Two Systems, Two Stances: A Novel Theoretical Framework for Game-Based Learning

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Abstract: Recent reviews of the research on game-based learning agree that digital games as pedagogical tools add limited value. A more sophisticated theory of learning is clearly required to advance game-based learning research. This poster presents our efforts to conceptualize game-based learning within a more general framework for human cognition, the "two-system" model. Our extension of this model mechanistically explains some of the complexities of game-based educational research and provides several potentially interesting research vectors.

Introduction and Goals

Reform perspectives on science education highlight the role of models in promoting student learning (Committee on Science Learning, 2007). Computer simulations are useful for modeling complex processes and relationships which are difficult to observe directly (Windschitl & Andre, 1998). Clark, Nelson, Sengupta & D'Angelo (2010) argue that digital games can be accurately described as simulations encased within game-like structures to increase student engagement, provide effective feedback, and promote self-efficacy. However, recent reviews have suggested that digital games provide only limited educational benefits (Young et al., 2012). The increasing sophistication of educational games promises to improve their outcomes, however, a unifying causal model that explains how people learn from games has remained elusive.

The goal of our proposed framework is to support a more sophisticated understanding of how and what people learn from digital games. We are motivated by the strong contrast between recent scholarship that finds little evidence that people learn much from digital games (Young et al., 2012). Opposite to that finding is the observation that players inhabit rich ecologies of knowledge about the games they play (Gee, 2007). The disconnect between the relatively low efficacy of games for learning and the often-impressive feats of cognition and inquiry observed by gamers "in the wild" motivates us to develop a more robust theoretical framework.

Software Models and Mental Models

Aside from principles related to multimedia learning, mental models are frequently featured as the causal mechanism behind learning outcomes from digital games. The proposed mechanism for game-based learning is that students purposefully investigate the digital environment, "try hard to make sense" of it, and the product of their effort is a "coherent mental model" (Moreno, Mayer, Spires, & Lester, 2001, p. 185). This model enables students to solve problems both within the game *and* at a later time and in different context.

Our premise is that players do not necessarily form accurate mental analogues of the software models that drive the phenomena they experience in-game (i.e. the encased "simulation"); rather, they create a second-order model (i.e. a "simulacrum") that is oriented towards explaining the functioning of the simulation, predicting future states, and allowing the user to feel she understands the simulation and is in control of it.

"Learner" Stance and "Player" Stance

A person might have two distinct goals when engaging with their simulacrum. The first is to understand the simulation, its objects and relationships. The second is to use the simulacrum as a laboratory where actions can be planned and evaluated in terms of their effectiveness at creating a desired state. A student playing a digital game is constantly shifting in stance between (a) a problem-solver seeking a specific desired outcome, i.e. winning, and (b) an explorer purposefully and systematically investigating the operating principles of the virtual environment. These two sets of goals imply different forms of thinking. A user in the inquiry (or "learner") stance might probe the simulation for information that confirms their understanding. A user in the mastery (or "player") stance might engage in exploratory actions and observing if these actions lead to positive results.

The 2SM in Action

The interaction between the simulation and the simulacrum can be conceptualized using a two-system model of cognition (see Evans, 2008). Two-system models of cognition distinguish between effortless thought, or "intuition", and deliberate purposeful "reasoning". These modes of cognition are neutrally labeled as System 1 and System 2, respectively. The former is described as fast, automatic, associative, emotional, and opaque; the latter as slower, controlled, serial and self-aware. In our framework, we associate System 1 with the "player" stance and System 2 with the "learner" stance.

Starting from the two-system model of cognition, we propose this mechanistic explanation for how people play and learn from digital games. A person begins play, and a goal will be suggested to the player's thinking, immediately triggering a self-query, "how do I achieve this goal?" The self-query shifts the person towards the learning stance, and in response to the query a simulacrum is constructed. This simulacrum's functional requirement is that it suggests actions that will bring the simulation closer to the goal state. These actions are rendered as execution steps ("Do that") and enacted in the simulation through the game's interface. Actions that prove effective are reinforced and actions that have a negative effect are rephrased as avoidance steps ("Don't do that"). With repeated reinforcement, effective rules are matched to the context cues from the environment, and stored as conditionals, i.e. "If this, do that." These conditionals are easy to remember, quick to access, and require nearly no cognitive effort to execute: they fit the functional definition of heuristics.

Whenever the player finds themselves in a situation that is covered by one of her stored rules, she will in most cases default to doing what that rule stipulates. In other cases, the person must shift to a learning stance, reinstate the simulacrum and use it to find new possible actions. The simulacrum that is rebuilt is based on the one last used, since reinforcement of effective actions also reinforces the simulacrum that suggested that action. If the player is never without a rule to apply, the simulacrum is deactivated as the person defaults to System 1-style processing, i.e. fast, effortless, intuitive heuristics. Through play, a person gathers three forms of knowledge about the game: (a) the conditions that the game presents, (b) a set of heuristics, i.e. rules of action whose activation criteria match these conditions, and (c) a simulacrum, or second-order mental model, of how the game produces the conditions.

Implications and Possible Lines of Research

The baseline assumption of mental-model accounts of game-based learning is that once learners form their mental models, these models remain available in other contexts. Our framework problematizes that assumption since simulacra, like all System 2 processes, are pre-empted by System 1 processes such as rules and heuristics whenever these are available (Schwartz & Black, 1996). Given that System 1 is the preferred mode for everyday thought, it is unlikely that students retain a mental model that is useful in new contexts. How then can designers disrupt the learners' natural tendency to discard simulacra and reason from heuristics?

One possible approach is to design an educational game that is constantly offering new goals as well as rules and constraints. Since the player cannot cope with them using existing heuristics, she must shift back into the learner stance, reinstating the simulacrum. If this happens frequently enough, the student may eventually become habituated to reasoning from a context-unbound mental model, rather than context-bound heuristics. This may result in greater availability of the mental model for problem-solving in other contexts. This design approach suggests a radically different form of educational game, featuring a constantly increasing novelty, escalating complexity, and tighter coupling between the player's goals and the software model. Our first challenge is to build a game upon these two principles, and assess its effectiveness vis-à-vis alternative designs.

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