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INSTRUCTIONAL-DESIGN THEORIES AND MODELS, VOLUME IV

The Learner-Centered Paradigm of Education

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DESIGNING GAMES FOR LEARNING

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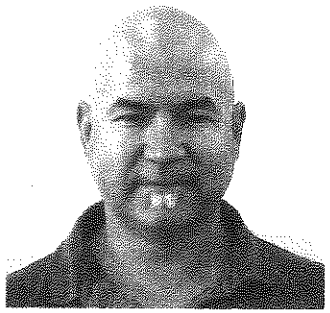

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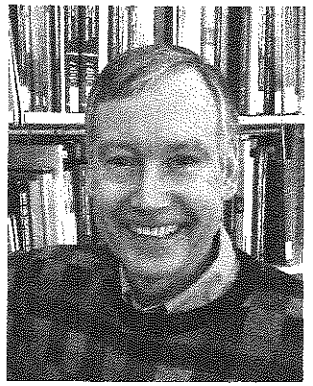

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EDITORS' FOREWORD

Preconditions (when to use the theory)

Content

- *All content.*

Learners

- *All students.*

Learning environments

- *Designed environments that have rich, immersive experiences that simulate to some degree relevant real-world conditions and challenge learners with authentic, situated, and increasingly difficult problems.*

Instructional development constraints

- *Likely significant, depending on design decisions regarding the scope of rich media and the complexity of immersive experiences.*

Values (opinions about what is important)

About ends (learning goals)

- *The development of situated problem solving skills (which games promote by presenting learners with obstacles that require reasoned actions to overcome) is highly valued.*
- *The promotion of transfer to real-world tasks (which games foster through authenticity and learning by doing) is highly valued.*
- *The enhancement of feelings of self-efficacy (which games support by providing a safe environment for risk-taking, by enabling collaboration and social learning, and by providing various forms of scaffolding) is highly valued.*
- *The appreciation of play as a fundamental source of learning experiences is highly valued.*

About priorities (criteria for successful instruction)

- *Effectiveness and appeal are highly valued, but efficiency in terms of the time and expense to develop a game may affect the decision to use this approach.*
- *The ability of games to foster intrinsic motivation is highly valued.*

About means (instructional methods)

- *Aligning the goals of the game with the learning goals is highly valued.*
- *Using authentic settings and tasks that promote learning by doing is highly valued.*
- *Providing interesting challenges that are optimized for the learner's current knowledge and skills to promote immersion and flow is highly valued.*
- *The learner's actions should result in natural consequences and, when appropriate, additional explanatory feedback.*
- *Including scaffolding that adjusts difficulty, provides guidance and support, and offers part-task practice when needed is highly valued.*
- *Requiring cooperative play and authentic roles for players is highly valued when learning goals include team development and collaboration skills.*

About power (to make decisions about the previous three)

- *In a rich, immersive game, the learner may have great latitude in choosing which challenges to undertake as well as when and how.*
- *The learner should have significant control over the frequency of non-diegetic instruction (instruction that is not an inherent part of the game).*

Universal Principles

1. Creating a vision of the game

A holistic, "fuzzy" vision of the game guides design decisions regarding the game space and the instructional space.

- *Learning goals: Specify what the learner will know, be able to do, and feel as a result of undergoing the game-based learning experience.*
- *Authenticity: The dimensions of authenticity should be consistent with whole, real-world tasks, including portrayal of values, attitudes, beliefs, and cultures and provision of situational understandings.*
- *Levels of difficulty: A game should be designed as a series of levels of increasing complexity and difficulty, each of which must be mastered before the next level is "unlocked." Each level is a version of the task and is made up of many individual performances of the task that share the characteristics of that version.*
- *Scaffolding and mastery assessment: A game's instructional overlay encompasses all aspects that are intended to enhance the effectiveness and efficiency of learning.*
- *Feedback: A game has four different kinds of feedback: natural consequences of decisions/actions, explanations, debriefing, and immediate feedback in the form of hints or explanations of causal influences or reasoning.*
- *Motivation: Various aspects of games stimulate intrinsic and extrinsic motivation. Motivation may be enhanced by collaboration with others, authenticity and relevance of the scenario and role, and confidence or expectancy for success.*

2. Designing the game space

- *Goals: The actions and strategies needed to succeed in the game should be aligned with those needed to achieve the desired learning outcomes.*
- *Game mechanics: Conceive or translate the desired learning outcomes into actions (including cognitive actions) that form the basis for playing the game.*
- *Rules: Rules should generate outcomes and feedback consistent with the real world to promote transfer.*
- *Players: Create roles for players to engage with the game either alone or in competition or cooperation with other players and non-player characters.*
- *Environment: Make design decisions regarding the environment based on the learning goals, the appropriate degree of fidelity, and the type or genre of game.*
- *Objects: Create game objects (components of the game system) that embody and enable the game mechanics or are affected by the player's use of the game mechanics.*
- *Information: Provide several types of information that players use to make decisions regarding which actions or choices will lead toward a goal.*
- *Technology: Select equipment (physical objects) required to play the game, likely including a computing device with various forms of input and output, a network, and data storage.*
- *Narrative: Use narrative to provide both a familiar frame for experience and a cognitive frame of reference (schema) to promote recall.*
- *Aesthetics: Make design decisions for all of the other game components in such a way as to create the overall aesthetic experience of the game—the emotional responses and felt experiences that arise in the player(s) through interaction with/in the game system.*

3. Designing the instructional space

- *Adjusting: Adjust aspects of the game to provide an appropriate level of difficulty for the player, thereby placing the player in his or her zone of proximal development.*
- *Coaching: Provide coaching (a form of scaffolding) that provides cognitive and/or emotional support to the player by providing information, tips, or a short demonstration.*
- *Instructing: Instructing should be used just-in-time whenever a significant amount of learning effort is required. This may include a significant amount of information to be memorized, a difficult understanding to be acquired, a difficult skill to be acquired, including appropriate levels of transfer and automatization, or a significant attitude change to be made.*

Situational Principles

Considerations for designing the game space

- *Kinds of game mechanics: Core mechanics are most fundamental in accomplishing the goal(s) of the game and should be introduced early and recur frequently.*

Compound mechanics consist of two or more core mechanics combined by a rule. Peripheral mechanics are optional or non-vital. Decisions about each of these kinds of mechanics will vary depending on situational variables for each game.

- *Parts of the game environment: The game environment consists of structure (discrete or continuous), dimensionality (linear, rectilinear, 2D, or 3D), perspective (the player's view), physics (how objects move), and time (real, compressed, extended, or variable). Decisions on each of these parts will vary depending on situational variables for each game.*
- *Kinds of information: Information about avatars, objects, events, the environment, and the system may be more or less accessible to the player depending on authenticity, level of difficulty, and cognitive load.*

Considerations for designing the instructional space

- *Kinds of adjusting: Difficulty adjustment may involve sequencing cases from easier to more difficult, or dynamically adjusting difficulty based on the learner's current zone of proximal development. Artificial prompts and automated task performance are alternative adjustments that may be used to scaffold the learner toward the desired performance.*
- *Kinds of coaching: Coaching can take the form of providing information, providing a hint or tip, or providing an understanding. It is typically provided when the learner just needs a little help to perform a part of his/her role.*
- *Timing of support: Instructional support may be provided to the player "just in time," or it can be triggered by certain player actions, or the player can request it at any time.*
- *Kinds of learning and appropriate instructional strategies: Different kinds of learning, such as memorization, skills, understanding, and attitudes and values, require different instructional and assessment strategies.*

– C.M.R., B.J.B., & R.D.M.

DESIGNING GAMES FOR LEARNING

I. Introduction

The game-based approach to instruction seeks to promote learning through rich, immersive experiences in designed environments that simulate to some degree relevant real-world conditions and challenge learners with authentic, situated, and increasingly difficult problems. This approach draws on several other instructional-design approaches, including the experiential approach (Lindsey & Berger, 2009), the simulation approach (Gibbons, McConkie, Seo, & Wiley, 2009), and the problem-based approach (Savery, 2009). Designers undertaking a game-based approach should be familiar with the principles and methods of these approaches.

