## Chapter 6 - Creating Instructional Simulations and Games

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.

**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

### 1. Overview

In this chapter 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 instructional simulations and games, including how to most effectively use them to assess learning 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.

### 2. Defining the Terms: Instruction, Simulations, and Games

Several authors have proposed categories and created taxonomies for understanding and distinguishing the qualities of 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 example, 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 3.1 below visualized the intersecting categories of *instruction*, *simulations*, and *games*.

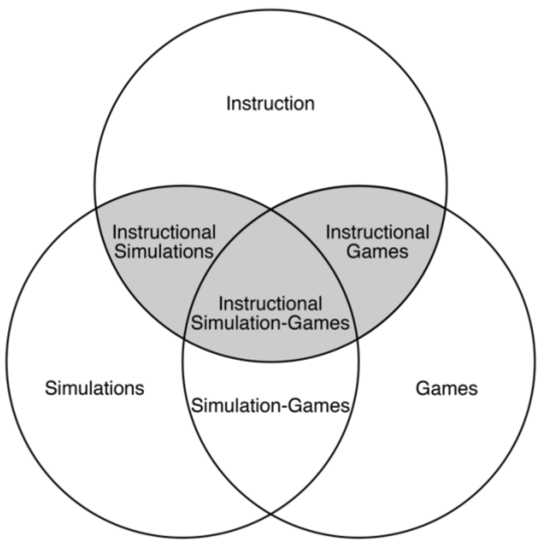


*Figure 6.1* The Intersection of Digital Simulations, Games, and Instruction.

In regards to the terms *simulations* and *games*, there are many good definitions, with one of the better treatments offered by Sauve et al (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.

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 very rare circumstances, where we feel there is an extraordinary balance between *simulation* and *game* elements.

**3. Commonly associated qualities of Instructional Simulations and Games**

In the following section, the qualities most closely associated with instructional simulations and games will be discussed.

A. **The qualities most commonly associated with instructional games** include Artificial Rules, Goals and Objectives, and Winning Conditions

    a. **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.

    b. **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* as they conducted a contest among themselves where they took turns killing multiple buffalo, even though they could only keep the meat from one kill. 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.

    c. **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).

B. **Qualities most commonly associated with instructional simulations** include Representation of a System Found in Reality, Focused Instruction, and Experimentation with Natural Rules.

**a. 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. 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. Or one could become a university administrator and make decisions related to higher education in the *Virtual U* project (2010). 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. 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).

**b. 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.

c. **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**

Most learner interactions are common to both instructional simulations and instructional games. There is also an additional set of learner interactions that are especially prevalent in instructional simulations.

A. **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.

a. **Decision-Making** and choice (or the illusion of it) are necessary and fundamental in instructional simulations and games. The term most often used to describe the degree of control that a player has in determining the outcome of the simulation or game is *agency*. 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.” Often choice in this case boils down to figuring out more efficient ways to run the rails, so-to-speak.

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 regards to learning more generally, Clark, Kirschner, and Sweller (2012) fully treated the notion of 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.

**b.** **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 OK, 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).

c. **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 and 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.

d. **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. 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 influence 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.

Educational Simulations' (2010) Real Lives 2010 (Appendix D) is a great example of a social awareness simulation that has strong role play and narrative components. Initially, a Real Lives 2010 participant is assigned a role or an individual life. Examples of these lives include a Mexican girl living in Mexico City, a Chinese boy living in Jiangsu province, and an Indian girl living in the state of Andhra Pradesh. Each learner's character progresses through the simulation one year at a time. During the simulation, the character's life events occur, such as the Chinese boy's mother being cured of trichuriasis, the Indian girl's older sister getting measles, or the Mexican girl's father being drafted into the military. These events are based on actual geographic statistics. Real Lives 2010 learners can find out additional information about these events within the simulation or from additional web pages. With the goal of increasing one's awareness and empathy for a region of the world, Real Lives 2010 teaches about human geography, politics, economy, health, and other related issues.

