Designing Games for Learning: What Instructional Designers Need to Know

Richard N. Van Eck

University of North Dakota

Valerie J. Shute

Florida State University

Lloyd Rieber

University of Georgia

Abstract

The design of games for learning has become more common, and more research and guidance exist now than when we first wrote this chapter. Changes in videogame design and technology continue to require adaptation of instructional design practices, yet established theory and practice remain relevant to the design of games. Instructional designers who intend to pursue game design as a professional path need to appreciate the unique aspects of videogame modalities, understand the guiding theoretical and design principles that remain relevant to game design, and know how to adapt existing practice to the unique aspects of this modality as they collaborate with multiple professions.

Introduction

We believe that games can be very effective learning tools. We believe this to be true for the same reason we believe that any mode of instruction, when designed using instructional design principles and processes, is effective. Our belief is backed up by research, as well. Meta-analyses of games have found, among other things, that game-based instruction can result in a 0.33 standard deviation improvement in learning when compared to non-game-based instruction in general and (more importantly) that theoretically augmented (i.e., well-designed) games account for a 0.37 standard deviation increase in learning when compared to nonaugmented games (Clark, Tanner-Smith, & Killingsworth, 2014).

This is but one of the numerous studies that purport to answer whether games are or are not effective for learning. In our opinion, however, that is not the central question. It is far more important to ask *when*, *where*, and *for whom* are they effective, and by what mechanisms they promote learning. Fortunately, many researchers have embraced this philosophy, and we now know much more than we did in 2015, when we last wrote about games in this volume.

The reader is (or will soon be!) competent to search the now extensive literature on games and learning. Doing so is an essential step on the journey to becoming competent as an instructional designer who wants to build games for learning. Our goal in this chapter is to address what we see as a significant gap in the literature regarding the design process for building such games: What are the core theories that can guide the game design process, what are the critical features of videogames for learning, who are the members of the design team, and what does an instructional designer need to be able to do to prepare to be a member of such a team?

As an instructional designer, you are skilled at analyzing a given modality for its ability to support desired strategies and outcomes. Just as we know that textbooks, video, or lecture-based instruction are not appropriate for every learning problem nor every learner, in all venues, nor at all times, neither are games. Games are effective when they align with the instructional outcomes and strategies within the constraints and affordances of the medium, the given environment, and the set of learners.

However, videogames are not like other modalities, and instructional designers often struggle to recognize the multiple ways in which they differ and to modify their design processes accordingly. First, videogames require interactivity to an extent and in a way that other modalities do not. To be sure, all instructional design processes require us to elicit learner performance and provide feedback *at key points* in the instruction. However, interactivity is a near-continuous feature of the videogame experience: the *sine qua non* of videogames. Designing educational videogames therefore requires a comprehensive understanding of how this interactivity modifies instructional design practices. Second, videogames have a specific language and toolset with which instructional designers must be well versed, and which places constraints on the design process. Understanding level design, skill trees, challenge levels, character classes and attributes, distributed point systems, and power-ups, for example, is essential to the design process. Third, videogames are not one medium, but many. Massively multiplayer online role-playing games (MMORPGs), single-player first-person shooters, and cooperative action games may share core features, but they can also differ radically. Understanding these differences is crucial when designing different games for different audiences. Fourth, games require a continual balancing act between learning outcomes (and their associated design practices) and play itself. Instructional design places learning at the center of the design process—strategies, media, and content are designed around the core learning outcomes and objectives. This creates an outcome-centric view of design that often leads instructional designers to “suck the fun” out of games (Prensky, 2004). With educational games, play and learning must be co-equal design considerations. Fifth, and finally, games require diverse design teams comprising graphic artists, voice-over artists, sound designers, videographers, animators, programmers, and measurement experts. Instructional designers typically do not understand the practices, vocabulary, or culture of these design teams, nor do the other team members understand instructional design. In our experience, learning to negotiate this landscape represents one of the most difficult challenges for the design of educational games.

It is not possible to address all of these ideas comprehensively here, of course, and we have written about these elsewhere (Hirumi, Van Eck, Appleman, & Rieber, 2010a; 2010b; 2010c). Instead, we hope that by sharing our own perspectives on game design, we can help you arrive at competency faster than we did by learning it all the hard way!

Part 1: Understanding Play

The question of what makes a game fun to play is very similar to the question of what makes a joke funny. In one episode of the classic television show, *Star Trek: The Next Generation*, Commander Data decided to confront the question "What makes something funny?" As an android, this question was very perplexing to him, and he set about answering it as an analytical engineer might: by breaking the construct "funny" into all of the conceivable rules. Data erroneously tried to come up with a grand "if/then" tree for "funny" (i.e., if I say this, then say that, in this way, etc., *then* it is funny). We can chuckle at Data's misguided attempt, but many people in the instructional design field seem to be following a similar rule-based "engineering" path to try to understand how to design a game that is fun and also leads to learning.

We argue that a game is engaging, or fun to play, if it triggers the play phenomenon in the player. So we must take some time to understand the play phenomenon. Fortunately, much research has been done on play from a multitude of disciplines such as education, psychology, sociology, and anthropology.

