The “I’s” Have It: A Framework for Serious Educational Game Design

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Serious educational games have become a topic that has seen increased popularity in recent years. This article describes lessons learned and a framework for people interested in designing educational games. Although there are many critical components of a quality educational game, a nested model of 6 elements for educational game design is presented. These nested elements are grounded in research and theory in both education and psychology, along with instructional technology and the learning sciences. The 6 elements of educational game design are derived from several studies on game design and development from Grade 5 through graduate school.

Keywords: computer games, child development, education, mass media

Video games designed for use in educational settings are beginning to gain their sea legs. When I started working in this arena some 12 years ago, it was seen as a frivolous endeavor without substance or support in theory. As time progressed, technology evolved, and more experts in a variety of areas began to envision educational environments in three dimensions. It is critical those of us who have been working in this area share what we have learned and learn from those just beginning to engage in research on educational video games.

Many great scholars in education, cognition, and psychology have worked tirelessly on educational games over the years. Researchers have looked at the implications of commercial games on learning, attitudes, and efficacy, the three areas most reported (Durkin, 2010; Ferguson, 2007; Gee, 2008; Kato, 2010; Shaffer, 2006; Spence & Feng, 2010; Squire, 2008; Steinkuehler & Williams, 2006). Others have created their own games and studied the impact of those games on learning, attitudes, and efficacy. At North Carolina State University, students and scholars are working to create a video game authoring platform where teachers and students can create their own games that align with content standards in science, mathematics, and technology education, although the platform is usable in many other domains. This is not a new idea but rather a recycling of many proven educational theories and practices into the video game world.

Research tells us from a constructivist viewpoint that people learn through ascertaining prior schema and ultimately constructing new knowledge by connecting a new experience to a prior experience. This is the backbone of our work. Allowing students, and sometimes teachers, to construct a game means relinquishing control to the consumer while enabling the consumer to become the producer. As a science educator, it was even more critical to give students the ability to create an experience that was impossible to re-create in the traditional sense (i.e., testing Galileo’s experiment on the moon). As far back as 1910, Dewey advocated that children should experience science and not be passive recipients of ready-made knowledge. He contended that knowledge is “not information, but a mode of intelligent practice and habitual disposition of mind” (p. 124). Linn (2004) proposed four metapriniples to support knowledge integration in information and communications technology-mediated science:

1. Making science accessible,
2. Making thinking visible,
3. Helping students to learn from each other, and

If we take into account Dewey’s and Linn’s work, we can see how learning through the creation of, rather than just playing, video games might have the greatest potential for these software applications on education.

It is important to distinguish between serious games, serious educational games (SEGs), simulations, and virtual worlds. In short, serious games are electronic/computer-access games that are not designed for commercial purposes but rather for training users on a specific skill set. For example, the military have been the leaders in serious games in which soldiers train on combat missions that could not be replicated completely in trainings in the physical world. SEGs juxtapose serious games by targeting K–20 content knowledge. They allow teachers and students to connect real-world scenarios with common school content, thus answering the age-old question, “Why do I need to know this?” A simulation, by our definition, has the same function of a serious game or SEG but does not keep a score or have an economy. We define economy as a means of buying and selling in game artifacts. Think of this like the board game Monopoly. You do not really “keep score,” but the winner is clearly determined by the amount of money and real estate gained at the game’s conclusion. Finally, virtual worlds are customarily three-dimensional environments used more for social interaction (open to the entire world or a large targeted audience) than are games or simulations focused on specific skills or content. Common examples are Activeworlds, Second Life, and There. This is not to say that games and simulations cannot be part of a virtual world, however. There are many other types of electronic games,
including mobile games, but this article focuses solely on designing SEGs.