Empathy itself was the focus of a research group at the University of Wisconsin-Madison. They created the learning game Crystals of Kador, and successfully demonstrated that playing their game, especially reading the facial cues of other simulated avatars, increased in the neural connectivity of players in the region of the brain associated with empathy. (Spoon, M., 2018)

B. There are four primary qualities of instructional simulations: Higher Order Thinking Skills, Data Analysis and Visualization, System Modeling, and Scenario Situated Exchanges.

   a. **Higher Order Thinking Skills** – The ultimate goal for completing an instructional simulation is for learners to determine a credible solution for a problem through making decisions. This problem solving typically involves higher-order thinking. Effective instructional simulations can promote higher order thinking skills (Leemkuil, de Jong, de Hoog & Noor, 2003). If properly designed, they can lead learners to "big" ideas and concepts through discovery and role modeling (Akilli, 2007), "higher-level principles, procedures and cause-effect relationships" (Gibbons & Fairweather, 1998), and highly complex and technical concepts and principles (Chen & Howard, 2010). The basis of an instructional simulation is rooted in the ability to present ill-structured content where a problem may be solved by more than one acceptable method. There is a natural progression from complex problem solving to higher order thinking skills. In instructional simulations this often comes via the systematic collection and analysis of *data* from the simulation. While learners may also do this in an instructional game, this activity is largely associated with instructional simulations.

   b. **Data Analysis and Visualization** is a particular form of higher order thinking and data processing that requires the manipulation of facts, figures, and data. The purpose of this instructional strategy is for learners to gather, interpret and visualize the various relationships of the data associated with the simulation or game. Learners also may visually rearrange data to create alternative interpretations of a particular phenomenon. Learners are able to alter particular features of a simulated object or event in order to visually see a wide range of interactions and outcomes. This ability to visualize data can be located in existing case studies, embedded in the actual scenario, job aids, progress bars that measure learners' current performance or other, similar means.

   c. **System Modeling** occurs when learners interact with a replica of the environment/system and its corresponding features. By their representational nature, instructional simulations provide a model of an environment or system. System modeling simulations emphasize the actual system and the focus of these simulations is on learners interacting within that system (e.g., predicting the results of the greenhouse effect, dissecting a frog, or flying a 1903 Wright Flyer). The goal is to present a dynamic representation of the simulated object or environment in which learners can experiment with phenomena and underlying principles. Within a system model simulation, learners have the opportunity to perform a series of related actions repeatedly with the goal of achieving a particular goal or optimum sequence, enabling them to test out causal relationships in a safe environment that is connected to the real-world setting.

A particularly good example is the PhET simulation that deals with the Greenhouse Effect (Appendix B), whereby learners observe the "level of atmospheric greenhouse gases" during a selected period of time, such as the ice age, 1750, 21st century, or in the future. By increasing or decreasing the greenhouse gas concentration, one is able to monitor the effects of these gases on Earth's temperature. In the Greenhouse effect simulation, learners are able to add devices, such as clouds and glass panes, to see additional effects on the Earth. Being immersed in this greenhouse system model, learners test out variables and understand how they alter the Earth's temperature. Similar to this system modeling activity, learners can role-play particular behaviors and actions within an instructional simulation. Upon entering the simulation, learners are assigned a role within a defined set of circumstances. These role-playing activities enable learners to see how specific actions can affect a particular situation.

In Froguts'(2010) frog dissection (Appendix C), learners assume the role of a biologist performing a frog dissection. Learners pin, make incisions in a bullfrog's abdomen, and identify body parts of a frog. In each of these activities, learners experiment with the frog specimen as if they were in an actual physical classroom lab. This type of learner interaction can be highly effective in encouraging interpersonal skills between various roles within a work environment. This role modeling enables learners to see how their actions can affect real world settings and can repeat their actions until they are able to master a particular skill set.

d. In **Scenario Situated Exchanges** learners focus on interacting with a particular scenario or series of scenarios. By participating in a scenario, learners practice and refine a particular skillset, solve a problem, acquire new skills, and ultimately prepare for similar activities. This scenario may focus upon an historical event such as settling the Jamestown colony, or a realistic situation that highlights cause and effect, such as selling lemonade within a community during specific weather conditions. In a scenario, learners react to events and learn how to interact with issues and problems within the simulated environment. Learners are given specific tasks to complete within the scenario. In this type of simulation, learners assume a role and solve problems within the situation. Learners need to resolve the situation or crisis entirely or attempt to minimize the problem. In a scenario or story, learners can make several choices; potentially there can be multiple and varied story lines or branches. As one can imagine, this story branching can vary from simple to quite complex (see Figure 6.2 below for a typical branching model). Goal-based scenarios (Shank, Berman, & Macpherson, 1999) are a prime example of this instructional approach, and this type of scenario is currently found in several instructional simulations.