Making play a co-equal objective of learning via an educational game requires a paradigm shift for most designers—one that is very learner-centered and constructivist in nature.

To understand this paradigm, you need to understand the difference between merely "playing" a game and being "at play." The former can be mandated by a teacher to students or a trainer to a group of employees, and these participants can dutifully "play the game." However, these individuals may never have been "at play," meaning that they never entered the conceptual cognitive or cultural space in which play occurs (Huizinga, 1950).

Everyone reading this chapter has probably experienced play within the last 24 hours, even though you may resist, as many adults do, using that word to describe it. You may have experienced play while engaged in a hobby such as gardening, woodworking, photography, painting, or some craft. You may have experienced it while caring for a son or daughter and enjoying each other's company. You may have experienced it while reading a book, playing a musical instrument, or playing a videogame. A lucky few have experienced it while writing a chapter in a book!

Regardless of the activity, it probably happened during your leisure time, although if you are fortunate enough to love your job, it may have happened at work. It was definitely something you *wanted* to do, and you would say that you did it voluntarily. You found the activity intrinsically motivating and so you were not concerned about "getting something" out of it. You were also doing something actively and possibly physically. Finally, you were likely in a state where you were not conscious of yourself or of your place in the world but rather felt wholly absorbed in the activity. This state also carried a feeling of being very free from risks. You felt free to try new things or to experiment with different ways of doing or thinking—after all, it was only play. Your awareness of time likely disappeared, and you were probably surprised by how much time had passed when the activity had ended (see Pellegrini, 1995; Rieber, 1996; and Sutton-Smith, 1997, for formal definitions and attributes of play).

Educators and other educational stakeholders (e.g., parents, state legislators) are quick to ask “What good is play? Does it lead to some productive outcome or result?” The seminal work of Jean Piaget remains an important starting point for such questions (Phillips, 1981; Piaget, 1951). Piaget felt that play and imitation were core and innate human strategies for cognitive development. With play, a child could rehearse a newly formed concept to make it fit within what he or she already knew and understood (assimilation). As a child experiences new events, activities, ideas, or rituals, imitation is used to build entirely new mental models (accommodation). The child continues in this way to achieve an orderly, balanced world while constantly confronting a changing, shifting environment. Just as the mental processes of assimilation and accommodation continue throughout life, so too do play and imitation remain important cognitive tools for people from childhood through adulthood.

There are other examples of research literature, while not overtly aligning with play, that are clearly in the same camp. The research on self-regulated learning (Zimmerman, 1990, 2008) is one example, especially with its emphasis on an individual actively working toward goals within intrinsically motivating activities. However, the attributes of flow theory proposed by Csikszentmihalyi (1990) are the most similar to that of play, especially in the context of game design. For example, flow theory specifically addresses the need to optimize challenge, so as to continually avoid anxiety and boredom. Activities that induce flow have clear goals, coupled with clear and consistent feedback about whether a person is reaching these goals. Another important attribute of flow is that it takes effort to attain a state of flow, requiring a clear and deliberate investment of sustained attention.

Part II: Theoretical Frameworks for Educational Game Design

Games have been used for learning since at least the Middle Ages, when chess was used to teach war strategy (Institute of Play, n.d.), and they formed the basis of early childhood education with the founding of the Play and Activity Institute by Friedrich Fröbel in 1837 (Fröbel, n. d.), later to be termed Kindergarten. So, in a sense, we have been using and researching the power of games for learning for centuries. When games made the leap from analog to digital (first, as arcade machines, then computers, consoles, and now mobile devices), research on their efficacy picked up in earnest. Seminal publications like Patricia Greenfield's *Mind and Media* in 1985 (see Chapter 7) and Jim Gee's *What Video Games Have to Teach Us About Learning and Literacy* (2003) promised to usher in an era of research practice founded on sound theory and experimental design. One of the key pitfalls awaiting new scholars in games for learning lies in assuming that "new" videogames can only be explained by "new" theories. All fields continue to evolve and new theories emerge (and are tested) as we build upon prior research, as new learning modalities emerge, and as learners continue to evolve. However, most learning is effective (or not) for reasons that can be explained by the same set of core theories and precepts of instructional design.

Therefore, it behooves the new and experienced scholar to have a core set of theoretical tools at his or her disposal. Principles of behaviorism (e.g., schedules of reinforcement, stimulus-response latency, and association) help us understand how Jeopardy-style games work for factual information. Constructivist principles (e.g., social negotiation of meaning) help us understand how people make meaning of their experiences in open worlds and MMORPGs. Sociocultural learning theory helps explain how culture mediates and situates knowledge, and of course, many other things like motivation, locus of control, and self-efficacy help predict how people will experience and persevere (or not) in game worlds. The learning theories that we choose to apply and combine in our design and analysis of games depends on our outcomes, learners, and constraints.