What follows are a description of and a connection to the six “I’s” of SEG design. These six elements are derived from some 12 years of developing and testing educational games and using research from commercial video games to inform SEG research (Annetta, 2008; Annetta, Cook, & Schultz, 2007; Annetta, Mangrum, Holmes, Collazo, & Cheng, 2008; Annetta, Murray, Gull-Laird, Bohr, & Park, 2006). Figure 1 illustrates a nested model of the six components we teach our students as they begin their game development process. SEGs encompass these six elements that appear in an order of magnitude beginning with identity and ending with instructional. It can be argued that each of these elements is of equal value; however, our position (at least in SEGs or serious games) is that identity is an important component of games, but it is the first stage of an eclectic, intertwined mix of elements that make a good educational game. In other words, this model functions as a hierarchy with identity as the basic foundational element. Yet, this model is different from other models with the inclusion of the idea of informed learning. Specifically, this entails embedding scaffolds (learning support) into a game design and, unique to educational games, the idea of embedded assessments for educational learning outcomes.

Identity

The enticing power of these three-dimensional worlds (regardless of whether or not they are considered a serious game, simulation, or virtual world) is arguably their ability to capture the player’s mind and trick him/her into believing he or she is a unique individual within the environment. “Playing one’s character(s) and living in [these virtual worlds] becomes an important part of daily life. Since much of the excitement of the game depends on having personal relationships and being part of [the] community’s developing politics and projects, it is hard to participate just a little” (Turkle, 1995, p. 184).

In many modern video games, the player’s identity is represented through a unique character called an avatar. The word avatar is derived from Hindu, meaning an incarnation of a deity in a human or animal form. In game worlds, avatars become the incarnation of the player and convey his or her identity, presence, location, and activities to others (Benford, Greenhalgh, Rodden, & Pycock, 2001). Regardless of the camera view (e.g., first-person or third-person perspectives), avatars allow the players to be individual members of a team or community of players or learners. The idea of being an individual is an intrinsic part of human nature. We all have the need to feel as if we belong even as we have a need to be unique.

Annetta and Holmes (2006) reported that using avatars increased social presence and built a strong community of practice. During game play, students who had a choice of which avatar they would like to represent them reported greater course satisfaction and felt closer to their classmates and instructor than students who could choose only between a standard male or female avatar (Annetta, 2008). This was an interesting study because two sections of the same graduate-level class played the same SEG, yet...

Figure 1. Nested elements of educational game design.
Immersion

Being immersed in these SEG environments means that players have a heightened sense of presence through individual identity, are engaged in the content, and thus are intrinsically motivated to succeed in the challenge of the game’s goal. If these three criteria are met, then the player may enter a state of flow. Flow (which will be discussed in greater detail later) is an underlying goal of all good game design.

If players feel like individuals in the game application, then they have a true identity and feel like they are present in the virtual world. We use the definition of presence of Witmer and Singer (1998) as the psychological perception of being in or existing in the game environment in which one is immersed. In a study of high school genetics students, participants showed much higher engagement (time on task, concentration, etc.) during game play than a similar class doing a traditional genetics laboratory experiment (Annetta, Minogue, Holmes, & Cheng, in press). These results suggest that engagement was due to students’ feeling present and having a unique identity.

When game players have a sense of identity and are immersed, they become motivated to proceed through the game’s obstacles and objectives. Gamers prefer to be immersed in a digital world where they become the main character or empathize with other characters in a game’s narrative. Games clearly motivate users in ways that conventional instruction, including online nonroutine challenge problems, does not (Yee, 2006). People find themselves immersed in games because they find games intrinsically satisfying. Motivation refers to a set of reasons why one repeatedly engages in a particular behavior. Intrinsic motivation encompasses such areas of challenge, curiosity, control, and purpose. When people are motivated intrinsically, they become more engaged in the task at hand. Video games are the 21st century medium comparable to losing oneself in a book that could be read for hours or in a movie in which the consumer empathizes with the main character and is physically exhausted on exiting the theater.