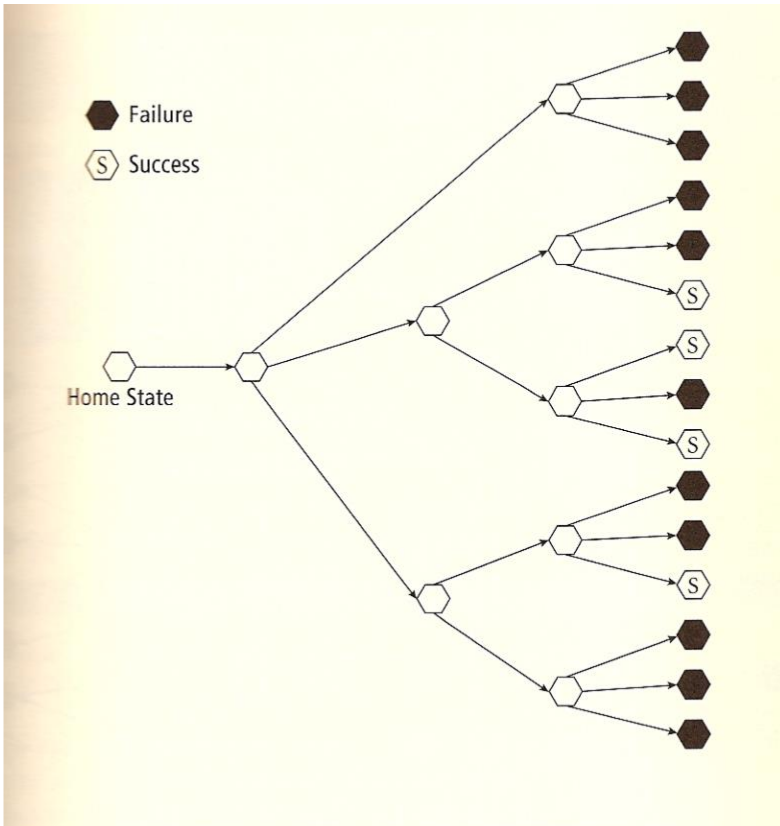


*Figure 6.2:* Pure Branching Story Model from Aldrich (2005)

History Globe's (2010) *The Jamestown Online Adventure* and the Lemonade Stand Game (2010) are excellent examples of this scenario-based element. In *The Jamestown Online Adventure,* a ship's captain must first decide where to land his boat. Should he or she land the boat on a bay island, on the coast, inland (close to the forest and hills) or in the bay marsh? Then, the new Jamestown colonist needs to decide which structure that he or she should build (either a town, small castle or a fort). In the Lemonade Stand Game (2010), learners have the goal of making as much money as they can within 30 days by selling lemonade in a fictitious town. Beginning with $20, participants need to purchase specific amounts of paper cups; lemons; sugar and ice before the first day. Participants are made aware of the specific weather conditions (e.g., cloudy, 65 degrees, etc.) prior to making this decision. After making their purchases on the first day, potential customers come by the stand and decide to purchase lemonade or not. Afterward, Lemonade Stand learners are given an overall assessment that details how much lemonade was purchased and how much money they made during this first day. Based on these results, lemonade stand owners/learners again need to make the same four purchases while taking into consideration tomorrow's weather forecast. The goal of this 30-day scenario is for learners to discover the best purchasing strategy for selling lemonade according to particular weather conditions. These scenario-based activities enable learners to practice and try out newly acquired skills within a realistic setting.

A related scenario-based type of simulation is a virtual field trip. Through guided exploration from the instructor, students participate in a series of website visits to learn about a particular content area. This "visit" essentially simulates an actual field trip in which students might participate.

## 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 develop 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 E).

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. A full treatment of a large scale, formal game development process is included in the Wikipedia (Video Game Development, 2018)

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 instructional simulation should combine interactions reactively short, achievable groups. In game-development circles these are commonly referred to as progressively more complex "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 6.3). 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).

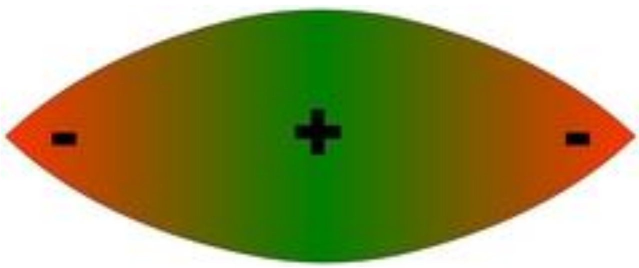


*Figure 6.3* Convexity of available choices during a challenge (Bura, 2008)

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 6.4).