A report by the Joan Ganz Cooney Center at the Sesame Workshop (Takeuchi & Vaala, 2014) that surveyed 694 teachers from across the United States found that nearly 75% of K–8 teachers reported using digital games in their classrooms and that more than 40% of them were doing so to meet local, state, and national standards. Yet, the vast majority of K–8 teachers are using what have sometimes been described as "drill and kill" games that focus on lower-level taxonomic outcomes (verbal information and concepts, in Gagné's taxonomy [Gagné, Wager, Golas, & Keller, 2004], and knowledge and application in Bloom's taxonomy [1984]) that can be accomplished in a single classroom session. We would argue that there are many instructional strategies and modalities that can address lower levels of learning as, or perhaps more, effectively than games and at much lower cost. The true advantage of games as a medium is their potential to address higher levels of learning (e.g., rules and problem solving, or synthesis and evaluation) along with other outcomes that are traditionally difficult to address (e.g., attitudes and metacognitive skills).

The design of games that promote these kinds of outcomes can be driven by many theories, but there are three that we think are critical. The first is situated cognition (e.g., Brown, Collins, & Duguid, 1989; Lave, 1988), which argues that to "know" something is to "do" something, and that "doing" is inextricably bound to the contexts in which that knowledge is relevant and demonstrated. Instructional designers, by extension, should consider designing learning *environments* that embed the intended learning outcomes. The classic example often cited is of children in Brazil who were taught mathematics in a decontextualized manner in school (e.g., lesson and workbooks full of formulas and operations) but actually learned (and demonstrated) mathematics through selling goods on the streets (Carraher, Carraher, & Schliemann, 1985). School exams could not measure this knowledge because the assessment was not embedded in the learning context.

Videogames are a clear example of situated cognition; the intended learning takes place and is assessed in the context of the game. By embedding "knowing" in "doing," situated cognition approaches may also promote transfer of learning. We often hear educators, parents, and politicians lament that students cannot solve "real world" problems, even when they have "demonstrated" the knowledge on (decontextualized) school exams. There is evidence that games designed around these principles can indeed promote transfer of learning (Van Eck & Dempsey, 2002).

One of the key concepts to designing situated cognition learning is authenticity, which refers to the extent to which actions *taken* within that designed environment reflect the actions and processes that would normally occur when *demonstrating* that knowledge in that environment. It also means that the environment *behaves* authentically, in that actions taken by the learner result in the kinds of responses by the environment (and the people, tools, and resources within it) that would happen in that environment. As you will see in Part III, this is also a key concept for assessment of learning in games. This is not to say that the game must be a fully realized simulation of the real world, of course. There are many aspects of the environment that do not apply to a given learning situation (e.g., one need not experience a virtual world with gravity in order to learn how to react to angry customers in customer service training), and research on simulations has suggested that irrelevant details (seductive details) actually interfere with learning (e.g., Harp &

Mayer, 1997). Even *relevant* information may be problematic if the learner's level of expertise is insufficient (e.g., Adcock, Watson, Morrison, & Belfore, 2010).

While "real world" and "authentic" may sound like synonyms, there are important distinctions between them. Asking a student to solve a word problem about dividing up a *Pokemon* card collection is not a real-world example; it is a problem *about* a real-world problem. Putting kids in groups with actual *Pokemon* cards and telling them to work out a fair way to divide them so each person has the same value is *almost* a real-world problem—about as close as we can get in school settings. Having those students solve the problem by filling in worksheets or matrices based on provided values is not an *authentic* way of solving the problem; having them decide on the process to use, determine what a fair arbiter of true value is, and build their own value charts *is* as authentic as we can get in the formal educational environments. Research has shown that instruction built on these principles is effective in promoting initial and long-term learning as well as increasing the likelihood of transfer of learning to new contexts.

The third theoretical area of relevance to the design of games is the research on problem solving itself. As an instructional outcome, problem solving refers to the ability to synthesize multiple rules and defined concepts and apply them to problems that do not have a known solution. It is generally believed that the only way to promote problem solving is, therefore, to present the learner with multiple problems to solve within a given domain. This is often done in the context of instructional strategies that scaffold problem solving, sometimes called problem-centered or problem-based learning. Thus, problem solving may be thought of as both a strategy and an outcome, yet problems are always at the heart of the instruction.

Problem solving is an oft-cited benefit of videogames but one that is routinely oversimplified. For example, it is important to recognize that there are many different kinds of problems that vary in their cognitive composition, degree of structuredness, and required domain knowledge. Jonassen (2000) has proposed a typology of 11 different types of problems, each of which requires specific design and instructional strategies to promote. It follows that if we must teach (and if learners must bring specific prerequisite knowledge to) each problem in a specific manner in face-to-face instruction, then we must also differentiate and do so for the problems we hope to embed in games designed to promote specific problem-solving skills. This is hardly a full treatment of any of these areas, of course, but good resources are widely available for those who want to study them further. It is also not necessary to make use of every theory when designing games—as with all instructional design, our strategies rely on our learners, environment, content, and context. There are many different ways to blend these different approaches. One way to do so is a framework called situated, authentic problem solving (Van Eck, 2015), but there are other models that have been used with success as well (e.g., Barret & Johnson, 2010; Borchert, et al., 2010).