Reasons for Using Games for Learning

Games capitalize on the relationship between action and cognition (learning by doing).* A well-designed game can provide authentic practice in thinking and working in specific roles and contexts. Rather than acquiring knowledge divorced from instrumentality, a player must use acquired knowledge (and continue to acquire new knowledge, often on a just-in-time basis) within the game environment to solve problems in order to overcome obstacles and proceed toward the goal. This generally involves formulating strategies by using inductive and heuristic reasoning, logic, and hypothesis testing. Through the gaming experience, players learn to reflect on their failures and successes because those new insights will be crucial in subsequent attempts as well as in new situations.**

Games promote team development, social learning, and social cohesion. All games provide some sort of competition, whether it is between a single player and the game system or between multiple players or multiple teams. However, games can also be designed to require cooperation among players. Again, the competition may be between a team and the game system or between teams of players. Multiplayer games provide shared experiences that can be collectively examined, discussed, and recalled when relevant to new situations. When players take on roles within cooperative games, they develop and learn to utilize distributed knowledge, that is, they learn to recognize and draw on the resources of their fellow players, which is a critical component of effective teamwork. Cooperative gameplay provides practice in these and other teaming skills and leads to increases in the collective efficacy of the players.***

Games enhance learner engagement and effort. Recent advances in our understanding of the neurology of learning have found that games trigger our brain's dopamine-reward system, generating feelings of pleasure and increasing motivation. The sense of immersion and flow that a player experiences while playing a well-designed game leads to prolonged and focused engagement. When learners devote more time to learning tasks, they naturally learn more (Berliner, 1990). In the game cycle of playing, failing, reflecting, and trying again until success, players gain a sense of control and autonomy. The resultant feeling of self-efficacy is an important influence on persistence and willingness to undertake new learning tasks (Schunk, 1991).

Games provide a safe environment for learning.† Many professions that involve hazardous conditions and/or responsibility for the health and safety

* *Editors' note: As discussed in Chapter 1, active learning is highly valued in the learner-centered paradigm of instruction.*

** *Editors' note: Compare this with the continuous-change framework of planning, performing, and reflecting discussed in Chapter 9 on self-regulated learning.*

*** *Editors' note: See Chapter 1 on the importance of learning from peers through collaboration.*

† *Editors' note: The principles of gamification discussed in Chapter 13 also emphasize the importance of providing a safe environment for learning.*

of others (e.g., military, police, fire fighting, surgery) have turned to games and simulations to provide practice in thinking and acting under pressure in critical situations. While it is necessary eventually to train in real-world settings, games and simulations can scaffold learners toward the required competencies before risking life and limb.

Games are customizable. Games can be designed so that they provide appropriate and variable levels of authenticity, which can be useful in reducing cognitive load for novices so that they can focus on the most critical aspects of a task. At the same time, the level of difficulty can be dynamically tailored to the learner's current knowledge and skills to provide optimal challenge. For a game to adapt appropriately, tasks in the game must be related to learning objectives so that they serve as formative assessment of the learner's progress. Furthermore, if the learner is failing to attain the objectives, the game can provide various types of just-in-time instruction via scaffolding.*

When a game incorporates formative assessment combined into scaffolding, the need for human instructors is greatly reduced, with the potential to greatly lower costs. Furthermore, learners have greater flexibility for when and where they participate in instruction. While developing a complex game for learning can be labor intensive, the overall cost efficiency for instruction can make the endeavor worthwhile if a sufficient number of learners is available.

II. Values

The values considered most important for the design of game-based learning are closely aligned with many of the reasons cited above for using games for learning, and they inform many of the design principles that follow.

Values about ends (learning goals) include:

- The development of situated problem solving skills, which games promote by presenting learners with obstacles that require reasoned actions to overcome.
- The promotion of transfer to real-world tasks, which games foster through authenticity and learning by doing.
- The enhancement of feelings of self-efficacy, which games support by providing a safe environment for risk-taking, by enabling collaboration and social learning, and by providing various forms of scaffolding.
- The appreciation of play as a fundamental source of learning experiences.

In terms of values about priorities, games value effectiveness and appeal over efficiency. Consideration must be given to both a) the time and cost required to develop the instruction (a game can take longer and be more expensive than traditional instruction) and b) the time required to reach mastery (a game with scaffolding can take less time and, given a sufficient number of learners, less expense than traditional instruction).

Values about means (instructional methods) include:

- The goals of the game should be closely aligned with the learning goals.
- The game should involve authentic settings and tasks that promote learning by doing.
- The game should provide interesting challenges that are optimized for the learner's current knowledge and skills to promote immersion and flow.
- The learner's actions should result in natural consequences and, when appropriate, additional explanatory feedback.
- The game should include scaffolding that adjusts difficulty, provides guidance and support, and offers part-task practice when needed.
- When learning goals include team development and collaboration skills, the game should require cooperative play and authentic roles for players.

In terms of values about power, the learner should have significant control over the frequency of non-diegetic instruction (instruction that is not an inherent part of the game).

III. Universal Principles

Universal principles applicable to designing games for learning may be grouped into three categories: those used for creating a vision of the game, those used for designing the game space, and those used for designing the instructional space.

Category 1: Creating a Vision of the Game

Games designed to promote learning are instructional systems with myriad components that interact on the basis of rules. The results of these complex interactions are often unpredictable, and game designers can quickly become mired in fine-tuning components and rules. Therefore, it is useful to begin by creating a holistic, "fuzzy" vision of the game that will guide design decisions regarding the game space and the instructional space. The following six universal principles are intended to assist designers in creating a vision of the game that focuses on helping learners to achieve the desired learning outcomes. The six principles are learning goals, authenticity, levels of difficulty, scaffolding and mastery assessment, feedback, and motivation.

Principle 1.1: Learning goals

Specify what the learner will know, be able to do, and feel as a result of undergoing the game-based learning experience. Because the primary purpose of

* *Editors' note: Customizing instruction and providing instructional support when it is needed are highly valued in the learner-centered paradigm.*

designing the game is to promote learning in an effective and engaging manner, these learning goals should inform other decisions regarding the design of the game.

Principle 1.2: Authenticity

The dimensions of authenticity should be consistent with whole, real-world tasks, including portrayal of values, attitudes, beliefs, and cultures, and provision of situational understandings. This means that the game is usually multiplayer, though non-player characters (NPCs) may be created to play some or all of the other roles. Many of these dimensions are covered in more detail in the discussion of the game space.

Scenario. The scenario is a description of the sequence of actions and settings that form the plot. While a story is not a necessary part of all games, role-playing games generally have some sort of narrative framework within which the player makes decisions and takes action. The scenario should have high authenticity, so as to enhance motivation and transfer of expertise to the real world.

Objects. Objects are the components of the game system that embody and enable the game mechanics (actions governed by rules), including avatars (players' representation in the game space) and NPCs. The objects should also have high authenticity, so as to enhance transfer of expertise to the real world.

Roles. A role defines the possible actions that a particular object may employ to effect change on the game state. An avatar's role usually includes special abilities and functions. Roles may be played by NPCs. However, a multiplayer game in which all real-world team members interact can serve an important team-building function. Each role, whether played by a learner or a NPC, should have high authenticity to enhance motivation and transfer to the real world.

Tools. Tools are objects that the players are able to manipulate to perform their roles. Authenticity of tools enhances both motivation and transfer of skills to the real world.

Actions. Actions are moves that can be made by any of the players or NPCs. They should have high authenticity to enhance transfer.

Causal dynamics (consequences of actions). Causal dynamics are the way the game system responds to the player's actions based on the rules that govern the associated game mechanics. Authenticity enhances the development of mental models and skills that are aligned with the real world.

Setting/contextual factors. The setting is the situation in which the scenario unfolds. It is a set of contextual factors that may or may not influence the objects and tools available and the actions that are possible. The setting, with all its contextual factors, should not only be authentic, but also be varied systematically from one episode of the game to another, to represent the full range of divergence that the player is likely to encounter in the real world (which enhances motivation and transfer).