When players are present, engaged, and motivated to continue the game’s challenge, they reach a state of flow. Players enter a flow state when they become completely immersed in an activity and feel at one with it. Csikszentmihalyi (1990) defines flow as “the state in which people are so involved in an activity that nothing else seems to matter; the experience is so enjoyable that people will do it even at great cost, for the sheer sake of doing it” (p. 4). Csikszentmihalyi identified eight characteristics that are recognizable (and required) when a person is in a flow state:

1. Feeling the activity can be successfully completed,
2. The player can concentrate fully on the activity,
3. The activity has clear goals,
4. The activity provides fast feedback,
5. The player is deeply involved in the activity,
6. A sense of control over the actions is necessary to perform the activity,
7. Self-awareness disappears during flow, and
8. There is an altered sense of time.

This is an important guideline to use as a basis for designing scaffolds within a game. Players are so engaged and absorbed by certain activities that they seem to “flow” along with it in a spontaneous and almost automatic manner.

Flow is a highly energized state of concentration and focus. Flow can further be considered a psychological state based on concrete experiences, which acts as a reward by producing intrinsic motivation and active engagement. Flow is achieved by increasing the level of challenge as the individual’s skill level increases so there is a dynamic tension between the states of boredom and frustration. Finnean and Zhang (2005) stated that flow represents a state of consciousness, and that during flow, people are so absorbed in an activity that they show high performance without being aware of their surrounding environment.

“Games should be usable and provide clear goals and appropriate feedback to the players in order to facilitate the Flow experience” (Kii, 2005, p. 19). According to Kii (2005), inappropriate challenges of the game environment and bad usability of the computer games reduce the possibility of flow experience. Feedback within games is a crucial idea that is even more important in educational games. In early games, feedback involved the assignment of “points,” although this is less often the case in more modern games. Feedback lets players know where they are in the game’s narrative and what they need to do to succeed in future quests within the game narrative. Interestingly, educational game feedback does not need to be only content feedback but also performance feedback. These feedback channels should facilitate stealth learning, a concept discussed in more detail later. Pitke (2004) emphasized the user interface (i.e., the controls used in manipulating the game) of computer games and stated that user interface should be as clear and user-friendly as possible to reduce unnecessary cognitive processing. The more interaction a player has with the computer, the higher probability for engagement and flow to exist.

Interactivity

Games allow players to be social communicators, whether it is with other players in a multiplayer environment or with the machine, communicating with computerized agents who are considered nonplayer characters (i.e., characters in the game not controlled by any human player). A study by Hoyt, Blascovich, and Swinth (2003) suggested that those playing in the presence of
nonplayer characters demonstrated classic social inhibition performance impairment effects relative to those performing alone. In other words, players react to nonplayer characters in a similar manner to other players.

As communication and working as a team are important to the learning process, immediacy is an important characteristic to consider in educational game design. When SEGs become multiplayer, geographic distance becomes a major factor, and thus communication is a driving force behind game success. Mehrabian (1967) defined immediacy as the extent to which selected communicative behaviors enhance physical or psychological closeness in interpersonal communication. In other words, immediacy can be understood as “those communication behaviors that reduce perceived distance between people” (Thweatt & McCroskey, 1996, p. 198). Immediacy can have verbal and nonverbal forms. Nonverbal immediacy would therefore be understood as a sense of psychological closeness produced by physical communicative behaviors such as facial expression, eye contact, posture, proximity, and touch. Verbal immediacy would thus be a sense of psychological closeness produced by word selection or, in some cases, text. In video games, photorealistic environments and facial movements and expressions by other players (in a multiplayer context) and nonplayer characters increase immediacy.

Many people prefer using media for enjoyment and to escape the difficulties of social life (Kutner, Olson, Warner, & Hertzog, 2007; Olson, 2010; Sherry, 2004). Besides their fantasy and fun characteristics, games not only provide a vehicle for distant communication but also have potential to foster children’s ability to learn how to communicate and interact with others. It can be more difficult to gain a state of flow during multiplayer games, not impossible, but more difficult because most auditory input is transient and visual input is more continuous. The use of meaningful auditory and visual inputs together has the ability to disrupt the focus of attention. Visual dominance is a concept in which visual presentations oppose instinctive tendencies such that humans have to switch attention to auditory or tactile stimuli. Because of their rich three-dimensional graphics, games tend to dominate a player’s visual channel. Good games use ambient music or noise to temp the auditory channel, but if spoken words dominate a player’s visual channel. Good games use ambient music or noise to temp the auditory channel, but if spoken words most auditory input is transient and visual input is more continuous. The use of meaningful auditory and visual inputs together has the ability to disrupt the focus of attention. Visual dominance is a concept in which visual presentations oppose instinctive tendencies such that humans have to switch attention to auditory or tactile stimuli. Because of their rich three-dimensional graphics, games tend to dominate a player’s visual channel. Good games use ambient music or noise to temp the auditory channel, but if spoken words are critical to the game’s goal, the game’s movement stops or a separate window opens. This allows the player to focus on auditory inputs.