We mentioned in the beginning that one of the biggest challenges facing instructional designers on game design teams is the delicate and complicated dance of designing for learning AND for fun. In Part IV, we will provide some advice for overcoming the related challenges of language, culture, and interactivity in the world of educational game design. But first, we focus on one of the biggest challenges facing designers of games: one that took decades to resolve effectively and which left a trail littered with games that failed to teach, engage, or both.[1] Assuming we are able to modify our design practices to balance game interactivity and fun while remaining true to the intended learning outcomes, how must our assessment design practices also be modified?

[1] The reader is referred to the literature on "edutainment" games in the 1980s and the discussions of intrinsic and extrinsic motivation, game mechanics, and ludology of the 1990s and early 2000s.

Part III: Stealth Assessment and Evidence-Centered Design in Games

Assessing learning processes and outcomes in a game occurs via analyzing in-game performances and providing timely and relevant feedback. This requires us to know what a person is doing within the game at any time. We cannot just let students play a learning game and then give them a test—we have to know how knowledge and skills are developed and demonstrated throughout the instruction (game) itself. This need has been met by an assessment design framework called evidence-centered design (ECD; see Mislevy, Steinberg, & Almond, 2003), which we argue is critical for instructional designers who want to work with games.

In games, as players interact with the environment, the values of different game-specific variables change. For instance, getting injured in a battle reduces health and finding a treasure or other object increases one's inventory of goods. In addition, solving major problems in games permits players to gain rank or "level up." One could argue that these are all "assessments" in games—of health, personal goods, and rank. But now consider monitoring educationally relevant variables at different levels of granularity in games. In addition to checking health status, players could check their creativity, problem solving, and teamwork skills, where each of these competencies is further broken down into constituent knowledge and skill elements. If the values of those skills were to get too low, the player would likely feel compelled to take action to boost them.

One main challenge for educators who want to employ or design games to support learning is making *valid inferences* about what the student knows, believes, and can do—at any point in time, at various levels, and without disrupting the flow of the game (and hence engagement and learning). One way to increase the quality and utility of an assessment is to use ECD which informs the design of valid assessments and yields real-time estimates of students' competency levels across a range of knowledge and skills (Mislevy, Steinberg, & Almond, 2003). Accurate information about the student can be used as the basis for a) delivering timely and targeted formative feedback, as well as b) presenting a new task or quest that is right at the cusp of the student's skill level, in line with flow theory and Vygotsky's zone of proximal development (1978, 1987). ECD will be described in more detail shortly.

To use educational games that support learning in school settings (and elsewhere), we need to ensure that the assessments are valid, reliable, and also pretty much invisible (to keep engagement intact). That's where "stealth assessment" comes in (see Shute & Ventura, 2013). During gameplay, students naturally produce rich sequences of actions while performing complex tasks, drawing on the very competencies that we want to assess (e.g., persistence, spatial skills, understanding the laws of force and motion). Evidence needed to assess the competencies is thus provided by the players' interactions with the game itself (i.e., the *processes* of play), which lies in stark contrast to the norms in educational and training environments, where the product of an activity (e.g., score on a test) is the main focus.

Making use of this stream of evidence to assess students' knowledge and skills (as well as beliefs, feelings, and other learner states and traits) presents problems for traditional measurement models used in assessment. First, in traditional tests, the answer to each question is seen as an independent data point. In contrast, the individual actions within a sequence of interactions in a game are often highly dependent on one another. Second, in traditional tests, questions are often designed to get at one particular piece of knowledge or skill. Answering the question correctly is evidence that one may know a certain fact: one question—one fact. By analyzing a *sequence* of individual actions within a quest (where each response or action provides incremental evidence about the current mastery of a specific fact, concept, or skill), we are able to make valid inferences about what learners know and can do. Now, because we typically want to assess a whole cluster of skills from evidence coming from learners' interactions within a game, methods for analyzing the sequence of behaviors to infer these abilities are not as obvious. As suggested earlier, ECD can address these problems.

The fundamental ideas underlying ECD came from Messick (1994) and were then formalized by Mislevy and colleagues (e.g., Almond et al., 2015; Mislevy & Haertel, 2006; Mislevy et al., 2003). Basically, the ECD framework requires an assessor to: a) define the claims to be made about learners' competencies (competency model), b) establish what constitutes valid evidence of a claim and how to measure that evidence (evidence model), and c) determine the nature and form of tasks or situations that will elicit that evidence (task model). In games with stealth assessment using models created via ECD, the competency model for a given student dynamically accumulates and represents belief about the targeted aspects of skill, expressed as probability distributions for competency-model variables. Evidence models identify what the student says or does that can provide evidence about those skills and express in a psychometric model how the evidence depends on the competency-model variables. Task models express situations that can evoke required evidence. Two different examples of stealth assessment in games include measuring creativity in a physics game (see Shute & Rahimi, 2021) and measuring problem-solving skills in a commercial game (see Shute, et al., 2016). Moreover, current findings suggest that stealth assessment a) is a theoretically grounded and psychometrically sound method to assess, support, and investigate learning in technology-rich environments (see Rahimi & Shute, 2023), and b) significantly improves learning (and not at the expense of enjoyment) regardless of gender or ethnicity (see Shute et al., 2020).