Representations. Representation is the fidelity with which visual, audio, tactile, and movement elements of the game are portrayed. If cognitive or perceptual overload is likely, then the representations should initially have lower fidelity or authenticity, but should progress to high fidelity by the end of each level of difficulty.

Principle 1.3: Levels of difficulty

A complex task has many versions of the task. Each version can be thought of as a class of performances or cases of the task that are similar in many ways. Some versions of the task are more complex and therefore more difficult than others (Reigeluth, 1999). Instruction that starts with the most complex version of a task usually creates cognitive overload (Sweller, 1994). Therefore, a game should be designed as a series of levels of increasing complexity and difficulty, each of which must be mastered before the next level is "unlocked."* Each level is a version of the task and is made up of many individual performances of the task that share the characteristics of that version.**

Versions should be arranged in a progression of difficulty by using the Simplifying Conditions Method (Reigeluth, 1999) to identify the conditions that distinguish more complex versions from simpler versions. Levels of complexity should be identified (where the versions all build on each other), but dimensions of complexity should also be identified (where they do not build on each other, so any dimension can be done before any other). Different dimensions of complexity offer opportunities for flexibility in sequencing, based on such factors as learner preferences, frequency of encounter in the real world, risk to personnel or assets, and much more.

There is often a lot of variation within a version of the task. In such cases, mastery is required by each learner (role), not just on one performance of the version of the task (the level of difficulty), but on several divergent performances that represent the full range of "dimensions of divergence" for that version of the task. Some dimensions of divergence may be more difficult than others, in which case the performances can be arranged in an easy-to-difficult sequence if cognitive load is a concern. And cognitive load may be further reduced, if necessary, by reducing representational fidelity.

Principle 1.4: Scaffolding and mastery assessment

A game's scaffolding encompasses all aspects that are intended to enhance the effectiveness and efficiency of learning. Support may be provided to the player

* *Editors' note: This mastery approach is consistent with attainment-based instruction as described in Chapter 1 and competency-based education described in Chapter 2.*

** *Editors' note: For more on task-centered instruction, see Chapters 1 and 2.*

"just in time," or it can be triggered by certain player actions, or the player can request it at any time. *Diegetic* instruction seamlessly occurs within the context and actions of the game through naturally occurring consequences. Diegetic instruction may be improved by tracking the player's performance and dynamically adjusting the tasks to provide optimal difficulty and promote immersion and flow. *Non-diegetic* instruction occurs outside the normal game activities as coaching (providing cognitive and/or emotional support) or instructing (activities that do not affect game progress but prepare the learner to perform in the game). Further details regarding the scaffolding are discussed as principles for designing the instructional space.

When a learner is performing the task in a version of the game, he or she may begin a new part of the task only to find that he or she lacks certain knowledge, skills, and attitudes (KSAs) to be successful, at which point he or she (or a virtual mentor) pauses the game and activates the scaffolding. Alternatively, the virtual mentor may step in prior to the negative consequences and advise the learner that he or she needs some preparation for the next part of the task. Either way, part-task instruction (van Merriënboer, 1997; van Merriënboer, Clark, & de Croock, 2002) is initiated, and it is fully integrated with an assessment function—each learner continues to do the practice activities for each of the KSAs in his or her part of the task until the established criteria (usually for accuracy and/or speed of performance) are attained. At that point, a record of the attainment is automatically entered into the learner's file, time is unfrozen for the game, and the player uses the KSAs just acquired to perform his or her part of the task, until additional coaching or instruction is needed. This cycle of game play—instruction/assessment, and game play again—is repeated throughout the game, utilizing both criterion-referenced testing (Cronbach, 1970; Glaser, 1963; Haertel, 1985) and mastery learning (Block, 1971; Bloom, 1968; Carroll, 1963).

It is important to note that the practice and accompanying criteria include the full range of *divergence* (Merrill, Reigeluth, & Faust, 1979) expected in the real world (for skills and understandings), the level of *automatization* (Anderson, 1983, 1996) required in the real world (for memorization and lower-level skills), and the level of *consolidation* (Kamradt & Kamradt, 1999) required in the real world (for attitudes and values).

Principle 1.5: Feedback

The game has four major kinds of feedback. Foremost is *natural consequences* (Baek, 2009), which are built into the logic of the game. This is a major aspect of experiential learning and promotes a variety of higher-order thinking skills, including anticipation, diagnosis, and strategic planning. A second kind of feedback is *explanations* of natural consequences of the learner's actions and of other learners' perspectives and actions that are relevant to the learner's performance.

The action is often reviewed with "instant replays" from a "god's-eye view" that encompasses the learner's role and other relevant roles. The virtual mentor provides this feedback either upon request of the learner or when the system is programmed to offer it (at which point the learner can reject it). However, this kind of feedback is only provided when it does not interrupt the flow of the game.

A third kind of feedback is *debriefing* (Fanning & Gaba, 2007; McDonnell, Jobe, & Desmukes, 1997; Raemer, Anderson, Cheng, Fanning, Nadkarni, & Savoldelli, 2011), which is similar to explanations except that the virtual mentor provides it at the end of an episode (which is a part of the whole task for a given level of difficulty). The virtual mentor attempts to cultivate heuristic reasoning and mental model formation by eliciting or providing explanations about the performances, not just performances of the learner, but also of other characters involved in that episode of the task, as well as contextual factors and cultural issues.

Finally, *immediate feedback* is provided in the scaffolding. This feedback is often given in the form of hints or explanations of causal influences or reasoning to encourage more active cognitive processing and mental model development, but it may also take the form of simple confirmation, and it has motivational elements when warranted.

Principle 1.6: Motivation

Motivation is key to the acceleration and quality of learning. A motivated learner is enthusiastic, engaged, focused, and persistent (Garris, Ahlers, & Driscoll, 2002), and games foster these traits by inducing a state of flow (Csíkszentmihályi, 1990) for extended periods of time. Various aspects of games stimulate intrinsic and extrinsic motivation. Malone and Lepper (1987) argue that games promote intrinsic motivation through challenge (providing optimal difficulty for the player), curiosity (providing novelty, uncertainty of outcomes, and incongruity with existing mental models), control (promoting a sense of agency in taking on challenges), and fantasy (providing an appealing setting and a compelling narrative context).

Furthermore, many elements of games contribute to extrinsic motivation. One element is *scorekeeping*.* The quality of the learner's performance is reflected by a score that is often displayed continuously or at the end of an episode of play. In a multiplayer game, each player has his or her own score, but there may also be a team score. The score may take the form of points or objects (e.g., new tools or virtual currency) or a variety of other forms. Peer recognition of one's mastery can be highly motivating, so individual and team achievements in multiplayer online games are often posted for all to see.

* *Editors' note: Scorekeeping is an important aspect of structural gamification as described in Chapter 13.*

Motivation is enhanced by *collaboration* with others—through personal friendships and loyalties, peer recognition, not wanting to let down one's teammates, and for some people, the need for affiliation (McClelland, 1976). Collaboration is appropriate when the real-world task itself entails collaboration. Motivation is also enhanced by the *authenticity* and *relevance* of the scenario and role (Jonassen, Howland, Marra, & Crismond, 2008). Most people want to be successful in their lives, so the more authentic and relevant the task is to the real world, the more motivated they tend to be.

Finally, motivation is enhanced by building *confidence* through appropriate levels of difficulty (Keller, 1983, 1987). Confidence, or expectancy for success, is an important motivator for learning. Receiving training that is within their zone of proximal development (Vygotsky, 1978) is important to building learners' expectancy for success, and the levels of difficulty help to keep instruction within their zone of proximal development. Table 8.1 shows a summary of the six principles in Category 1. In the next section, we describe universal

TABLE 8.1 Summary of Principles in Category 1: Creating a Vision of the Game

A holistic, "fuzzy" vision of the game based on the following six principles guides design decisions regarding the game space and the instructional space.	
1.1 Learning goals	Specify what the learner will know, be able to do, and feel as a result of undergoing the game-based learning experience.
1.2 Authenticity	The dimensions of authenticity should be consistent with whole, real-world tasks, including portrayal of values, attitudes, beliefs, and cultures and provision of situational understandings.
1.3 Levels of difficulty	A game should be designed as a series of levels of increasing complexity and difficulty, each of which must be mastered before the next level is "unlocked." Each level is a version of the task and is made up of many individual performances of the task that share the characteristics of that version.
1.4 Scaffolding and mastery assessment	A game's scaffolding encompasses all aspects that are intended to enhance the effectiveness and efficiency of learning. Support may be provided to the player "just in time," or it can be triggered by certain player actions, or the player can request it at any time.
1.5 Feedback	A game has four different kinds of feedback: natural consequences of decisions/actions, explanations, debriefing, and immediate feedback in the form of hints or explanations of causal influences or reasoning.
1.6 Motivation	Various aspects of games stimulate intrinsic and extrinsic motivation. Motivation may be enhanced by collaboration with others, authenticity and relevance of the scenario and role, and confidence or expectancy for success.

principles related to the elements that create the game space in which play and learning occur.