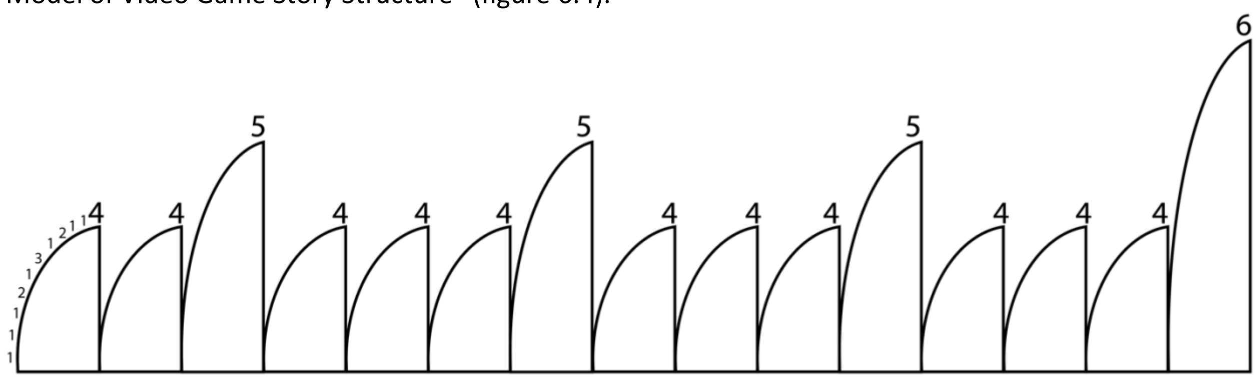


*Figure 6.4* The “Chainsaw” model of Video Game Story Structure (Betrus, 1996)

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 6.1 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 notebook that includes:

i. Design Sketches (graphical representations of the art assets in your game)
ii. Sketches of your interface designs
iii. Your core interactions available in the game
iv. How your scenarios (convexities) are arranged (eg. linear vs. non-linear)
v. A list of interactive elements available in each scenario
vi. Your instructional Goals and Objectives associated with the game, as well as with each scenario.
vii. 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
viii. A production flowchart and anticipated timeline for major milestones

And 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 regards 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, 7$^{th}$ grade Science simulation or 12$^{th}$ 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 advantages associated with using instructional games outlined by Betrus and Botturi (2010) are also relevant to instructional simulations

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. **Simulations facilitate transfer to real-world settings**. The overall rationale is to enable learners to directly transfer their recently acquired knowledge to an actual setting.
6. **Learning by Doing.** Explicit contact with the topic area and corresponding activities can facilitate highly effective learning experiences for 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).
7. **Simulations encourage learner buy-in.** By interacting with an instructional simulation, learners essentially "own" the event and are internally motivated to complete the assigned tasks and activities.
8. **Simulations are best suited for higher-order thinking skills.** By representing real-world activities in a simulated setting, learners can experiment, discover, role model, and perform other similar activities in order to acquire knowledge about the higher-order thinking skills, concepts and/or principles.
9. **Simulations can safely present dangerous situations.** Learning from our mistakes is an effective teaching tool, but this can't always be done in the real, authentic environment. Simulations offer learners the chance to make mistakes in dangerous situations without the dire real-world consequences of their actions.

The primary disadvantages associated with using games was also 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.

Two case studies Appendix F (Radiation Safety Training) and Appendix G (Designing an Instructional Card Game) are presented as mini case studies that describe real instances of creating instructional simulations and games.

**7. Common 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, and 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.

A simulation coach can be conveyed through pop-up or just-in-time prompts within the simulation. These coaching messages offer specific tips on how to complete certain actions. In History Globe’s (2010) *The Jamestown Online Adventure*, learners can seek the advice of a colonist, a Native American, or the colonists’ charter. In USC Annenberg’s Redistricting game (USC Annenberg, 2007), learners get advice from specific district representatives who describe his or her particular interest in the redistricting effort. These specific perspectives enable learners to consider the strategies and techniques employed by an expert and potentially incorporate these practices while interacting with the content area.