One effective tool that has been used in such competency and evidence modeling efforts is Bayesian networks (e.g., Pearl, 1988). That is, Bayes nets may be used within learner models (i.e., competency models tied to a particular learner) to handle uncertainty by using probabilistic inference to update and improve belief values (e.g., regarding current competency levels). For more details on the what-how-why of using Bayes nets to accumulate evidence in digital environments to make inferences about evolving competency levels, see Almond et al., 2015.

In a nutshell, the "what" of stealth assessment is that it is an approach that embeds ongoing, formative assessments (built with ECD models) deeply into the digital learning environment (like well-designed games), blurring the distinction between learning and assessment. Interacting with an immersive game or learning environment, students continually produce rich sequences of actions as data points which are captured in log files. The captured data are automatically scored by in-game rubrics, then aggregated in real-time by Bayesian networks (or other statistical models), which show evolving mastery levels on targeted competencies. Shute, Lu, and Rahimi (2021) provide more information about the specific steps needed to develop a stealth assessment. The "how" of stealth assessment is that it uses ECD to craft models (e.g., competency and evidence models) and uses automated scoring and evidence accumulation techniques (e.g., Bayesian networks) to assist in making valid inferences of current competency states, all quietly working inside of a game. This is coupled with automated data collection and analysis tools which not only collect valid evidence of students' competency states but also reduce teachers' workloads in relation to managing the students' work (or "play") products. If a particular game were easy to employ and provided integrated and automated assessment tools, then teachers would more likely want to utilize the game to support student learning across a range of educationally valuable skills. Stealth assessment is intended to help teachers facilitate learning, in a fun and engaging manner, of educationally valuable skills not currently supported in school.

Part IV: Case Studies in Game Design

A few examples from our own experience may help to illustrate how all of the challenges and design processes we have discussed play out in real-world design of educational games. In a game called *Rusty vs. Radon* (2018), the goal was to address radon (a carcinogenic, colorless, odorless gas found in many homes) education, specifically the need for and process by which homeowners to test and remediate. We hypothesized that a game in which middle school students learn about radon, paired with free radon test kits, would result in change agency efforts by the children to get their parents to test for radon in the home (something that is rarely done). We generated radon education objectives and selected those best suited to game play, reserving the rest for more formal education. In the game, students play Rusty, a junkyard robot who performs home inspections with his companion Ozzy, a cute cartoon worm. Ozzy can perform instant inspections of plumbing and wiring in homes from the inside, but he is 1000 times more sensitive to Radon than humans are, so any exposure to Radon levels can make him sick or kill him. Therefore, Rusty has to do the radon testing *first* to determine whether it is safe for Ozzy to enter the home to complete the inspection. The manner in which he does so must reflect the best practices associated with radon testing and thus the learning principles that underly that process.

Subject matter experts wanted to develop traditional pretest–posttest multiple choice assessment to measure whether players learned about radon. Instead, the instructional designer suggested a simplified evidence-centered design approach by which the gameplay and sequence of choices made by the player would serve as evidence of learning. One of the key learning outcomes for radon as it relates to radon testing is that radon is heavier than air. This means that it is not possible to have high radon on the first floor of a home but not in the basement, that the first place to test for radon is in the basement, and that low radon in the basement means it is not necessary to test for radon on the first floor. Another learning outcome of radon as it relates to radon testing is that radon can pool or accumulate in the basement and expand up to the first floor of a home. Therefore, the presence of high levels of radon in the basement requires testing on the first floor. A third principle of radon as it relates to radon testing is that radon levels can vary widely and unpredictably in a very small area. This means that one home (or several in a neighborhood) can have low radon levels and a house next door (or one home in an entire neighborhood) can have high levels. To assess all of these learning outcomes in an evidence-centered manner, we first designed a nine-house neighborhood of homes arranged in a grid, each with a basement and a first floor. We then assigned radon levels to each floor of each house, resulting in homes with low radon on both floors, high radon on both floors, and high radon in the basement only. We then arranged these houses in a pattern where houses with high radon were next to each other, houses with low radon were next to each other, and houses with high radon were adjacent to at least one house with low radon.

We determined that there were five possible behavioral sequences for each home, each of which would demonstrate understanding (or lack thereof) of radon principles. Table 1 presents these sequences for a home with high radon in the basement but not on the first floor. Sequence 5 indicates the highest potential failure because no floors were tested at all, and Oz may be invited to both floors. Sequence 3 indicates the most potential learning because the player tested the basement first and, when found to be high, tested the first floor before (potentially) inviting Oz to the first floor but not to the basement. Regarding the last principle (variance of radon levels from house to house), we determined that players might choose to skip a house that was adjacent to one or more that they had tested and found to be low or they might not invite Oz into a house that was adjacent to one or more houses that they had tested and found to be high. In order to uncover this misconception, we provided a bonus score for those who completed their testing of the neighborhood quickly (the bonus was negated by inviting Oz into untested homes, regardless of radon levels in that home).

Table 1. Evidence-centered design table for scoring radon testing actions for a home with high radon in the basement and low radon on the first floor.

