Exploring a Studio Critique Model for STEM Evaluation

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Abstract: Through the principles of “leveling up” and “epic win,” gaming builds assessment into the process of learning (Gee, 2003).Gaming provides a model to evaluate the user’s quest for knowledge as well as the synthesis of material beyond the accumulation of time on task. These ideas of progression parallel the non-linear aspects of visual accomplishment that studio educators seek to quantify. This paper seeks to explore the connections between game theory, studio/lab practice, and the ways that educators are framing the component aspects of a complex learning experience. The goal will be to propose methods of formal evaluation and rubric generation to facilitate accountability for these highly complex learning environments.

In her paper, Semiotic Pedagogy and Art Education, (1995) Deborah L. Smith-Shank suggests that the current teaching dynamic “…assumes that there is a correct body of knowledge for a teacher to communicate to students. These models assume a hierarchical architecture of facts and ideas with higher forms of knowing built through some concatenation of simpler forms. In order to move away from the dominant hierarchical model, it is necessary to develop an entirely different framework.” The notion of “student as receiver of information” needs to evolve to “student as author of understanding”.

Design Thinking and The Scientific Process

Recent studies indicate that complex and immersive games can contribute significantly to student understanding of difficult concepts in the sciences because they entertain and motivate students to engage in complex thinking and problem solving. Applying modern game paradigms to STEM learning promotes several learning principles, including the achievement principle where players earn intrinsic rewards from learning, the material intelligence principle where they use objects in their reasoning efforts, and the transfer principle where they are given multiple opportunities for practice and applying learning to novel contexts (Gee, 2003). In a comparative study, Barab et al., (2009) found an immersive gaming experience to produce significantly higher learning outcomes than other science learning experiences.

Virtual Biology in a Box

The proposed *VBioBox* game series leverages the Biology in a Box K-12 outreach project’s mission of understanding STEM through scientific inquiry/practice to a global audience. Under this learning strand project we specifically will test the idea that an immersive video gaming experience that employs successful gaming paradigms and is deployed online (apps and web), can successfully engage students in learning STEM subjects and gain their interest in STEM fields. We have chosen evolution by natural selection as the theme for our first game entitled *Epoch Traveler Challenge* (ETC), because this difficult concept provides a unifying framework to understanding and integrating the immense body of knowledge available on biological systems. ETC is designed to immerse students in STEM (science, technology, engineering, and mathematics) educational experiences where they will function as biologists gaining the practices, tool sets, and understanding of concepts needed to meet single player virtual world traveling and multi-player shark design challenges.

This project represents a quantitative examination of the potential benefits of edutainment to student learning and perception of STEM disciplines. Can immersion in a role-playing game infuse in students an understanding of the process of science, draw their interest towards STEM fields and, in this particular ETC game, provide them a deep understanding of the factors underlying biodiversity? Role-playing (Riechert et al. 2011) allows students to explore evolutionary processes for themselves. Including the mathematical, physical science, and geological underpinnings of biology in our ETC and future *VBioBox* games illustrates to the students the inherent quantitative nature of biology and allows them to make connections between concepts taught in biology and other STEM courses. In evaluating this game, we will examine the relationship between student progress through the game environment and their corresponding gain in knowledge of concepts and practices achieved during the course of play. We are most interested in whether a student’s level of understanding of ideas and practices they are exposed to makes the progression beyond *knowing that* to *knowing how* and from being able to explain (*declarative knowledge*) to being able to actually do (*procedural knowledge*) (Schaffer, 2006).

The *VBioBox* game, targeted to high school students, fosters the formulation and testing of hypotheses (reflectivity; scientific inquiry; and trial-and-error learning), based on available data and observations (exploratory learning), promoting deep understanding through agency (Murray, 1997). The game features a seamless integration of *iterative* (Salen and Zimmerman, 2004) and *incremental* (Schell, 2008) design, implementing meaningful progressive steps to success. In fact, players can reformulate hypotheses applying new understanding and knowledge acquired through in-game challenges tailored to their level of expertise, made visible through continuous assessment and feedback. The goal is to offer the appropriate amount of challenge to the players, stimulating their curiosity and promoting active learning in their Zone of Proximal Development (Vygotsky, 1978).

The game, as opposed to a traditional approach of *learning science*, is a *doing science* experience. In fact, it puts the player in the role of an apprentice in a science lab, whose ultimate mission is to ensure survival of the human race over time. The knowledge acquired through the game (e.g., collecting and analyzing fossils) constitutes *evolutionary building blocks* that will be used to create the "fittest" shark, and, finally, acquire knowledge that will benefit mankind. This process stimulates the transfer of scientific knowledge across evolutionary domains (from fossils to sharks to human beings), advancing scientific thinking and promoting a comprehensive approach to STEM learning.

This learning trajectory requires a form of assessment capable of identifying and valuing, rather than measuring, the efforts and progress of each player. In this context, the *VBioBox* research team is working on two entwined assessment features: 1) a *rubric*, considering the multifaceted dimensions described above, in relation to the subject (science/biology) and the targeted audience (high school students); 2) a *representational model*, which includes visual and graphic elements to represent the learning process, and to communicate and situate the progress to both teachers and students, in a meaningful way (rather than providing letters, numbers, or general comments). Through this approach, the game makes the integrated assessment relevant and visible, in order to advance the understanding about student's knowledge, attitudes, and perceptions toward biology and STEM disciplines.

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