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 can 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.

The debriefing process outlined above will ensure that learning has taken place, but it is also important to know whether there is a match between the specific instructional product and the instructional goals. We have developed a tool that is intended to be used to evaluate instructional simulations and games (Appendix H). The questions it asks are largely focused around determining if the instructional intent is matched by the learning outcomes.

## 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
    - Paper Based Game: https://www.thegamecrafter.com/games/the-many-hats-of-an-instructional-designer
    - Online Digital Game:

      https://www2.potsdam.edu/betrusak/manyhats/manyhats.html

Appendix A

Featured Instructional Simulation: **MicroSim Inhospital**


*Image 6.1*: Laerdal's (2010) MicroSim Inhospital

<u>Scenario</u>: 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.

*<u>Learner activities</u>:* The learner must make several critical decisions based on the patient's medical condition. Each learner decision alters 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.

Appendix B

Featured Instructional Simulation: **Greenhouse Effect**

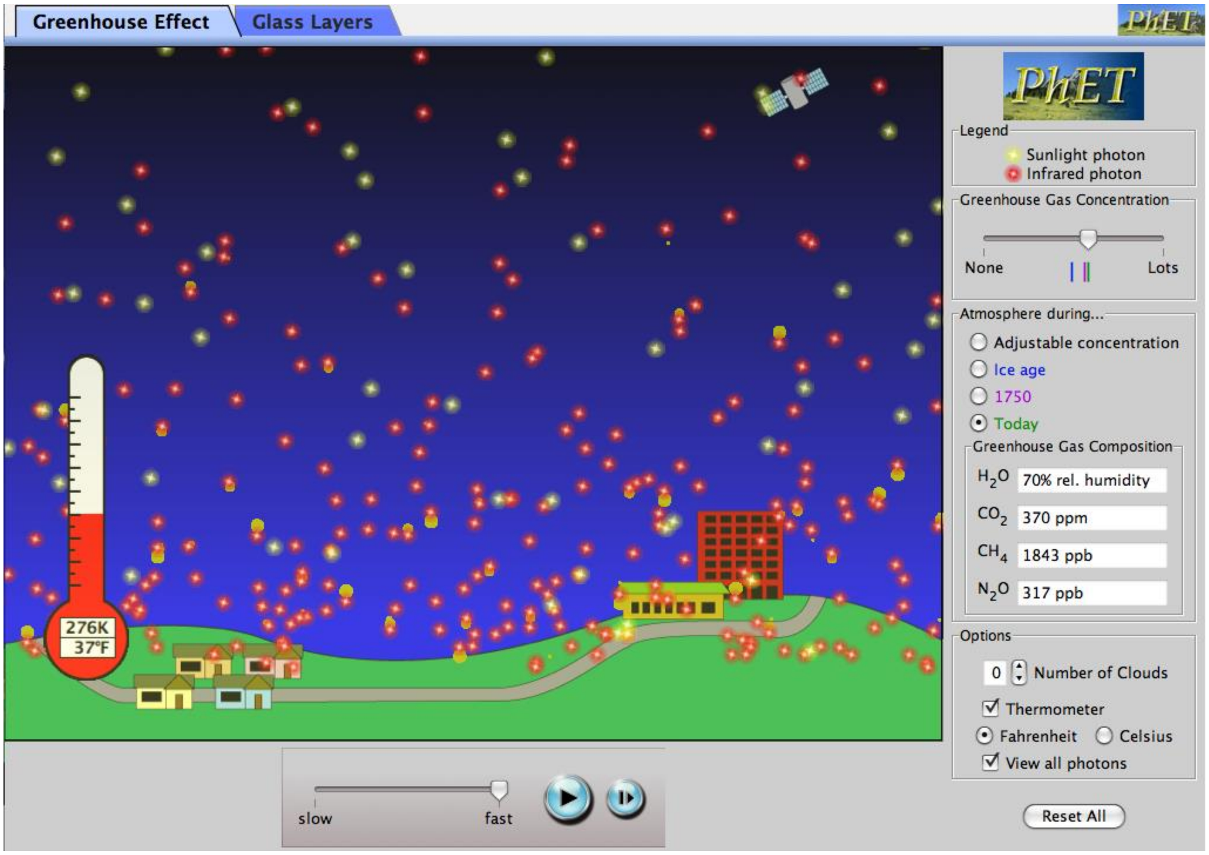


*Image 6.2*: PhET's (2010) Greenhouse Effect

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.
- 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 C