	Floor Tested 1st	**Floor Tested 2nd**	**Thinking Bonus**	**Floor(s) Not Tested**	**Oz invited to Basement (B)?**	**Oz Invited to 1st Floor?**
Seq. 1	1	B	-1	–	Yes (-5) No (+5)	Yes (-5) No (+5)
Seq. 2	1	–	-3	B	Yes (-5) No (0)	Yes (-5) No (+5)
Seq. 3	B	1	+10	–	Yes (-5) No (+5)	Yes (-5) No (+5)
Seq. 4	B	–	-5	1	Yes (-5) No (+5)	Yes (-5) No (-5)
Seq. 5	–	–	-7	B 1	Yes (-10) No (0)	Yes (-10) No (-10)

A second example of the challenges of serving as an instructional designer on an educational game design team comes from a game called *GeriPop* (2023), a game for Geriatric Population Health that is currently being developed. The instructional designer for this game worked with the subject matter experts (SMEs) and principal investigator to build a interactive design prototype using in *Microsoft Excel* whereby the selection of geriatric care principles to a patient population would result in changes in overall health, longevity, and cost. The game design team members were then invited to begin the UI (user interface) and UX (user experience) phases of game design. As the UI/UX design iterations unfolded, the desire to make the game fun continually ran up against the need to achieve (and measure) learning outcomes. The instructional designer correctly pushed back on these design choices, but incorrectly did so by insisting that the mechanics stay true to the original prototype (which was well aligned with the learning objectives). Eventually, the instructional designer came to realize that he was overly focused on the initial mechanics as the "only" way to achieve the outcomes. Once he realized that doing so was working against the necessary evolution needed to make the game fun and engaging, he gave up "ownership" of the initial game mechanics and instead focused solely on the instructional outcomes. From that point on, every time a new game design feature was proposed, the instructional designer would consider whether doing so would still achieve the learning outcomes and, when the answer was unclear, asked the team to resolve the issue in a way that respected both learning outcomes and "fun."

Summary and Conclusion

Our goal for this chapter was to connect the dots between games and learning and to help you identify the tools and challenges you will need to be part of an educational game design team. We hope we have helped point the way forward for you if games are a part of your intended professional path. If you are not yourself a game player, we also highly recommend that you begin playing games to become conversant in the language, culture, and features of commercial videogames. We recommend the AAA console and PC games as a great place to start. You can begin with the older precursor games to today's modern blockbusters like *Halo, Gears of War, Call of Duty*, the Tom Clancy series, and *Left for Dead*. Play games both as a single player as well as cooperatively to understand how different the experiences can be. Explore games like

World of Warcraft to get a sense of MMORPGs. From there, we recommend moving forward in time to modern day games to see how the technology and game features continue to evolve. Games like those in the *Divinity*, *Sacred*, and *Elder Scrolls* series are good intermediary games to play before moving on to modern classics such as *Elden Ring* and the Dark Souls series of games.[2] You will need a lot of help, so find experienced players who are willing to help guide you through the process. Take advantage of all of the "cheats" and "walkthroughs" and online help you can find. In doing so, you will learn a lot about the social culture, the nature of help (just-in-time, just-for-me, just enough) and support in games. Pay close attention to the game mechanics and features of each game you play, with particular attention to skill trees, which allow you to "invest" game points as you progress to unlock additional powers and build a character with specialized powers that reflect your personal style of game play. Learn how games allow players to set difficulty levels and how games become progressively more challenging as expertise increases. Understand the dynamics of character classes (e.g., magician, barbarian, archer), attributes (e.g., wisdom, intelligence, strength, dexterity), and equipment (e.g., armor, weapons) as well as how the choices you make as a player result in wildly divergent approaches to game play. Finally, learn how economies (e.g., gold, merchants) and reward systems influence behavior and play style during games. All of these features have analogs in educational game design if carefully and creatively considered!

Well-designed games are a potentially powerful vehicle to support learning, particularly in relation to new competencies not currently embraced by our educational system but needed to succeed in the 21st century. Making effective use of games requires us to understand the nature

[2] There are, of course, many other excellent games along a wide continuum of styles. Our purpose here is not to be exclusive, but to highlight some of the most popular games that make use of commonly accepted features and approaches. We also encourage the reader to explore the vast diversity of games to understand other play styles.

of play and interactivity, the primary theoretical models that are compatible with videogames, the nature of game play from the player perspective, and the implications for changed design and assessment practices in games. Mastering this knowledge means we are better prepared to navigate the challenges of collaborating with others in the design of good educational games that are both fun to play AND effective learning modalities.

Summary of Key Principles and Practices

1. Good games trigger the play phenomenon in the players.
2. Videogames make extensive use of interactivity which requires instructional designers to have both a personal and professional understanding of videogames.
3. The design of games requires instructional designers to work with multi-disciplinary teams with different values, vocabularies, culture, goals, and design practices.
4. Despite the continual evolution of game technology, core theoretical frameworks remain critical to the design of learning games.
5. There are many kinds of games, each with their own features and characteristics which must be aligned with principles of instructional design in order to take best advantage of the modality.
6. Assessment of learning in games requires a fundamental shift in our thinking about assessment, from responses to external "test questions" to embedded actions and patterns within games.
7. Good games for learning can use the information from ongoing stealth assessments to provide timely and targeted feedback to players and present new game tasks that suit the student's current skill level.
8. Good games for learning, like all good learning activities, should be active, goal-oriented (with goals valued by the players), contextualized, and designed with adaptive challenge and support.