Category 2: Designing the Game Space

To transform the fuzzy vision into a designed learning environment, designers must understand the game space, the essential elements that comprise that space, and the kinds of decisions they must make regarding those elements.

*The **game space** is the context in which the rules of a game pertain.* The game space may encircle a literal space (e.g., a board, field, or screen) or simply be an agreement among people to play, thereby transforming their shared space into a *magic circle* (Huizinga, 1955; Klabbers, 2009). From a systems perspective, the magic circle is a boundary which players cross to engage with and within the game system. The game space created by designers contains the potential for experiences that are realized through rule-based play.

*The **elements** of the game space are all of the aspects of the game that must be designed in order to create the necessary conditions for the game experience.* Various game designers and game scholars have described the elements of the game space in different ways but with some consistency in terminology and meaning (Avedon, 1971; Brathwaite & Schreiber, 2009; Koster, 2005; Schell, 2008). We have synthesized these attempts to identify standard game elements, using as a foundation Järvinen's (2008) approach, which is based on a thorough empirical analysis of over a hundred games of various types. Our intent is to provide guidance regarding the kinds of decisions that instructional designers must make in designing games for learning. Therefore, we focus on the *elements that must be designed* rather than aspects that emerge during the game experience. For example, game state is the configuration of game elements at a given time during gameplay. It is an important aspect of gameplay and is useful in analyzing gameplay, but it is not directly created by the game designers. The ten elements we discuss are goals, game mechanics, rules, players, environment, objects, information, technology, narrative, and aesthetics.

There is no single standard or "correct" way to undertake the design of a game. The elements of a game system are so intricately inter-related that decisions regarding one influence decisions regarding others. Some games are conceived based on theme or scenario, while others are born of the designers' desire to explore a (set of) mechanic(s). If the purpose of the game includes identity transformation (not only learning something but also becoming something; see Brown & Duguid, 2000; Gee, 2003; Shaffer, 2008; Squire, 2006), then the designers may choose to begin by determining an appropriate role for the player.

Principle 2.1: Goals

*The **goal** of a game is to achieve a configuration of game elements that matches the winning state defined in the rules.* In games for learning, the goal of the game

should require accomplishment of the learning goals identified in the vision of the game. Therefore, the actions and strategies needed to succeed in the game should be aligned with those needed to achieve the desired learning outcomes. This kind of activity-goal alignment also helps to ensure that the game elements that are intended to increase engagement and motivation do not distract from the meaningfulness of the activities from a learning perspective (Shelton & Scoresby, 2011). If a player is able to achieve the goal of the game without also achieving the desired learning outcomes, this is a design failure that calls for redesign. This design failure is avoided by making the goals and tasks of the game functionally the same as the goals and tasks that the learner must attain in the post-instructional environment (the principle of authenticity).

The subgoals of a game can be conceived as two types. The most common conception is related to subtasks whereby the performance of all subtasks is combined to perform the task, and the achievement of all subgoals is combined to achieve the goal of the game. The second conception is related to typical games in which players master one level before moving on to another level of the game. In this conception, each subgoal represents a different level—a different version of the task corresponding to progressively higher levels of complexity or difficulty. Therefore, design decisions regarding goals and subgoals may be influenced primarily by the universal principles of authenticity, levels of difficulty, and motivation.

To facilitate integration and transfer, goals should require the completion of whole, authentic tasks that have an appropriate degree of fidelity with the real world. Subgoals should be created for the various levels of difficulty within and across task classes. These subgoals should be obtainable only by completing interesting and challenging tasks of optimal difficulty for the player. The player's intrinsic motivation is fueled by cycles of acquiring abilities and tools required to complete the tasks, developing skillfulness through repeated attempts at the tasks, and finally achieving the subgoal through mastery.

Principle 2.2: Game mechanics

The term *game mechanics* is commonly used in the field of game design, but there seems to be no standard definition (Lundgren & Björk, 2003; Sicart, 2008). Avedon (1971) makes a clear distinction between mechanics and rules, with mechanics being a "procedure for action" and rules governing the action and the results. This distinction is useful for designers as it facilitates thinking about an *action* separate from all of the possible *constraints* on and *outcomes* of that action, which may vary greatly from game to game.

Following this approach, *a **game mechanic** is an action governed by rules that a player may take with or on one or more other game elements.* It is important to note that a mechanic may consist of several discrete actions combined into a procedure. A mechanic usually involves several elements at once, often including

the player's avatar, one or more game objects, the game environment, and the associated rules. Kinds of game mechanics are discussed as situational principles for designing the game space.

Through interaction with game mechanics, players come to understand the underlying rules of the game and to formulate strategies for leveraging those rules. It follows that instructional designers should conceive of or translate the desired learning outcomes into actions (including cognitive actions) that form the basis for playing the game (the principle of authenticity). The range of possible actions and the rules for the results of these actions should be directly related to the prior attainments of the learner and his or her current abilities and skills.

Principle 2.3: Rules

***Rules** define the possibilities of and constraints on actions in a game, as well as the rewards and penalties for those actions.* Thus, they are tightly bound with mechanics, and together these elements make different games both similar (by using common mechanics) and unique (by governing their use in distinctive ways). When players encounter a mechanic, they have certain expectations based on their prior experiences with that mechanic in other games. Therefore, when creating the rules of a game, designers often rely on precedent established by other games and then tweak their mechanics and rules to fit the particular game being designed. Instructional games may further need to align their rules with outcomes and feedback consistent with the real world to promote transfer (the principles of authenticity and feedback).

Principle 2.4: Players

*The **players** are the individuals who choose to enter the magic circle and undergo the experience of a game.* Designers must decide whether a game will be single-player or multiplayer, and if the latter, the possible configurations of players. These configuration patterns may include NPCs and other players in cooperation or competition (see Avedon, 1971).

***Game dynamics** are the emergent patterns of interplay between mechanics, rules, and players,* and for this reason are not discussed as a separate designed element. In poker, for example, bluffing is not mentioned in the rules. It is a strategy that emerged as a result of players interacting with the specified mechanics and rules of the game. ***Game balancing** is the art of designing the relationships among all of the elements of a game to promote the desired game experience.* There is no standard process for balancing a game other than the use of playtesting. ***Playtesting** is a method used throughout the game design process to systematically test the game elements and their relationships to each other.* Playtesting is an important method for determining whether players' interactions with game mechanics (and with each other) are resulting in unexpected dynamics and undesired experiences.

Principle 2.5: Environment

*The **environment** is the setting in which the action of the game takes place and the diegetic objects* (see **Objects** below) *of the game reside.* Video game environments may have numerous settings, such as the spaceship and locations on several planets in *Mass Effect* (BioWare Corp., 2007). Aspects of the environment include structure, dimensionality, physics, and time, and these are discussed as situational principles for designing the game space.

Principle 2.6: Objects

***Game objects** are the components of the game system that embody and enable the game mechanics or are affected by the player's use of the game mechanics.* Diegetic objects exist in the game setting and, when the game includes an avatar, are accessible to the avatar. Non-diegetic objects exist outside the game setting and are accessible to the player but not to the avatar, mainly through the virtual (on-screen) interface. These may include menus, heads-up displays (HUDs), and other means of obtaining information about or controlling the game.