Featured Instructional Simulation: **Froguts**

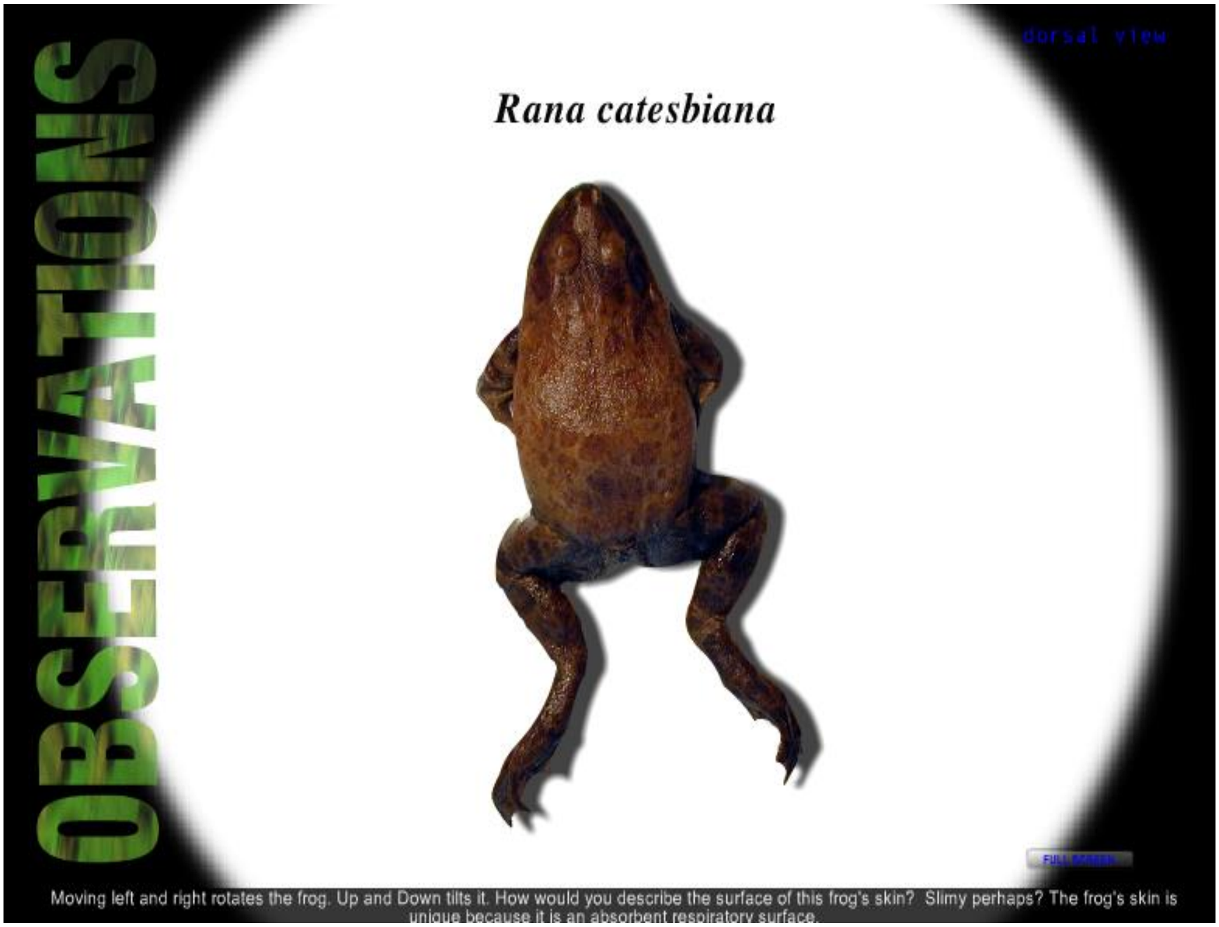


*Image 6.3*: Froguts (2010)

Website: http://www.froguts.com/

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.