Wickens (1992) argued that only abrupt auditory signals would gain attention over visual signals. What is interesting is that nonattended auditory information continually connects to long-term memory channels at a preattentive level. As games become more complex, interactivity with other players or nonplayer characters becomes increasingly more important.

Less prominent in the research literature is the idea of intrapersonal communication. Cognitively speaking, this is how players use their “mind’s eye” and inner voice to solve problems. We would tentatively hypothesize that interactivity within oneself decreases as the visual and auditory channels become congested. This is a fruitful area for future research.

**Increased Complexity**

Good games often have multiple levels. This can be accomplished through loading new three-dimensional maps (a level or single virtual game world) or increasing difficulty within one map. Connecting levels in a game provides a platform for increasing complexity of concepts and content in an SEG. This is where classic educational psychology has been surreptitiously used in the game design process. Piaget (1951/1062) observed that certain kinds of games precede others and studied their relationship with the cognitive, affective, and social evolution of children. He classified games in three main stages: games of exercise, symbolic games, and those with rules. The first stage includes games performed by babies and young children. In the second stage, it is common that children symbolically associate one object with a different one (e.g., a piece of wood might become a “gun”). When children are about 7 years old, they get involved in a new form of play that involves rules (the third stage), like soccer or racing. Not surprisingly, Piaget named this third stage “games with rules,” and it develops while the child goes through the socialization process. These three main groups of play behaviors emerge, according to Piaget, as the child develops, but the three classes remain intact during adulthood.

Piaget (1951/1962) suggested the main organizing element in game play consists of explicit rules that guide children’s group behavior. Game play is very organized compared with sociodramatic play (free play, creative, and imaginative social interaction). Games usually involve two or more sides, competition, and agreed-on criteria for determining a winner. Children use games flexibly to meet social and intellectual needs. Regarding video games, in single-player games, the “other side” in the competitive duo is the machine through interaction with nonplayer characters. This allows for learning to be replicable and the learning objects to be met by a variety of learners who possess a variety of skills and competencies. The rules need be explicit so learning can increase and become more complex as the player proceeds through the game environment. The actions of the player are usually repetitive and serve to explore the environment and its objects.

There is a balancing act when designing complex SEGs. This is not unlike designing a complex science activity. It involves juggling multiple objectives, choosing what to prioritize and when, what to defer, and what conceptual levels to tap. This is arguably the most difficult part of SEG design. The designer wants to be sure that the player always progresses but must also be certain the player is rewarded for his or her qualities and in-game decisions. If the player reaches the pinnacle of a flow state, then the player reaches pleasurable frustration. This is where a challenge is exciting, yet difficult. Gee (2004) and others have argued that pleasurable frustration is the confluence of deep learning and good gaming.

Students prosper when the subject matter challenges them to the extent of their abilities. Making lessons too difficult causes frustration, whereas making lessons too easy causes the player to become disengaged and bored. Cognitive psychologists call this the regime of competence principal. As opposed to other forms of entertainment, video games uniquely rely on the regime of competence. Movies and TV shows do not start out with simple dialogue or narratives and build in complexity like video games. Books do not pause midchapter to check vocabulary skills. By contrast, even a very early and basic video game such as Pong got more challenging as game time passed (Johnson, 2005). When an
educational game progresses, the abilities of the player should improve and, hence, the game’s challenges should become more difficult. Keeping a game in flow is difficult because it depends on the player. To keep the player in flow, there needs to be a lofty reward in playing on a more difficult level or the player will regress from flow and eventually become disengaged. Another option is to let players skip certain challenges and complete alternative quests that are better suited to their abilities. Many role-play games employ what is sometimes called the “sandbox” design in which players exist in a functional virtual world with clearly defined boundaries and may choose from among numerous “quests” to complete. This idea could be employed for educational games as well. This is where artificial intelligence within game engines could be the structured interactivity through increasing complexity of content and game play.