Gaming and Learning: Application Questions

1. Design a non-digital game with everyday objects found in your home or classroom (e.g., paper cups, paper clips, ping pong balls, etc.). Ask friends to play it, then ask them if they think the game is any fun. Ask them for ideas to improve the game. Using any of their ideas, and others you thought of, redesign the game and ask another group of friends to play this new version. Is the game more fun? Try to list or chart out the design process you experienced. Does the game have any value for learning? If not, what is missing?
2. Choose a learning theory that you feel is compatible with games. What kind of videogame do you think it would be most compatible with? Why? What are the design implications of adopting that theory for a given game? Name one example of a specific design element in a game that is compatible with your theory.
3. Identify an instructional outcome at the level of problem solving and try to come up with a narrative description of a game that could promote that outcome. How would you make it situated? Authentic? Where would it take place, who would be involved, and what would it look and feel like?
4. Using the game idea from number three, above, or for another game idea/outcome of your choice, describe an approach to stealth assessment that could be built into that game. Be specific in addressing how it aligns with your learning outcome, how you would measure it, how you could integrate it surreptitiously, and how it could be used for assessment, to modify game performance in some way, or both.

5. If you have not played any/many AAA console games, find a friend or family member who does and ask them to help you get started with a game. Keep a diary of your experiences, describing things like:
   - What is the player experience like?
   - Do you find yourself frustrated while you are learning?
   - How do the features of the game help drive engagement?
   - Which do you see aligning with established instructional design principles and practices?
   - What are the implications for how you approach the design process (i.e., what has to change in your current practice in order to be successful)?

References

Adcock, A. B., Watson, G. S., Morrison, G. R., & Belfore, L. A. (2010). Effective knowledge development in game-based learning environments: Considering research in cognitive processes and simulation design. In R. Van Eck (Ed.), *Gaming and Cognition: Theories and Perspectives From the Learning Sciences*, 152–168. Hershey, PA: IGI Global.

Almond, R. G., Mislevy, R. J., Steinberg, L. S., Yan, D., & Williamson, D. M. (2015). *Bayesian Networks in Educational Assessment.* NY: Springer. http://doi.org/10.1007/978-0-387-98138-3.

Barrett, K. A., & Johnson, W. L. (2010). Developing serious games for learning language-in-culture. In R. Van Eck (Ed.) *Interdisciplinary Models and Tools for Serious Games: Emerging Concepts and Future Directions*, 281–311. Hershey, PA: IGI Global.

Bloom, B. S. (1984). *Taxonomy of Educational Objectives Book 1: Cognitive Domain*. White Plains, NY: Longman.

Borchert, O., Brandt, L., Hokanson, G., Slator, B. M., Vender, B., & Gutierrez, E. J. (2010). Principles and signatures in serious games for science education. In R. Van Eck (Ed.) *Interdisciplinary Models and Tools for Serious Games: Emerging Concepts and Future Directions*, 312–338. Hershey, PA: IGI Global.

Brown, J. S., Collins, A., & Duguid, P. (1989). Situated cognition and the culture of learning. *Educational Researcher*, *18*, 32–42.

Carraher, T. N., Carraher, D. W., & Schliemann, A. D. (1985). Mathematics in the streets and in the schools. *British Journal of Developmental Psychology*, 3, 21–29.

Clark, D. B., Tanner-Smith, E. E., & Killingsworth S. (2014). Digital games, design, and learning: A systematic review and meta-analysis. Menlo Park, CA: SRI International.

Csikszentmihalyi, M. (1990). *Flow: The psychology of optimal experience*. New York: Harper & Row.

Fröbel, F. (n.d.). In *Wikipedia*. Retrieved May 10, 2015, from http://en.wikipedia.org/wiki/Friedrich_Fröbel.

Gagné, R. M., Wager, W. W., Golas, K. C., & Keller, J. M. (2004). *Principles of Instructional Design* (5th ed.). Belmont, CA: Wadsworth/Thomson Learning.

Gee, J. P. (2003). *What video games have to teach us about learning and literacy*. New York: Palgrave Macmillan.

Geri-Pop (2023). [videogame]. Geriatrics education on the 4Ms. New York: Triad Interactive, Electric Funstuff.

Greenfield, P. M. (1985). Mind and media: The effects of television, video games, and computers. Cambridge, MA: Harvard University.

Harp, S. F., & Mayer, R. E. (1997). The role of interest in learning from scientific text and illustrations: On the distinction between emotional interest and cognitive interest. *Journal of Educational Psychology, 89*, 92–102

Hirumi, A., Van Eck, R., Appelman, R., & Rieber, L. (2010a). Preparing instructional designers for game-based learning, part 1: Game design as an instructional design process. *Tech Trends*, *54*(3), 27–37.

Hirumi, A., Appelman, R., Rieber, L., & Van Eck, R. (2010b). Preparing instructional designers for game-based learning, part 2: Game design as an instructional design process. *Tech Trends*, *54*(4), 19–27.