Appendix D
Featured Instructional Simulation: **RealLives** (2010)

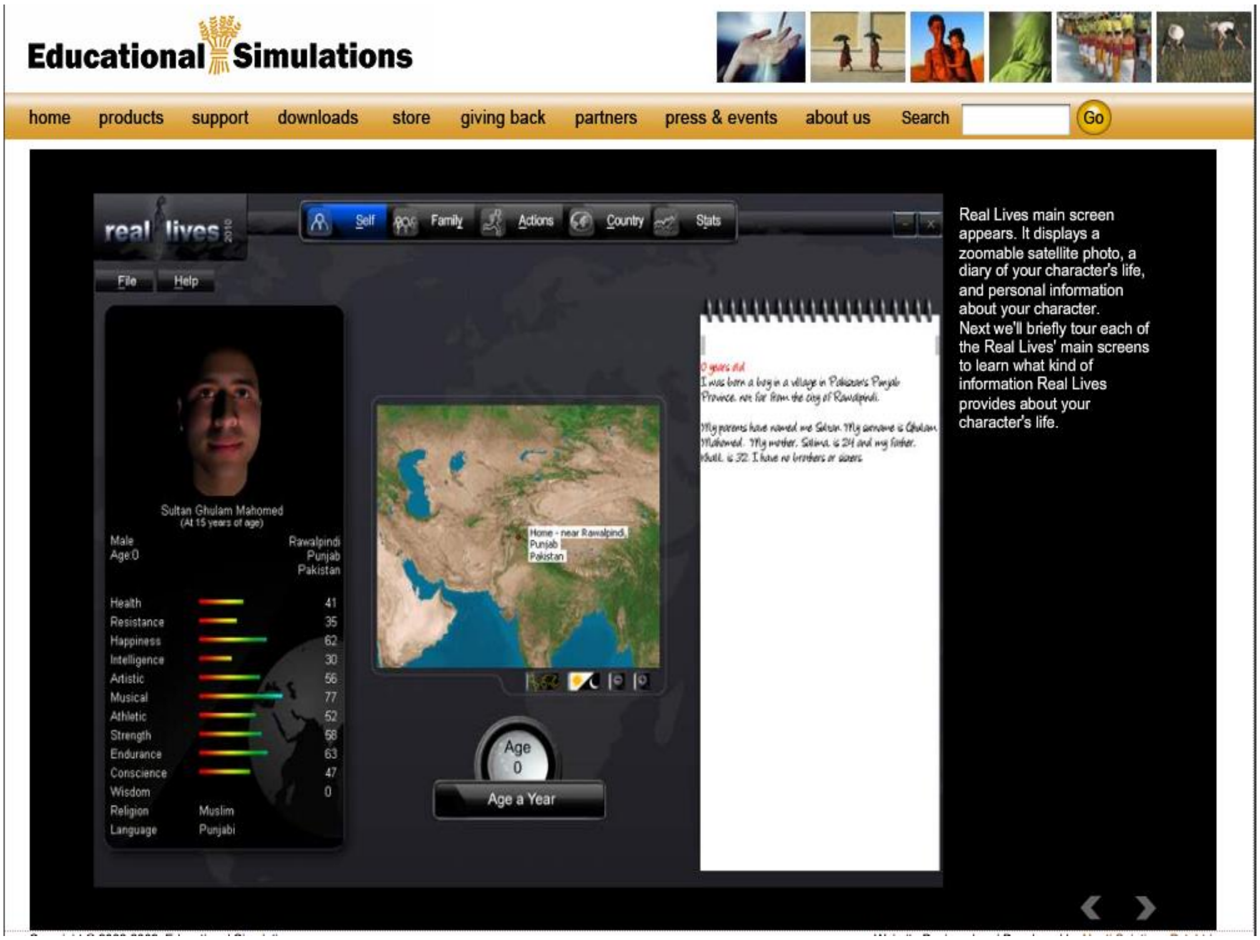


*Image 6.4*: RealLives (2010)

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.

Appendix E

Featured Instructional Game

Minecraft: Education Edition (2011)

*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/

Appendix F
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 were 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.

Appendix G
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 core learning outcomes associated with the framework was to have novice instructional designers understand and appreciate the wide variety of roles and responsibilities that are that experienced instructional designers employ every day.

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).

Appendix H

Instructional Simulation/Game Evaluation Form:

| | |
|---|---|
| Instructional simulation/game title/URL: | |
| 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)** | |
| What, if any, are the stated instructional goals of this simulation or game? **(Instructional Goals)** | |
| Based on your observation, and in your own words, what are the goals of this simulation or game? **(Instructional Goals)** | |
| Do the stated goals match with your observed goals? **(Instructional Goals)** | |
| 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*)** | |
| 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)** | |
| 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)** | |
| 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*)** | |

**References**

Aldrich, C. (2005) Learning by Doing: A comprehensive guide to simulations. Pfeiffer, San Francisco, CA.