**Informed Teaching**

For artificial intelligence to work in SEGs, there must be a mechanism for events and behaviors to be recorded. We define informed teaching as the feedback and embedded assessments within SEGs. The resulting feedback is what I have referred to as virtual observations. In education, it is not uncommon for researchers to observe subjects in classroom settings, code the observations, and run subsequent analyses. However, when SEGs become the classroom, it is nearly impossible to physically observe subjects. The notion of virtual observation allows the researcher to collect server-side data that include unique user login IDs, time, location (within the virtual environments), patterns of use and interaction, chat logs, and in-world decision data, through bots or recorded events that in turn serve a similar role as the traditionally coded observation data. The upside is that coded data for all students are available rather than sampled populations in observations in the traditional sense. The ability to track data over time and during each game experience is an arena not completely tapped in educational research.

Informing teaching through virtual observation informs instruction and ultimately informs learning. We see informed teaching as a new way to assess student understanding. As high-stakes testing continues to be at the forefront of teacher accountability, assessing student understanding through performance in SEGs might be the 21st century mechanism for standardizing standardized tests.

**Instructional**

Learning is the goal of any educational endeavor. For SEGs to be instructional, they need to have all of the aforementioned components in addition to the following concepts. Vygotsky (1934) contended that, unlike animals (who react only to the environment), humans have the capacity to alter the environment for their own purposes. It is this adaptive capacity that distinguishes humans from lower forms of life. The animal can only be trained. It can, through exercises and combinations, perfect its intellect, but it is not capable of mental development through instruction in the real sense of the word. This has never been truer than with today’s learners. The net generation, or digital natives as they have been called, have the seemingly innate ability to expand visual-spatial abilities and cognitive load. They thrive in environments that challenge them, making them adapt to those challenges and predict avenues to circumvent other challenges. Many studies have been conducted on cognitive models with both textual and visual stimuli, but, often times, these studies assessed students not yet ready for SEGs in the classroom. However, in one study with Grade 5 students, Annetta et al. (2009) suggested positive gain scores for students from pregame to postgame testing. In this particular study, a teacher-created game was seamlessly integrated into a science classroom. The game became part of the curriculum. The teacher built the game with the other unit activities in mind. Therefore, the game was not a one-time adventure for the students, but something that connected to traditional lab activities and was replayable.

To ultimately ascertain the power of these environments, artificial intelligence or intelligent tutoring systems can overlay a game environment. There is much work on intelligent tutors in gaming environments in which the game ascertains a player’s abilities and the underlying code changes as the player successfully navigates the most basic to most complex challenges. Many modern classrooms are challenged by a heterogeneous mix of student ability. It is not uncommon for the teacher to leave behind either end of the student intellectual spectrum. Content that comes easily for the most gifted students causes those students to get bored as they wait for the teacher to work with their peers who did not assimilate the content as easily. Conversely, students who grapple with difficult concepts or content are often left behind if the teacher decides to challenge the students who understood the material with ease. An SEG with artificial intelligence could challenge the students who “get it” and scaffold learning for those who do not. To this end, the notion of increased complexity comes into play. If the machine understands the strengths and weaknesses of the user, then the environment can adapt accordingly to arrive at the ultimate goal of learning.