Hirumi, A., Rieber, L., Appelman, R., & Van Eck, R. (2010c). Preparing instructional designers for game-based learning, Part 3: Game design as a collaborative process. *Tech Trends, 54*(5), 38–45.

Huizinga, J. (1950). *Homo Ludens: A study of the play element in culture*. Boston, MA: Beacon Press.

Institute of Play (n.d.). History of games and learning. Retrieved May 21, 2015, from http://www.instituteofplay.org/about/context/history-of-games-learning/

Jonassen, D. H. (2000). Toward a design theory of problem solving. *ETR&D, 48*(4), 63–85.

Lave, J. (1988). *Cognition in practice: Mind, mathematics, and culture in everyday life*. New York: Cambridge University Press.

Messick, S. (1994). The interplay of evidence and consequences in the validation of performance assessments. *Education Researcher, 32*(2), 13–23.

Mislevy, R. J., & Haertel, G. D. (2006). Implications of evidence-centered design for educational testing. *Educational Measurement: Issues and Practice, 25*(4), 6–20.

Mislevy, R. J., Steinberg, L. S., & Almond, R. G. (2003). On the structure of educational assessment. *Measurement: Interdisciplinary Research and Perspective, 1*(1) 3–62.

Pearl, J. (1988). *Probabalistic reasoning in intelligent systems: Networks of plausible inference*. San Francisco: Morgan Kaufman.

Pellegrini, A. D. (Ed.). (1995). *The future of play theory: A multidisciplinary inquiry into the contributions of Brian Sutton-Smith*. Albany, NY: State University of New York Press.

Phillips, J. L. (1981). *Piaget's theory: A primer*. San Francisco, CA: W.H. Freeman.

Piaget, J. (1951). *Play, dreams, and imitation in childhood*. New York: W.W. Norton & Company.

Prensky, M. (2004). Keynote presentation for the Department of Education Secretary's NCLB eLearning Summit, July 13, 2004, Orlando FL.

Rahimi, S., & Shute, V. J. (2023). Stealth assessment: A theoretically grounded and psychometrically sound method to assess, support, and investigate learning in technology-rich environments. *Educational Technology Research and Development*, 1-25. doi:https://doi.org/10.1007/s11423-023-10232-1

Rieber, L. P. (1996). Seriously considering play: Designing interactive learning environments based on the blending of microworlds, simulations, and games. *Educational Technology Research & Development*, *44*(2), 43–58.

Rusty vs. Radon (2018). [videogame]. Radon awareness population health game for middle school students. Raleigh, NC: Triad Interactive.

Shute, V. J., & Rahimi, S. (2021). Stealth assessment of creativity in a physics video game. *Computers in Human Behavior*, *116*, 1–13. https://doi.org/10.1016/j.chb.2020.106647.

Shute, V. J., & Ventura, M. (2013). *Measuring and supporting learning in games: Stealth assessment*. Cambridge, MA: The MIT Press.

Shute, V. J., Lu, X., & Rahimi, S. (2021). Stealth assessment. In J. M. Spector (Ed.), *The Routledge Encyclopedia of Education* (pp. 1–9). London, UK: Taylor & Francis Group.

Shute, V. J., Wang, L., Greiff, S., Zhao, W., & Moore, G. R. (2016). Measuring problem solving skills via stealth assessment in an engaging video game. *Computers in Human Behavior, 63*, 106–117.

Shute, V. J., Rahimi S., Smith, G., Ke, F., Almond, R., Dai, C-P, Kamikabeya, R., Liu, Z., Yang, X., & Sun, C. (2020). Maximizing learning without sacrificing the fun: Stealth assessment, adaptivity, and learning supports in Physics Playground. Journal of Computer-Assisted Learning, 37, 127–141. doi:10.1111/jcal.12473

Sutton-Smith, B. (1997). *The ambiguity of play.* Cambridge, MA: Harvard University Press.

Takeuchi, L. M., & Vaala, S. (2014). Level up learning: A national survey on teaching with digital games. New York: The Joan Ganz Cooney Center at Sesame Workshop. Retrieved from www.joanganzcooneycenter.org.

Van Eck, R., & Dempsey, J. (2002). The effect of competition and contextualized advisement on the transfer of mathematics skills in a computer–based instructional simulation game. *Educational Technology Research and Development, 50*(3), 23–41.

Van Eck, R. (2015). SAPS and digital games: Improving mathematics transfer and attitudes in schools. In T. Lowrie and R. Jorgensen (Eds.), *Digital games and mathematics learning: Potential, promises and pitfalls*. New York: Springer.

Vygotsky, L. S. (1978). *Mind in society: The development of higher mental processes*. Cambridge, MA: Harvard University Press.

Vygotsky, L. S. (1987). *The collected works of L. S. Vygotsky.* New York: Plenum.

Zimmerman, B. J. (1990). Self-regulated learning and academic achievement: An overview. *Educational Psychologist, 25*(1), 3–17.

Zimmerman, B. J. (2008). Investigating self-regulation and motivation: Historical background, methodological developments, and future prospects. *American Educational Research Journal, 45*(1), 166–183.