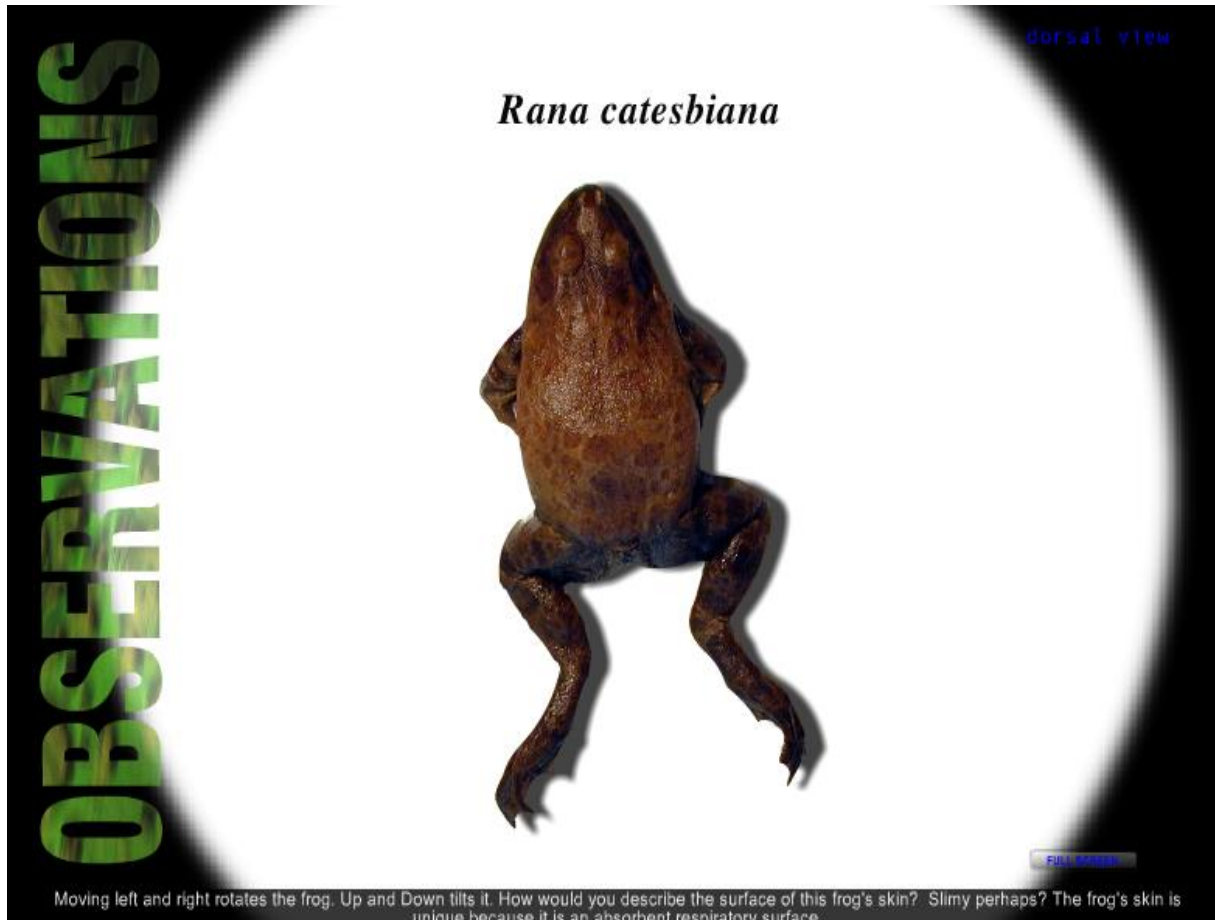Appendix E
Featured Instructional Simulation: Froguts

Image 6.3: Froguts (2010)

Scenario: Based upon ISTE's goals for 9th-12th grade science curricula, *Froguts* offers learners the opportunity to dissect, inspect and assess the following specimens, including: a frog, a fetal pig, a cow eye, an owl pellet, a starfish, a fruit fly and a squid. Situated in a virtual science lab, the learner plays the role of a scientist exploring and experimenting with the particular specimen.

Learner Activities: Learners have several virtual lab tools to make their observations, such as a scalpel, microscope, injectors, scissors, x-rays, and forceps. Using these tools, learners can identify particular anatomical parts (e.g., frog's external nares or liver). Learners also can observe the specimen in 3-D. After completing each module, one can assess learners' recently acquired knowledge.

Image 6.5 Minecraft Education Edition with Blockly Coding

Website: https://education.minecraft.net/

Scenario: Minecraft was originally created as an open-world game, where players have freedom to interact with the world. It was quickly picked up as a learning tool by schools, and is often used as a form of computer assisted design (CAD), whereby the students collaboratively plan and build buildings, villages, cities, and even worlds. In 2014 Microsoft purchased Minecraft, and in 2017 they released Minecraft: Education Edition, with the intention of more formally introducing promoting Minecraft in Education through teacher training and professional development. See especially: https://education.minecraft.net/class-resources/trainings/

Learner Activities:
In educational settings, students typically conduct research on a given era, including especially design features of the buildings from that era. They use Minecraft to recreate those buildings in the virtual world. Varying degrees of interactivity with the environment can be created, depending on the age and ability of the creators. One significant addition to Minecraft: Education Edition is the inclusion of *blockly* coding as a formally supported add-on to the game. This encourages students to develop basic coding skills, and if used in conjunction with code.org, this can provide a strong foundation of coding skills for more further coding training.