Video games have rich visual structures. Visualization is a powerful cognitive strategy, and researchers have long recognized visualization as an essential problem-solving strategy (Rieber, 1995; Treagust, Chittleborough, & Mamialo, 2002). Although both static and dynamic (animated) graphics demand visually attentional resources, animations have increased cognitive demands over static graphics (Lowe, 2003; Seufert, 2003). There may be an issue as to whether cognitive processing can keep up with the rate of presentation (Bodemer, Ploetzner, Bruchmuller, & Hacker, 2005), but we contend that we have not even scratched the surface of cognitive load with younger learners. Modern youth arguably have become the masters of multitasking. They listen to music, instant message, play games, and watch TV simultaneously without much trouble. In fact, they prefer environments such as this. Their cognitive loads seem to have higher capacity than their older counterparts.

The core cognitive information-processing model used by Mayer (2001), Sweller, van Merrienboer, and Paas (1998), and others holds that new information is first received by the sensory system prior to processing by short-term memory. In short-term memory, a number of factors help determine which chunks of information are integrated into long-term memory via schemas. This sequential process means that new information must first be received by a sensory system prior to entry into short-term working memory and possible inclusion in long-term memory. However, material must be meaningful to the learner and must activate prior knowledge for long-term memory to be activated.
long-term memory comes assimilated learning. Games provide a platform for self-regulation where the player can choose how much information he or she can tackle at a given time.

Self-regulated learning in an SEG is most closely based on the stage independent component of Piaget’s theory that can be summarized as epistemic conflict and self-reflection (Forman & Pufall, 1988; Taradi, Taradi, Radic, & Pokrajac, 2005). Learning cannot occur unless an individual is in a mental state of disequilibrium. Learning can be defined as the construction of new knowledge resulting from the resolution to a conflict. Piaget theorized that knowledge is always transitory. Assimilation is the process of understanding the world through existing schemes, whereas accommodation is the process of building new schemes (based on refinements and blending of existing schemes; Phillips, 1981; Piaget, 1952). When we tap learners’ existing knowledge base (schema) in SEGs, players take new experiences and connect them to their prior knowledge and experiences, thus allowing players to assimilate the embedded content. SEGs also need to be organized so that information is efficiently recalled.

To do this, we have used problem-based, experiential learning to aid the transfer of experiences in SEGs to those outside through allowing students to construct their own knowledge by constructing their own game. Although there are numerous benefits to problem-based learning, the literature indicates that implementation can be challenging. Technology creates “new opportunities for curriculum and instruction by bringing in real-world problems into the classroom for students to explore and solve” (Bransford, Brown, & Cocking, 2000, p. 195). Problem scenarios must also be complex. Students should recognize that a problem does not necessarily provide them with all needed information. If students are not challenged by the problem, they may assume there is a single, obvious solution and be reluctant to invest effort in the problem. Students must not get frustrated or feel like a problem is too difficult to solve. They must also feel like the problem can be solved in the time allotted within the game environment (Cook, 2007). SEGs can bring about a lifelike experience to problem-based learning that cannot be replicated in the traditional classroom or even on field trips (Annetta et al., 2007). If playing SEGs influences learning in terms of constructing a connection between virtual life and real life and encouraging critical thinking (Lim, Nonis, & Hedberg, 2006; Mitchell & Savill-Smith, 2004; Turvey, 2006), then building SEGs should influence more long-term memory channels.

When students are actively immersed in an SEG environment, learning is stealthy. That is, students do not realize they are learning embedded content. Active learning assumes that meaningful learning occurs when learners engage in active cognitive processing, which includes attention to incoming words and images, mentally organizing them into coherent verbal and visual representations, and mentally integrating them with prior knowledge (Mayer, 1997). If students are the designers, then they provide the framework for when words and images emerge and the learning scaffolds, by which they inherently understand the material to reach an SEG’s climax. SEGs are at their best when active learning is stealthy.

In a classroom setting, the teacher is responsible for creating scaffold-structuring interactions and developing instruction in small steps based on tasks the learner is already capable of performing independently. The instructor is also charged with providing support until the learner can move through all tasks independently. When students create SEGs, the instructor becomes the facilitator and in essence models good practice by scaffolding the design process that students will use to incorporate learning scaffolds in the SEG.