Alessi, S. and Trollip, S. (2001) Multimedia for Learning: Methods and Development, 3rd Edition, Pearson.

Baptista, R., Coelho, A., and Carvalho, C. (2015) Relationship Between Game Categories and Skill Development: Contributions for Serious Game Design. Proceedings of the European Conference on Game Based Learning, Vol 1, p34-42.

Betrus, A. (2006, October 31). A Universal Game Theory: Implications for Improving Game-free and Game-based Instruction. Speech presented at Serious Games Summit, Crystal City Marriott, Arlington, Virginia. (link)

Betrus, A. and Botturi, L. (2010). Principles of Playing Games for Learning. Chapter 2 in *Playing Games in School*, Hirumi, A. editor. ISTE. Eugene, OR & Washington, DC. (link)

Bura, Stephane (2008) Emotion Engineering: A Scientific Approach for Understanding Game Appeal. *Gamusutra*, retrieved June 29, 2018 from https://gamedev.stackexchange.com/questions/92490/what-is-convexity-in-the-context-of-game-design

Clark, R., Kirschner, P., and Sweller, J. (2012) Putting Students on the Path to Learning: The Case for Fully Guided Instruction. *American Educator*, Spring 2012. (link)

Crane, S. (2012) Super Press Space To Win: A Postmodern Deconstruction of Gaming. *Venturebeat*, Jan 24, 2012. (link)

Gecawich, M. (2017). Can typing with 2 fingers be as fast as with 10? Typing.com. June 22nd, 2017. Retrieved June 29, 2018 from https://blog.typing.com/hunt-and-peck/

Gredler, M. E. (2004). Games and simulations and their relationships to learning. In D. H. Jonassen (Ed.), *Handbook of research for educational communications and technology* (2nd ed., pp. 571-82). Mahwah, NJ: Lawrence Erlbaum Associates.

Heinich, R., Molenda, M., and Russell, J. (1993) *Instructional Media: The New Technologies of Instruction.* Macmillan. New York, 1993. ISBN 9780023530609 002353060X in HathiTrust

Kluge, A. (2007) Experiential learning methods, simulation complexity and their efforts on different target groups. *Journal of Educational Computing* Research. 36(3): 323-349.

Leemkuil, H., de Jong, T., de Hoog, R. KM Quest: A collaborative Internet-based simulation game. *Simulation and* Gaming. March 1, 2003

Moreno, R. and Mayer, R. (2007) Interactive Multimodal Learning Environments. *Educational Psychology Review*, 19, 309-326.

Ritterfeld, U., Cody, M., and Vorderer, P. (2009) *Serious Games: Mechanisms and Effects*. Routledge, Sept 20, 2009.

NGSS Lead States (2013). Next Generation Science Standards: For States, By States (3-5-ETS1-3 Engineering Design). Retrieved from http://www.nextgenscience.org/pe/3-5-ets1-3-engineering-design June 29, 2018.

Sauvé, L., Renaud, L., Kaufman, D., & Marquis, J. S. (2007). Distinguishing between games and simulations: A systematic review. Educational Technology & Society, 10 (3), 247-256.

Sugar, W. and Betrus, A. (2002). The Many Hats of an Instructional Designer: The Development of an Instructional Card Game. Educational Technology. January /February.

University of Washington Institute for Science (2014). Failing Forward: Managing Student Frustration During Engineering Design Projects. Retrieved from http://stemteachingtools.org/brief/36 June 29, 2018.

USC Annenberg (2007) Redistricting can be fun and games. June 11, 2007. Updated Nov 18, 2016. Retrieved September 8, 2018 from https://annenberg.usc.edu/news/around-usc-annenberg/redistricting-can-be-fun-and-games

Spoon, M. (2018) Video Games Can Teach Empathy. *Neuroscience News & Research*. Retrieved September 8, 2018 from https://www.technologynetworks.com/neuroscience/news/video-games-can-teach-empathy-307396

"Video Game Development,"(n.d.) accessed June 29, 2018, https://en.wikipedia.org/wiki/Video_game_development

Virtual University (n.d.) Retrieved September 8, 2018 from https://en.wikipedia.org/wiki/Virtual_university