SUNY Potsdam's Educational Technology program, with support from National Education Foundation, supports an annual Minecraft Competition for schools. In the most recent contest emphasize the building of a Smart Village or City.
http://academies.cyberlearning.org/minecraftcompetition/

Professional Practice Case Study 5A

Instructional Simulation Scenario

"Radiation Safety Training"

Ms. Vanessa Juleman contacted Ms. Sarah Bearson, Senior Learning Technologist, in the Learning Technologies division about the following situation. According to Ms. Juleman, Director of Management and Finances, several of her radiation safety employees have had multiple complaints about the required online training that each radiation safety employee was required to complete after 1000 hours, usually twice per year. She described specific complaints from individual employees, but the bottom line is that the current online training is not *engaging at all* for these employees. As one can imagine, these employees prefer to learn on the job hands-on training in a face-to-face setting. Currently, the Learning Technologies division only has existing, canned instruction that is, in Ms. Bearson's own words, awful.

Developed by JBS company, this instruction essentially is one gigantic training manual where each topic or lesson is listed alphabetically. To re-certify one's credentials, Ms. Juleman said that each employee must complete seven topics in at least three specific areas, namely reducing radiation exposure, current safety regulations, and radioactive sealed containment. Employees can select other areas according to their interests. Though this online training includes digital media components, such as videos, diagrams, and other visual aids, Vanessa was straightforward when commenting that this existing training is *not* necessarily going to make these a better radiation safety worker. "Seriously" she said, "you can't rely on developing and practicing skills as a radiation safety professional by just learning from the computer." She was even more direct in stating, "They [radiation safety employees] hate it" and "I would get rid of it [the online training] if I could." Ms. Juleman did offer an alternative solution. She noted that these employees learn best when they touch the parts and try to put a part in place, assemble, and disassemble things and she described that the "most effective thing I've seen with radiation safety workers is when we bring vendors and experts who bring in actual equipment. They demonstrate actual procedures and then they ask employees to demonstrate their skills." Both Ms. Jaleman and Ms. Bearson agree that the company needs to incorporate alternative types of training where these employees "play" and interact with actual pieces of equipment. By doing this, these employees are much more engaged that way.

The Learning Technologies Division realized that bringing in vendors and providing this hands-on training is quite cost prohibitive and impacts the division and the overall company's bottom line. Providing *effective* online instruction is the better option but the Learning Technologies division needs to deliver instruction that these radiation safety employees cannot only enhance their professional skills but also be engaged in this learning. What features of instructional simulations or games would you recommend? Propose a design that would address a particular radiation safety topic (e.g., reducing radiation exposure, current safety regulations, and radioactive sealed containment). In addition, prepare a rationale that Ms. Bearson can provide to Ms. Juleman and to address her "just learning by computer" and not engaged concerns.

Professional Practice Case Study 5B

Instructional Game Development Scenario
"The Many Hats of an Instructional Designer"

The co-authors of this chapter, Dr. William Sugar and Dr. Anthony Betrus, collaborated from 1999-2002 to first create a paper-based instructional card game, and then a digital version of the game, with the purpose of exposing students to major responsibilities of an instructional designer, and to give these students insights into what exactly an instructional designer does. The initial concept came from a conference presentation given by Dr. Sugar, where he outlined five *Archetypes:* Problem Solver, Artist, User, Counselor, and Performer. Together, the intention was that these sere a framework for capturing the core competencies of an instructional designer. Each archetype has associated with it four attributes that further described the archetype. For example, the Archetype "Designer as Counselor" has as its four attributes: "Be a good listener," "Be empathetic and understanding," "Develop and maintain a trusting relationship," and "Be accepting and uncritical." The organization of the information as presented appeared to be fundamentally sound, and after the presentation Dr. Betrus approached Dr. Sugar and suggested that he would, with his permission, like to take a host a turning these concepts into a game.

The intention was to have novice instructional designers understand and appreciate the wide variety of roles and responsibilities that experienced instructional designers employ every day. These learning outcomes could have been achieved in any number of alternative ways, including: presenting the information via *PowerPoint* presentation, asking the students to write down the information for a later quiz, preparing flash cards with the information on them, or having them write a short story about a time when they had to take on one or more of the roles or responsibilities. We chose the game as our tool because we wanted this important information to be "sticky" early on in the class.

The development of the paper-based game was relatively simple, and the game quickly took the form of a basic matching game, whereby the players had to match the attributes to the archetypes (and later elaborations of these attributes were created). Rules and points were added to the game, and it was used for a number of semesters, with an additional reflection and extension assignment added at the end of last round of gameplay. The students were required to pick two roles with associated responsibilities from the 20 unique Archetype-Attribute-Elaboration sequences, which in total comprised the instructional designer core-competency framework. (Note: the full framework can be viewed on page 48 of Sugar and Betrus (2002)). The students then wrote short anecdotal stories about their experiences in that role, which they shared via online discussion forum with the other students. This extension activity served multiple purposes, including: helping the students to remember the framework, getting to know their fellow students better, and getting introduced to the rules associated with the online discussion forum.

After two years of analog play, a digital version of the game was developed using Adobe Flash. Because the game was transformed from a 4-8 player live game into an individually played online game, the game mechanics had to be changed significantly. Adobe Flash was used as the development tool, and the art assets used in the creation of the card game were re-used in the digital game. The textual from the cards remained primarily the same, although some simple clarifications were made to some of the attribute and elaboration cards. No sound was added to the game, and the scoring and interface design went through multiple

iterations before finishing on its current design. The live card game is available at "The Game Crafter," and the digital version is available to play online (see Appendix A for links).

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