Scaffolds develop learners’ zones of proximal development (ZPD). Vygotsky defined ZPD as the difference between a child’s actual and potential levels of development (i.e., what a child can do alone and with the assistance of an expert/computer agent). According to Vygotsky (1978), play creates a broad ZPD, both in cognitive and socioemotional development. In make-believe play, children perform above their own cognitive abilities—logical thinking, memory, and attention. We have found that students construct SEGs with play in mind. They want to create an SEG that is fun and fantastic. Using creative processes is the essence of make-believe play. Students are essentially playing as they create. Vygotsky would likely contend that instruction cannot be identified as development, but it could be that properly organized instruction will result in the child’s intellectual development, will bring into being an entire series of such developmental processes that were not at all possible without instruction. Accordingly, the teaching methodology that aligns with ZPD “integrates several approaches to form a comprehensive agenda for research of the genesis, development, function, and structure of the human psyche” (Hedegaard, 1996, p. 229).

Conclusion

In conclusion, SEGs are not a panacea; they are simply an instructional tool for potential use by all ages. What is different from traditional instruction is the infusion of technology to create games and arguably, more important, to assess learning in those games. Leveraging artificial intelligence in SEGs allows them to react to a wide spectrum of learning ability. The biggest issue limiting SEGs is the lack of good artificial intelligence to generate good and believable conversations and interactions (Gee, 2003). Video games exploit both verbal and visual information that are processed in different cognitive subregions. Words are processed only in the verbal region, whereas images are processed in both regions (Paivio, 1986), the other region is the visual region allowing for greater depth of processing and increased availability of multiple retrieval cues. According to Vygotsky, such developmental factors as memory, skill acquisition, and reasoning ability affect a child’s capacity to incorporate new knowledge into existing schemes of thought. Incorrect preconceptions need to be confronted in an appropriate manner to help students develop a deeper understanding. Metacognitively guided learning or reflection, constructing conceptual representations through thought experiments and graphical representations, argumentation coupled with model-based reasoning, and idealized representations are effective methods that should be incorporated in the learning progression modules (Vygotsky, 1962) in educational video games.

Finally, SEGs have the potential to be the new standardized test. Regurgitating facts on bubble sheets has proven to be an unsuccessful endeavor in ascertaining student knowledge based on norm-referenced testing results. Either through play or constructing SEGs, learning is assessed in a performance-based manner. In science, we often ask our students to construct a laboratory experiment to see how well they understand the mechanism by which
the group out of this ravine.

information needed to solve the question of the orbs that will lead
must be solved by choosing one of the variously colored floating
orbs and provides players wishing to escape with a question that
the players can piece together is that a guardian ant resides over the
professor vanished into thin air and has not been seen again. What
hopes of finding a means of escape and confronted a set of strange
language. The professor awoke the graduate student of the team in
their strange clicks and squeals as if they were part of a human
language. The professor awoke the graduate student of the team in
hopes of finding a means of escape and confronted a set of strange
glowing orbs at the far end of the ravine; on touching the orb, the
professor vanished into thin air and has not been seen again. What
the players can piece together is that a guardian ant resides over the
orbs and provides players wishing to escape with a question that
must be solved by choosing one of the variously colored floating
objects. The game’s intent is for the player, as the lead scientist on
the team, to talk to the local ants and try to pick up on any valuable
information needed to solve the question of the orbs that will lead
the group out of this ravine.

Almost immediately, the player is given an identity (a lead
scientist of the research team). The player then becomes immersed
in the SEG by the motivating factor to learn about the ants,
communicate with them, and answer the questions of the orbs before
time runs out. Interacting with other members of the re-
search team and eventually the invasive ant species further im-
merges the player. As the player learns about the invasive ant
species, he or she must answer the questions of the orbs, which
become increasingly more complex as the game progresses. The
teacher who designed the game was able to access the clicks and
answers to the questions provided by his student players from the
game’s database. These results informed his teaching practice and
allowed him to adjust the game’s scaffolds and develop other instruc-
tional activities to align with the learning objectives in the SEG.

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