Objects have properties (or attributes) with either static or dynamic states (Schell, 2008). For example, a gun may have a static property for the amount of ammunition it can hold and a dynamic property for the amount of ammunition it currently holds. In order to be usable, objects should have affordances (Norman, 1988) that make apparent how the object is used.

Principle 2.7: Information

Gameplay is goal-directed and rule-based action within a system. Every action creates a change in the state of the game system. Players' decisions regarding actions are guided by the available information about the game state. Many game objects are conduits for information, which may be presented as text (e.g., a popup window with instructions; a letter from a NPC), icons (e.g., an icon that indicates which weapon is currently active; a health meter), or visual/aural attributes of objects that serve as cues of state (e.g., a clicking sound to indicate that the chosen door is locked). Five types of information may be available to the player—information about avatars, objects, events, environment, and system; these are discussed as situational principles for designing the game space.

Principle 2.8: Technology

***Equipment** consists of the physical pieces required to play the game.* Video game equipment generally includes some sort of computing device (a *platform*), a screen and speaker(s), and a *physical interface* for interacting with the game system, usually via a *virtual interface* designed to enable the particular mechanics of the game.

Other technology considerations for video games include a network and data storage. A ***network*** is a group of connected devices that, in this case, facilitates multiplayer game experiences. In video games, ***data storage*** is used to preserve game state and game history. Data may be stored locally (on the gaming device), portably (on a memory card), or remotely (on a server). For learning games in particular, designers should ensure that relevant performance data are captured and stored for analysis as "interaction trails" (Myers, 2012). If the game is designed so that the learning objectives are directly tied to the use of game mechanics, capturing data for these events alone may provide sufficient evidence of mastery.

Principle 2.9: Narrative

*A **narrative** is a sequence of events that tells a story.* From a learning perspective, the use of narrative in games utilizes the power of episodic memory for structuring and storing our experiences as narratives (Bruner, 1991). Designing a game with a clear narrative structure, especially a monomythic pattern such as the hero's journey described by Campbell (1968), provides both a familiar frame for experience (an idea of what to expect) and a cognitive frame of reference (schema) to promote recall.

The use of narrative in a game may be influenced by game genre. For example, a first-person shooter game such as *Halo* (Microsoft Corporation, 2001) may have some narrative trappings like a one-dimensional character and a simple, linear plot held together by cut scenes (brief, non-interactive in-game movies that move the plot forward), but it is primarily focused on developing skills associated with game mechanics; on the other hand, a role-playing game such as *Oblivion* (Bethesda Softworks, 2006) is likely to have a customizable avatar and multiple storylines that vary according to the player's actions and choices. But even within a particular genre, narrative may be employed in very different ways.

Game designers have tremendous leeway in deciding how to incorporate narrative into a game. For example, a narrative structure (or *plot*) may be linear, branching, or foldback (with multiple branches that all eventually lead to a single event [Adams, 2010]) and may use devices like flashbacks and cut scenes. Game narratives are often divided into episodes (levels/missions/quests), each with its own buildup of dramatic tension and release.

Games often require the player to assume a *role* within the narrative and to take action in a manner consistent with that role. Shaffer (2006) has argued that a player's role in a game for learning should be based on an epistemic frame, which he defines as a set of "skills, knowledge, identities, values, and epistemology that professionals use to think in innovative ways" (p. 12). Clearly this approach is related to the authenticity of a game. One viable option for game designers is to begin by identifying the real-world role, the attributes of

its epistemic frame, and the whole set of tasks associated with the role. These constraints can then be used to determine the game mechanics and rules (which the player experiences as causal dynamics within the game) that will enable the player to develop proficiency in thinking and acting in the role. With these key decisions made, the designers can envision a scenario that provides a context for the role and mechanics. As the design process proceeds, decisions regarding the sequencing of tasks and levels of difficulty will influence the emerging narrative structure, and the original fuzzy vision of the game will come into sharper focus.

Game designers should also consider the roles that might be played by NPCs. The most common roles for NPCs are adversaries, teammates, and information sources. As adversaries, NPCs provide obstacles that the player must overcome in order to reach goals. The level of difficulty may be adjusted by changing the number of adversaries or by changing the skill levels of the adversaries. Similarly, NPCs as teammates can also be used to adjust difficulty by having them provide more or less assistance. In some games, the player may make high-level tactical decisions about the placement and actions of NPC teammates in order to carry out strategies. NPCs (either adversaries or teammates) may also function as information sources, although the player may need to judge the trustworthiness of the NPC.

Principle 2.10: Aesthetics

For the purposes of this discussion, *aesthetics* refers to the emotional responses and felt experiences (McCarthy & Wright, 2004) that arise in the player(s) through interaction with/in the game system. Design decisions for all of the other game components create the overall aesthetic experience of the game, so deciding how a player will feel while playing the game is a crucial part of the fuzzy vision early in the design of the game. Hunicke, LeBlanc, and Zubek (2004) proposed a short list of terms for describing the aesthetics of games, including feelings of challenge (game as obstacle course), fellowship (game as social framework), discovery (game as uncharted territory), expression (game as self-discovery), and fantasy (game as make-believe). Naturally, more than one of these feelings may be present at any given time, and all may occur throughout gameplay. If the game follows a narrative, the type and timing of events and their emotional flow may be dictated by the story arc.

Decisions regarding aesthetics are directly influenced by the degree of authenticity required to achieve learning and transfer. The dimensions of authenticity discussed above should be consistent in their levels of realism (or fidelity), where realism ranges from abstract to realistic. Types of realism include physical (feels real), perceptual (seems real), functional (acts real), cognitive (matches mental model), and emotional (evokes reality). In general, novices benefit from initial lower fidelity (to reduce cognitive load and promote automaticity), but as they approach mastery, higher fidelity promotes transfer.

A game is a designed experience comprised of the ten elements described above and summarized in Table 8.2. When designing these elements, game designers can create the conditions for the desired experience by applying the six universal principles for creating a vision of the game described in the previous section. Through this process, designers gradually refine the fuzzy vision of the game. However, as with any medium used for instruction, in games special attention must be given to the instructional methods to ensure that players attain the learning objectives. In the next section, we describe universal principles related to the elements of the scaffolding and strategies for promoting the desired KSAs.

Category 3: Designing the Instructional Space

The instructional space of a game for learning consists of three major types of scaffolding: adjusting, coaching, and instructing.* There are four major mechanisms for deciding when to use these types of scaffolding; the first three apply to adjusting and coaching, and all four apply to instructing. The first is *universal*, which, if the authentic situation allows, is offered within the game scenario to prepare the player for a new situation before the action starts, or even during the action. The second is *triggered*, in which its use is based on certain events (usually a mistake made by the player). The third is *requested*, in which the player asks for it when he or she feels the need for a little help to perform a part of his/her role. Finally, the virtual mentor could *suggest* pausing for some instruction but leave the decision up to the player.

Principle 3.1: Adjusting

The least intrusive type of instructional support is a variety of scaffolding (Cazden, 1983; Wood, Bruner, & Ross, 1976) that is achieved by *adjusting* aspects of the game to provide an appropriate level of difficulty for the player. The intent is to place the player within his or her zone of proximal development (Vygotsky, 1978). It is the least intrusive because it occurs "behind the scenes," leaving the player unaware that any instructional support has been provided.

Adjusting should be used when a task or part of a task (episode) is too difficult for a player to learn without support, as long as the adjusting is more efficient to use than either coaching or instructing. The kind of adjustment made to accommodate the learner depends on the particular situation; therefore, the major kinds of adjusting are discussed as situational principles for designing the instructional space.

* *Editors' note: Scaffolding in task-centered instruction is also discussed in Chapters 1, 3 (Principle 1), 4 (Principle 3), 6 (Principle 6), and 13 (Principle 3).*

TABLE 8.2 Summary of Principles in Category 2: Designing the Game Space

The game space is the context in which the rules of a game pertain. The following ten elements of the game space are all aspects of the game that must be designed in order to create the necessary conditions for the game experience.

