Collaboration, Communication, and Problem Solving:

Virtual Environments Designed to Facilitate Cognitive Growth

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Technology is continuously evolving, and there has been hope throughout that it can “improve, and even revolutionize, how students learn and teachers teach” (Bruning, Schraw, & Norby, 2011, p. 215). The technologies of today hold the same potential when designed and used in optimal ways for cognitive growth. One such technology is virtual reality, the use of three-dimensional digital environments in which “participants assume an avatar persona and explore and/or engage with the on-screen objects” (Clark & Mayer, 2011, p. 474). Cognitive theories related to such virtual learning environments include cognitive load theory, self-regulated learning theory, and social cognitive theory (Bruning, Schraw, & Norby, 2011). Researchers have explored learning within a variety of immersive virtual environments in areas such as computer-supported collaborative learning (CSCL), narrative-centered learning (NCL), and Massively Multiplayer Online Games (MMOGs). McCreery, Schrader, and Krach (2011), researched the MMOG World of Warcraft (WoW) in respect to learning, and state that it provides users “with opportunities for problem solving, collaboration, and communication while in the pursuit of shared goals” (p. 474). When virtual environments are effectively designed for collaboration, communication, and problem-solving, learners become engaged and cognitive growth is facilitated.

Collaboration

Many virtual environments have been designed as a means for collaboration. Social cognitive theory stresses the central role of social interactions in learners’ cognitive growth (Bruning, Schraw, & Norby, 2011). In MMOGs such as WoW, players interact socially to accomplish complex objectives, their collaboration being necessary for success (McCreery, Schrader, & Krach, 2011). Another example is a CSCL entitled I-MINDS, in which intelligent agents are used to facilitate collaboration by assigning students to collaborative learning groups. Specific “group agents” are designed to support the groups by monitoring students’ interactions to evaluate their contributions as members (Soh, Khandaker, & Jiang, 2008). Collaboration among learners can foster self-regulation skills and provide excellent opportunities for modeling.

Self-Regulation

Self-regulated learning theory has three principal components that virtual environments can potentially promote: metacognitive awareness, motivational control, and strategy use (Bruning, Schraw, & Norby, 2011). For example, the MMOG WoW facilitates the planning sequence in metacognition by requiring extensive preparation, practice, and coordination among players to reach their goals (McCreery, Schrader, & Krach, 2011). The virtual environment of Second Life, when used for activities such as digital storytelling, provides a balance of challenge and skill that motivates and engages learners (Xu, Park, & Baek, 2011). Strategy use is a focus of the NCL environment Crystal Island, in which learners can gather information and move through the narrative using multiple methods. For example, “if a student squanders her available tests by using a haphazard problem-solving strategy, she must demonstrate her understanding of microbiology concepts in order to continue” (Rowe, Shores, Mott, & Lester, 2011, p. 120-121).

Modeling

In addition to improving learners’ self-regulation skills, virtual environments offer opportunities for modeling of these skills through teachers’ and/or learners’ avatars. Sanchez (2009) sees the sharing of created digital stories by learners in Second Life as “a type of asynchronous social learning and modeling” (as cited in Xu, Park, & Baek, 2011, p. 183). To aid in cognitive growth, Bruning, Schraw, and Norby (2011) suggest that teachers and students should model strategy use and self-efficacy for less regulated students, providing motivational and informative examples of expert performance. This is especially relevant to the MMOG WoW, as McCreery, Schrader, and

Krach (2011) found a significant difference in performance between expert and novice players. They cite Martin's (2008) description of virtual environments as "spaces where students are able to engage in cooperative learning that is supported through a broad range of instructional practices including role-play and modeling" (p. 479). In their multi-user virtual environment (MUVE), D. Charles, T. Charles, McNeill, Bustard, and Black (2011) ensure that "as a learner's avatar levels up, gathers achievements and thus gains stature, that person is offered the opportunity to lead or mentor younger or less capable members of the society" (p. 652).

Communication

In order for modeling or collaboration to occur, effective communication must be present. Virtual environments can be designed to allow for multiple means of discourse, allowing learners to interact in planning and in sharing feedback. For example, McCreery, Schrader, and Krach (2011) state that by design, MMOGs are intended to be "highly social, and typically connect thousands of players from across the world through a variety of communication tools" (p. 474).

Discourse

Communication tools allow for discourse between learners and/or teachers to foster cognitive growth. These discussions can potentially facilitate organization and extension of knowledge, externalization of thought, and reflection (Bruning, Schraw, & Norby, 2011). Means of discourse within virtual environments include various forms of text-based chat, e-mail, note card, blogs, whiteboard, voice software, and even gestures/movement of the avatars (McCreery, Schrader, & Krach, 2011; Soh, Khandaker, & Jiang, 2008; Xu, Park, & Baek, 2011).