2.1 Goals	The goal of the game should require accomplishment of the learning goals identified in the vision of the game. Therefore, the actions and strategies needed to succeed in the game should be aligned with those needed to achieve the desired learning outcomes.
2.2 Game mechanics	Through interaction with game mechanics, players come to understand the underlying rules of the game and to formulate strategies for leveraging those rules. Instructional designers should conceive of or translate the desired learning outcomes into actions (including cognitive actions) that form the basis for playing the game.
2.3 Rules	Rules define the possibilities and constraints on actions in a game. They should generate outcomes and feedback consistent with the real world to promote transfer.
2.4 Players	A player may engage with the game either alone or in competition or cooperation with other players and non-player characters.
2.5 Environment	The game environment is the setting(s) in which the action of the game takes place. Design decisions regarding the environment are influenced by the learning goals, the appropriate degree of fidelity, and the type or genre of game.
2.6 Objects	Game objects are the components of the game system that embody and enable the game mechanics or are affected by the player's use of the game mechanics.
2.7 Information	Games provide several types of information that players use to make decisions regarding which actions or choices will lead toward a goal.
2.8 Technology	Equipment consists of the physical pieces required to play the game and may include a computing device with various forms of input and output, a network, and data storage.
2.9 Narrative	A narrative structure can provide both a familiar frame for experience and a cognitive frame of reference (schema) to promote recall.
2.10 Aesthetics	Aesthetics refers to the emotional responses and felt experiences that arise in the player(s) through interaction with/in the game system. Design decisions for all of the other game components create the overall aesthetic experience of the game.

*Principle 3.2: Coaching**

Coaching (Nowack & Wimer, 1997) is defined here as another form of scaffolding that provides cognitive and/or emotional support to the player, and also preferably a human element that is performed by a virtual mentor. It primarily entails providing information or tips to the player, though it can include providing a short demonstration of a skill. More extensive demonstrations and practice with feedback go beyond coaching and are considered instructing. To enhance authenticity, coaching usually requires freezing time in the game, as in a "time-out" in sports scrimmages.

Like adjusting, coaching should be used when a task or part of a task (episode) is too difficult for a learner to accomplish without support, as long as the coaching is more efficient to use than either adjusting or instructing. It is typically used when the player needs only a little help. Larger amounts of help are best provided through adjusting and/or instructing.

Coaching is most often provided or requested before or during a performance episode. It can also be provided after a performance in the form of a debriefing or reflection on action to learn from the experience. When universal coaching is authentic to the task, it can be done without freezing time in the game. However, triggered and requested coaching commonly require freezing time to provide the coaching, due to the inauthenticity of providing coaching in the middle of a performance. For requested coaching, the player asks a question of the virtual mentor or asks for clarification or elaboration, so the system must be able to understand and respond appropriately, or a menu-driven system must be in place for making requests for coaching. Kinds of coaching are discussed as situational principles for designing the instructional space.

Principle 3.3: Instructing

Instructing is a kind of support for learning that provides the player with appropriate activities for learning, as well as information to promote learning (Merrill, 2013). All instruction should be just-in-time (JIT), meaning that it only teaches KSAs that the player will use in the next episode of the task in the game.

Instructing should be used just-in-time whenever a significant amount of learning effort is required. This may include a significant amount of information to be memorized, a difficult understanding to be acquired, a difficult skill to be acquired, including appropriate levels of transfer and automatization, or a significant attitude change to be made.

* *Editors' note: Coaching is a natural part of task-centered instruction and is discussed in some detail in Chapters 1 (Principle 2), 3 (Principle 4), and 10 (throughout).*

TABLE 8.3 Summary of Principles in Category 3: Designing the Instructional Space

The instructional space of a game for learning consists of three major types of scaffolding: adjusting, coaching, and instructing.	
3.1 Adjusting	The purpose of adjusting aspects of the game is to provide an appropriate level of difficulty for the player thereby placing the player in his or her zone of proximal development.
3.2 Coaching	Coaching is defined here as a form of scaffolding that provides cognitive and/or emotional support to the player by providing information, tips, or a short demonstration.
3.3 Instructing	Instructing should be used just-in-time whenever a significant amount of learning effort is required. This may include a significant amount of information to be memorized, a difficult understanding to be acquired, a difficult skill to be acquired, including appropriate levels of transfer and automatization, or a significant attitude change to be made.

There is a variety of formats in which the instruction can occur, each of which exists on a continuum. One continuum is *part-task selection*, which concerns whether the system diagnoses each player's needs regarding instruction on one extreme or just teaches all the part-tasks to all players in a given role on the other extreme. A midpoint on this continuum is for the instruction on each part-task to start with medium-difficulty practice (with feedback) using a computer-adaptive testing algorithm, and then provide richer instruction as needed. A second continuum for format is *use of a virtual mentor*, which ranges from extensive use of virtual mentor at all stages of the instruction to no use of a virtual mentor for any stages of it. A third continuum is *integration with the game*, which ranges from the instruction taking place as a natural activity within the game to pausing the game and offering the instruction completely separately and decontextualized, other than the player knowing that he or she will need to learn the KSAs to succeed in the next episode of the game.

Table 8.3 shows a summary of the three principles in this category. The kinds of instructional strategies used depend on the kinds of learning required; therefore, these are discussed as situational principles for designing the instructional space.

IV. Situational Principles

Some of the universal principles described above for designing the game and instructional spaces require further guidance in their application because certain design decisions are necessary only in some situations (Reigeluth & Carr-Chellman, 2009).

Category 4: Considerations for Designing the Game Space

Situational principles for the game space include kinds of game mechanics, parts of the game environment, and kinds of information available to the learner.

Principle 4.1: Kinds of game mechanics

The literature contains many proposed classifications of game mechanics (Järvinen, 2008; Salen & Zimmerman, 2004; Sicart, 2008). In this discussion, the classification consists of three types: core, compound, and peripheral.

***Core mechanics** are most fundamental in accomplishing the goal(s) of the game.* If a player fails to master a core mechanic, he or she cannot achieve the goal(s) of the game. Core mechanics should be introduced early in the game and recur frequently. Therefore, they should quickly become skill-based (automatic) through practice, including part-task practice in the instructional space, if necessary. Sometimes it may be desirable to challenge players by modifying a core mechanic (or the elements upon which it acts) once it has been mastered. For example, once a player has mastered the driving mechanic in a video game, a faster car may become available that requires increased proficiency by the player.

***Compound mechanics** consist of two or more core mechanics combined by a rule.* They are also necessary in accomplishing the goal(s) of the game, but they recur less frequently. They may remain rule-based or become skill-based, depending on the availability of practice for the player. For example, a player may need to learn how to use the driving mechanic and the shooting mechanic simultaneously to solve a problem and proceed toward the end state of the game.

***Peripheral mechanics** are optional or non-vital in accomplishing the goal(s) of the game.* They are usually novel (non-recurrent) and knowledge-based (i.e., require more cognitive processing). For example, in *Assassin's Creed: Brotherhood* (Ubisoft, 2010) if the player's avatar enters a body of water, a prompt informs the player about which game controls to use to make the avatar swim. However, swimming is not necessary to achieve the end state of the game.

Fabricatore (2007) describes a progression of mechanics usage. First, the player must learn the mechanic itself—how it is achieved using the game controls—and then gain some proficiency with it through practice. Second, the player must recognize an appropriate time to use the mechanic and then use it to achieve an end. Third, the player must increase proficiency with the mechanic in order to use it in more complex situations (sometimes in combination with other mechanics) to achieve a subgoal of the game. This kind of elaboration is common in video games (Gee, 2003) and is usually associated with levels of difficulty.

Because game mechanics are the elemental building blocks of games, design decisions should be guided by all six universal principles used in creating a

vision of the game. Mechanics should function as they do in the real world and provide authentic feedback if their use is to transfer outside the game context. Decisions regarding the progression of mechanics usage described above should be informed by the concepts relevant to designing levels of difficulty (e.g., cognitive load, simplifying conditions, etc.). If players are unable to master core mechanics through practice in the game, the scaffolding should provide appropriate assistance in the game or part-task practice until mastery is achieved.