Feedback

Discussions among learners and/or teachers within a virtual environment can be a channel for feedback to further enhance cognitive growth. For example, McCreery, Schrader, and Krach (2011) state that "researchers have concluded that communication within MMOGs is instrumental for promoting the pursuit of shared goals and objectives, authentic learning, the social construction of knowledge, cognitive apprenticeship, and expert to novice mentoring" (p. 475). Virtual environments can also be designed to provide immediate and specific feedback on performance, which Schute (2008) found to have a positive effect on students' self-efficacy, engagement, and subsequent performance (as cited in Bruning, Schraw, & Norby, 2011). An example of this type of design is the virtual learning landscape (VLL) within MUVE. Every time learners enter the VLL, individualized feedback for each learner or group is generated by means of the avatar-landscape interface, in which an "avatar's capabilities and characteristics are generated from learner statistics…and these attributes reflect on an avatar's capability to interact with the virtual world" (D. Charles, T. Charles, McNeill, Bustard, & Black, 2011, p. 652).

Problem Solving

Though communication and collaboration within virtual environments can result in cognitive growth, McCreery, Schrader, and Krach (2011) point out that learners "must first learn these communication skills and the tools associated with them, followed by applying those skills and tools in an appropriate manner" (p. 475). When the present state varies from the desired state, a problem exists (Bruning, Schraw, & Norby, 2011). Whether learning how to effectively interact within the environment or how to accomplish highly complex goals, one's problem-solving skills are fostered through acquisition of knowledge and practice.

Acquisition of Knowledge

Solving problems in a virtual environment, especially for the novice, requires obtaining both general and domain knowledge in order to acquire the information, skills, and strategies necessary for success. In reference to MMOGs, McCreery, Schrader, and Krach (2011) state that "players must identify what information is available, how to access that information, evaluate the information, and apply what they have learned" (p. 477). Though novices and experts possess similar levels of general knowledge, novices tend to lack domain knowledge, which is closely related to problem-solving abilities necessary for in-depth understanding of problems they encounter (Bruning, Schraw, & Norby, 2011; McCreery et al., 2011). In the CSCL environment of Sharlok, agents assist learners in gaining knowledge for problem-solving by observing their actions and then notifying them about other learners "(1) who are having the same problem, (2) who have a different point of view about the problem, and (3) who have the potential to solve the problem" (Soh, Khandaker, & Jiang, 2008, p. 144).

Practice

Gaining pertinent knowledge is not the only way to improve one's problem-solving skills. According to cognitive load theory, promoting automaticity of procedures through practice and repetition can improve cognitive growth by freeing up working memory for essential processing. This may also potentially assist in the transfer of problem-solving skills across domains (Bruning, Schraw, & Norby, 2011). In their study of the MMOG WoW, McCreery, Schrader, and Krach (2011) compared players with distinctly different amounts of practice with WoW: at least two years of experience, one or more avatars at maximum level, and one year of end-game raiding experience (experts); and zero experience (novices). McCreery et al. (2011) found that whereas experts were "able to engage in complex, situated activity involving collaboration and problem solving" (p. 490), novices had difficulty controlling even their avatar's basic movements, and showed an extremely low level of social engagement. Learners' automation of basic skills necessary in virtual environments through practice will allow for enhanced collaboration, communication, and problem-solving.

Design

In order for virtual environments to effectively facilitate cognitive growth, certain design principles should be followed so as to decrease extraneous cognitive load and focus on learning objectives. For example, the creators of the NCL environment Crystal Island abandoned their earlier, more elaborate versions of the program in favor of a narrative that was "sufficiently detailed to motivate the educational problem-solving task and preserve an authentic and consistent story world, but…simplistic enough to avoid distracting students from the software's primary learning objectives" (Rowe, Shores, Mott, & Lester, 2011, p. 129).

D. Charles, T. Charles, McNeill, Bustard, & Black (2011) describe an educational dilemma in the creation of virtual learning environments: how to enable learner self-determination without impeding learning objectives and pedagogical guidance. They suggest that, as shown in the design of MUVE, virtual environments should balance designer and user control; be highly interactive with learners embodied as avatars; and include both a hub to facilitate groupings and personal spaces to view feedback/achievements.

For e-Learning games and simulations similar to virtual environments, Clark and Mayer (2011) discuss design principles proven to maximize learning potential: match game types to learning goals; make learning essential to game progress and relevance prominent; build in proven instructional strategies along with guidance and structure; and manage complexity. Overall, Bruning, Schraw, and Norby (2011) state that educational technology programs should be chosen for their relevance to cognitive principles in order to "produce desired student learning, motivation, strategic behaviors, and metacognitive development" (p. 233).

Conclusion

As technology in general has advanced in its usefulness to education, so has the specific technology of virtual environments. One of virtual reality's unique capabilities is its "ability to provide students with the opportunity to learn in open-ended learning environments and to interact in ways that distance, time, or safety factors make unavailable" (Xu, Park, & Baek, 2011, p. 189). Virtual environments can be designed in a variety of formats such as CSCL, NCL, and MMOGs to promote engaging and purposeful learning experiences. The possibilities provided by virtual reality technology allow for “the prospect that students will be better able to master, retain, and share new knowledge as they actively engage in constructing knowledge in virtual learning environments” (Xu, Park, & Baek, 2011, p. 189). With proper design, virtual environments can facilitate cognitive growth through collaboration (supporting self-regulation and modeling), communication (including discourse and feedback), and problem-solving (fostered by knowledge acquisition and practice).

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