Principle 4.2: Parts of the game environment

In designing the game environment, four main aspects must be considered: structure, dimensionality, physics, and time. Movement in a game is determined by two primary aspects of the environment. First, the *structure* of the environment may be discrete or continuous (or a combination of the two). In the video game *Mass Effect* (BioWare Corp. 2007), the environment is divided into large discrete locations. Movement between locations (e.g., from planet to planet) is similar to moving from square to square in a board game, that is, jumping from one place to another. Movement within those locations is continuous, with the player using a controller to move his avatar to explore the location with few constraints.

The second aspect of the environment that affects movement is *dimensionality*. An environment may be linear (1D), rectilinear, 2D, or 3D (Björk & Holopainen, 2005). In many board games, the player's token moves linearly around the board. In a rectilinear environment, movement is constrained to paths between nodes, which is the case in strategy games such as *Risk* where an army may only move into an adjacent region. Movement is limited to two dimensions in a 2D environment such as chess. Many video games take place in environments with three dimensions (3D) and fluid, continuous movement.

Perspective or point of view in video games is the vantage from which the player visually perceives the environment. Many simulation and strategy games use either an isometric or a top-down perspective, which gives the player the feeling of acting *on* the environment from above rather than *in* the environment. By the early 1990s, personal computer technology was capable of simulating three dimensions, and shooting games like *Wolfenstein 3D* (id Software, 1992) and *Doom* (id Software, 1993) allowed players to maneuver avatars through hallways and rooms from a first-person perspective (hence the name *first-person shooter*), albeit with a fairly narrow field of vision. The third person perspective broadens the field of vision by moving out of the avatar's point of view and watching the avatar from a slightly removed position. Many games now refer

to this perspective metaphorically as a "camera" that can be moved around the avatar as though it were on a crane (Poole, 2001). Games may also allow the player to switch between first- and third-person views.

While *physics* is an important aspect of some non-digital games (e.g., billiards, tiddlywinks), many video games require a physics engine, which is *a computer program that handles the rules governing how objects in the environment move and respond to force*, as in *Angry Birds* (Rovio Entertainment, 2009). A deeper exploration of design options for game physics is beyond the scope of this paper, but designers should consider the degree of fidelity required to achieve the desired learning outcomes.

Another aspect of the game environment is the rate at which game *time* passes. Juul (2004) notes that the difference between the real world and a game world is reflected in the "duality of *play time* (the time the player takes to play) and *event time* (the time taken in the game world)" (p. 131). Event time in a game may be characterized as real, compressed (speeded up), extended (slowed down), or variable. The rate of event time may vary by event (e.g., eight hours of sleep for the avatar may pass in a few seconds), or event time may be manipulated by the designer to adjust difficulty and challenge for the player.

Design decisions regarding the structure, dimensionality, physics, and time of the game environment, along with the available perspective(s) for the player, are greatly influenced by the learning goals of the game and the type or genre of game.

Principle 4.3: Kinds of information

Five main kinds of information may be available to the player—information about avatars, objects, events, environment, and system. In general it is helpful to think of the player's access to information as being on an accessible-inaccessible continuum, the exact position depending on a number of factors, including authenticity (how much the player would know in the real-world situation being simulated), level of difficulty (withholding information can increase difficulty), and cognitive load (too much information overloads working memory).

- **Information about avatars** includes the role and attribute states of the avatar (e.g., current values for strength, speed, intelligence, etc.), the inventory of available resources and locations, and the avatar's current location.
- **Information about objects** primarily includes attribute states related to game mechanics. For example, a number or a graphic representation might indicate the amount of ammunition in a weapon, which might prompt the player to use the *reload* mechanic or the *switch weapon* mechanic. A special

type of information conveyed by objects is perceived affordance, an indication of likely actions that may be taken with an object (Norman, 1988).

- **Information about events** is of two types: feedback and narrative.
  - Feedback is the immediate result and consequences of the use of game mechanics expressed in one or more sensory forms. In video games, players learn the operational rules of a game by experimenting with game mechanics and interpreting the meaning of the feedback.
  - Narrative information about events includes salient descriptions (or recordings) of past performance in the game, usually key events from levels/missions/quests. It may also include backstory, cut scenes (non-interactive animated sequences that segue between playable sequences), listings of pending missions, reminders of tasks to be completed, and other information related to the unfolding story.

- **Information about the environment** includes maps of known and accessible locations. It also includes sensory cues (e.g., lighting, music) that convey the tone and mood of the environment. A well-designed environment creates in the player a sense of immersion and presence (Tamborini & Skalski, 2006).
- **Information about the system** includes indications of the current game state and the available procedures at the system level, for example, entering and leaving the game space, returning to a previous game state, accessing the scaffolding, etc.

The principles for Category 4 are summarized in Table 8.4.

Category 5: Considerations for Designing the Instructional Space

Situational principles for the instructional space include kinds of adjusting, kinds of coaching, and kinds of instructional strategies.

Principle 5.1: Kinds of adjusting

Three major kinds of adjusting include difficulty adjustment, artificial prompts or cues, and automated task performance.

- **Difficulty adjustment** may be as simple as sequencing cases so that easier cases are first, or preferably it may involve determining the learner's current zone of proximal development and adjusting the difficulty of the case accordingly. The latter approach requires collecting data to assess the learner's ongoing performance and attainments.

TABLE 8.4 Summary of Principles in Category 4: Considerations for Designing the Game Space

The following situational principles provide more precise guidance regarding the design of three elements of the game space.

4.1	Kinds of game mechanics	Core mechanics are most fundamental in accomplishing the goal(s) of the game and should be introduced early and recur frequently. Compound mechanics consist of two or more core mechanics combined by a rule. Peripheral mechanics are optional or non-vital.
4.2	Parts of the game environment	The game environment consists of structure (discrete or continuous), dimensionality (linear, rectilinear, 2D, or 3D), perspective (the player's view), physics (how objects move), and time (real, compressed, extended, or variable).
4.3	Kinds of information	Information about avatars, objects, events, the environment, and the system may be more or less accessible to the player depending on authenticity, level of difficulty, and cognitive load.

- **Artificial prompts or cues** (ones not present in an authentic case) may be provided to guide the learner's performance, though these should be removed from cases in which the learner will be summatively assessed.
- **Automated task performance** of parts of a task may help the learner to see the actions and understanding required for a particular case. This may be thought of as a partially worked example.

Principle 5.2: Kinds of coaching

Coaching can take the form of providing information, providing a hint or tip, or providing an understanding. It is typically provided when the learner just needs a little help to perform a part of his/her role.

- **Providing information** involves disclosure beyond what is normally available to the learner as described above in the discussion of kinds of information. For example, the learner may be shown a map of the game environment that includes one or more locations that are not normally displayed.
- **Providing a hint or tip** and **providing an understanding** go a bit further than providing information by guiding the learner toward a course of action. The *inquisitory form* of this approach occurs as questions to the learner that help the learner to discover an appropriate hint or understanding, as occurs in a Socratic dialogue. The *expository form* occurs as statements or visuals that provide the hint or stimulate the understanding.

Principle 5.3: Kinds of learning and appropriate instructional strategies

While space precludes an in-depth discussion, below we address kinds of learning that have the greatest impact on selection of instructional and assessment strategies.

- **Memorization** of information (rote knowledge) is achieved most effectively through drill and practice (Salisbury, 1990). Primary strategies for instruction are to present what is to be memorized and to practice recalling or recognizing it. Secondary strategies include repetition, chunking, spacing, prompting, and mnemonics.
- **Application of skills** (including higher-order thinking skills) is achieved through tutorial instruction that includes demonstrations of the skill, usually simultaneously with the primary strategy of explanations (generalities), and practice with immediate feedback until the player reaches the specified criteria for accuracy and speed of performance (Merrill, 1983; 2013; Romiszowski, 2009).
- **Understanding of causal relationships** is developed through observation and manipulation of causes and/or effects (Corrigan & Denton, 1996; Perkins & Grotzer, 2005; Reigeluth, 1983). Primary strategies for instruction are acquisition through either exploration or telling and showing the causal relationships, and application by providing opportunities to use the causal relationships (practice) with immediate feedback.
- **Understanding of natural processes** is developed through observation of the sequence of events that comprise the natural process, as well as descriptions of what preceded or followed any given event (Reigeluth & Schwartz, 1989). The primary strategies for instruction are to tell the player what the events in the natural process are (*generality*), show the player what they are (*demonstration*), and provide opportunities for the player to use the natural process (*practice*), with immediate *feedback*.
- **Conceptual understanding** is primarily a matter of understanding the relationships among concepts. Different kinds of relationships constitute different dimensions of understanding. The major types of relationships include: superordinate, coordinate, and subordinate (in which the concepts may be either parts or kinds of each other), analogical, and experiential (Reigeluth, 1983). The primary strategies for instruction are to portray the relationship (*description*) and to provide opportunities for the player to use the conceptual relationship (*application*), with immediate *feedback*. Demonstrations or examples do not exist as they do for skills, causal understanding, and process understanding, but they are used whenever the experiential relationship is important.
- **Attitudes and values** have three major components: cognitive, affective, and psychomotor (or behavioral) (Kamradt & Kamradt, 1999). Each requires a different primary strategy. The cognitive component requires *persuasion* through cognitive reasoning. The affective component requires *operant conditioning* to develop positive feelings about the attitude or values. This can be done vicariously through social modeling, such as observing a person with whom one can easily empathize in a film. The psychomotor component requires *demonstrations and practice with feedback* to develop the appropriate behaviors.

TABLE 8.5 Summary of Principles in Category 5: Considerations for Designing the Instructional Space

The following situational principles provide more precise guidance regarding the design of the instructional space.	
5.1 Kinds of adjusting	Difficulty adjustment may involve sequencing cases from easier to more difficult or dynamically adjusting difficulty based on the learner's current zone of proximal development. Artificial prompts or automated task performance are adjustments that may be used to scaffold the learner toward the desired performance.
5.2 Kinds of coaching	Coaching can take the form of providing information, providing a hint or tip, or providing an understanding. It is typically provided when the learner just needs a little help to perform a part of his/her role.
5.3 Kinds of learning and appropriate instructional strategies	Different kinds of learning, such as memorization, skills, understanding, and attitudes and values, require different instructional and assessment strategies.

The principles for Category 5 are summarized in Table 8.5.

V. Conclusion

Games can provide engaging and motivating learning experiences in which players take on roles to solve authentic and increasingly difficult problems in situated contexts. We have discussed three categories of universal principles applicable to designing games for learning: creating a vision of the game, designing the game space, and designing the instructional space. The principles within each category (see Table 8.6 for a summary) describe what we think are the most important considerations for creating a game that effectively promotes the desired learning outcomes. Certainly more can and should be said about each of these principles to develop more fully a common knowledge base. In particular, we hope that designers of games for learning will add to and elaborate on the situational principles to provide more detailed guidance on designing various types of games and game mechanics to achieve different learning outcomes.

TABLE 8.6 Summary of Universal and Situational Principles

Category 1: Creating a Vision of the Game

A holistic, "fuzzy" vision of the game based on the following six principles guides design decisions regarding the game space and the instructional space.

1.1	Learning goals	Specify what the learner will know, be able to do, and feel as a result of undergoing the game-based learning experience.
1.2	Authenticity	The dimensions of authenticity should be consistent with whole, real-world tasks, including portrayal of values, attitudes, beliefs, and cultures and provision of situational understandings.
1.3	Levels of difficulty	A game should be designed as a series of levels of increasing complexity and difficulty, each of which must be mastered before the next level is "unlocked." Each level is a version of the task and is made up of many individual performances of the task that share the characteristics of that version.
1.4	Scaffolding and mastery assessment	A game's scaffolding encompasses all aspects that are intended to enhance the effectiveness and efficiency of learning. Support may be provided to the player "just in time," or it can be triggered by certain player actions, or the player can request it at any time.
1.5	Feedback	A game has four different kinds of feedback: natural consequences of decisions/actions, explanations, debriefing, and immediate feedback in the form of hints or explanations of causal influences or reasoning.
1.6	Motivation	Various aspects of games stimulate intrinsic and extrinsic motivation. Motivation may be enhanced by collaboration with others, authenticity and relevance of the scenario and role, and confidence or expectancy for success.

Category 2: Designing the Game Space

The game space is the context in which the rules of a game pertain. The following ten elements of the game space are all aspects of the game that must be designed in order to create the necessary conditions for the game experience.

2.1	Goals	The goal of the game should require accomplishment of the learning goals identified in the vision of the game. Therefore, the actions and strategies needed to succeed in the game should be aligned with those needed to achieve the desired learning outcomes.
2.2	Game mechanics	Through interaction with game mechanics, players come to understand the underlying rules of the game and to formulate strategies for leveraging those rules. Instructional designers should conceive of or translate the desired learning outcomes into actions (including cognitive actions) that form the basis for playing the game.
2.3	Rules	Rules define the possibilities and constraints on actions in a game. They should generate outcomes and feedback consistent with the real world to promote transfer.
2.4	Players	A player may engage with the game either alone or in competition or cooperation with other players and non-player characters.
2.5	Environment	The game environment is the setting(s) in which the action of the game takes place. Design decisions regarding the environment are influenced by the learning goals, the appropriate degree of fidelity, and the type or genre of game.
2.6	Objects	Game objects are the components of the game system that embody and enable the game mechanics or are affected by the player's use of the game mechanics.
2.7	Information	Games provide several types of information that players use to make decisions regarding which actions or choices will lead toward a goal.
2.8	Technology	Equipment consists of the physical pieces required to play the game and may include a computing device with various forms of input and output, a network, and data storage.
2.9	Narrative	A narrative structure can provide both a familiar frame for experience and a cognitive frame of reference (schema) to promote recall.
2.10	Aesthetics	Aesthetics refers to the emotional responses and felt experiences that arise in the player(s) through interaction with/in the game system. Design decisions for all of the other game components create the overall aesthetic experience of the game.

Category 3: Designing the Instructional Space

The instructional space of a game for learning consists of three major types of scaffolding: adjusting, coaching, and instructing.

3.1	Adjusting	The purpose of adjusting aspects of the game is to provide an appropriate level of difficulty for the player thereby placing the player in his or her zone of proximal development.
3.2	Coaching	Coaching is defined here as a form of scaffolding that provides cognitive and/or emotional support to the player by providing information, tips, or a short demonstration.
3.3	Instructing	Instructing should be used just-in-time whenever a significant amount of learning effort is required. This may include a significant amount of information to be memorized, a difficult understanding to be acquired, a difficult skill to be acquired, including appropriate levels of transfer and automatization, or a significant attitude change to be made.

(continued)

TABLE 8.6 *(continued)*

Category 4: Considerations for Designing the Game Space		
The following situational principles provide more precise guidance regarding the design of three elements of the game space.		
4.1	Kinds of game mechanics	Core mechanics are most fundamental in accomplishing the goal(s) of the game and should be introduced early and recur frequently. Compound mechanics consist of two or more core mechanics combined by a rule. Peripheral mechanics are optional or non-vital.
4.2	Parts of the game environment	The game environment consists of structure (discrete or continuous), dimensionality (linear, rectilinear, 2D, or 3D), perspective (the player's view), physics (how objects move), and time (real, compressed, extended, or variable).
4.3	Kinds of information	Information about avatars, objects, events, the environment, and the system may be more or less accessible to the player depending on authenticity, level of difficulty, and cognitive load.
Category 5: Considerations for Designing the Instructional Space		
The following situational principles provide more precise guidance regarding the design of the instructional space.		
5.1	Kinds of adjusting	Difficulty adjustment may involve sequencing cases from easier to more difficult or dynamically adjusting difficulty based on the learner's current zone of proximal development. Artificial prompts or automated task performance are adjustments that may be used to scaffold the learner toward the desired performance.
5.2	Kinds of coaching	Coaching can take the form of providing information, providing a hint or tip, or providing an understanding. It is typically provided when the learner just needs a little help to perform a part of his/her role.
5.3	Kinds of learning and appropriate instructional strategies	Different kinds of learning, such as memorization, skills, understanding, and attitudes and values, require different instructional and assessment strategies.

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9

DESIGNING INSTRUCTION FOR SELF-REGULATED LEARNING

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