Learning as mediated by a nodal ecology: Findings from studies of *Gamestar Mechanic* and Quest to Learn

Abstract: The authors present two research studies related to game-based learning environments designed to help middle and high school students develop systems thinking skills. Pre and post testing and mixed-methods (quantitative and qualitative) longitudinal collection methods were used. The two studies focus on: (a) *Gamestar Mechanic*, an online video game, and (b) Quest to Learn, a games-based school which recently opened in New York City. Both studies assessed middle school students' ability to develop system-thinking skills as result of participating in these educational interventions. Levels of change in the development of systems thinking will be described in the paper, but the authors' main focus concerns *how* these gains were attained by the students. What role did context play in the learning process? The authors argue that a "nodal ecology" of redundant and predictable learning experiences serve to explain changes in cognitive development.

This poster presentation presents two studies that assessed middle school participants' development of systems thinking after participating in games-based learning environments. Both learning environments were designed using a "nodal ecologies framework," and claims about cognitive development have therefore been analyzed to understand the efficacy of this framework. Conceptualization of learning contexts as *learning ecologies* was guided by research and theories pointing to meaning making, cognitive development, and identity formation as a process whereby individuals travel through sets of varied but inter-related learning spaces (Bronfenbrenner & Morris, 1998; Goldman-Segall, 1998; Lave & Wenger, 1991; White, 2008). The learning ecologies for both studies discussed in this paper have been framed around a set of interacting, interdependent learning nodes. Nodes in a particular ecology are defined as interconnected, but distinct physical or virtual spaces that house predictable and redundant instances of specialized content (e.g, systems-thinking, algebra, fashion, basketball), social activity, learning tools, and a discourse the defines certain ways of knowing and doing.

One study employed a game called *Gamestar Mechanic*, intended to help middle and high school students develop basic game design skills. Both game design, as well as systems thinking skills, were conceptualized as dialogic in nature. The overall study, designed using design-based research methods (Barab, 2006; Barab & Squire, 2004), focused on testing the viability of using *Gamestar Mechanic*—and the learning ecology it instantiated—to improve students' systems thinking skills. A principal research question that guided the study was: Does a learning ecology generated and mediated by the game design of *Gamestar Mechanic* improve participants' ability to engage in systems thinking?

The second study, which is currently underway and uses both qualitative and quantitative methods (Shute, 2009), similarly considers the nodal ecology of Quest to Learn, a new games-based school that opened in New York City in September 2009, in relation to middle school students' development of systems thinking skills. Similar to the *Gamestar* study, Quest to Learn has designed a learning environment framed around a nodal ecology of learning experiences. Enabling students to develop systems thinking is also a core goal of the school.

Brief overview of systems thinking

We are currently witnessing a foregrounding of complexity as one of the defining characteristics of our new century. Stephen Hawking (2000) has said that we are living in the era of complexity and that complexity itself will form the science of the 21st century. Similarly, Heinz Pagel (1988) has written that those who master this science will form the economic, political, and cultural superpowers of this new century (see also Rambihar & Rambihar, 2009). Systems thinking for both studies is defined as the ability to see and understand the "big picture." This requires learners to solve problems using a wholistic versus a reductive (e.g., considering discrete variables) approach (Shute, Masduki, Donmez, et al., in press; Torres, 2009a, 2009b). Specific systems thinking skills that both studies assessed include: dynamic thinking (i.e., the abilty to account for reciprocal interactivity between variables), closed-loop thinking (i.e., the ability to

account for reinforcing and balancing feecback dynamics and time delays), and model transfering (the ability to see how similar system dynamics may be present in other seemingly dissimilar systems).

The crux: Implications and significance

While this presentation will offer an overview of systems thinking, along with quantitative learning gains students have made in their systems thinking development, the key issue concerns the research and design of learning environments. In most schools, students are given opportunities to learn in one primary node—the classroom context. Furthermore, in most instances they are learning *about* something instead of learning *to be* something, such as a chemist, historian, journalist, and so on. Seeing learning as intricately tied to identity development, both leaning interventions discussed here ask students to step into roles and specific identities (e.g., game designer, scientist, historian). The two studies we report on depart from a customary "learning about" approach to teaching and learning. Indeed, the notion of cognitive development resulting from social, physical, and mental activity through the passage of nodes offers a striking departure from the design of learning environments in schools today.

References

Barab, S. (2006). Design-based research: A methodological toolkit for the learning scientist. In R. K. Sawyer (Ed.), *The Cambridge handbook of the learning sciences*. Cambridge, England: Cambridge University Press.

Barab, S., & Squire, K. (2004). Design-based research: Putting a stake in the ground *The Journal of the Learning Sciences, 13*(1), 1-14.

Bronfenbrenner, U., & Morris, P. (1998). The ecology of developmental processes. In W. Damon & R. M. Lerner (Eds.), *in Handbook of Child Psychology*. New York: John Wiley & Sons.

Goldman-Segall, R. (1998). *Point of viewing children's thinking*. Mahwah, NJ: Lawrence Erlbaum Associates, Inc.

Hawking, S. (2000). Science in the next millennium Retrieved December 20, 2008, from http://clinton4.nara.gov/ Initiatives/Millennium/shawking.html

Lave, J., & Wenger, E. (1991). *Situated learning: Legitimate peripheral participation*. New York: Cambridge University Press.

Pagel, H. (1988). *The dreams of reason: The computer and the rise of the sciences of complexity*. New York: Simon and Schuster.

Rambihar, V. S., & Rambihar, V. (2009). Complexity science may help in defining health. *BMJ.* Retrieved on February 2, 2009, from http://www.bmj.com/cgi/content/extract/338/jan09_1/b32

Shute, V. (2009). Assessing Quest to Learn, MacArthur Funding Proposal, August 2009 to January 2011 (18 months).

Shute, V. J., Masduki, I., Donmez, O., Kim, Y. J., Dennen, V. P., Jeong, A. C., & Wang, C-Y. (in press). Assessing key competencies within game environments. To appear in D. Ifenthaler, P. Pirnay-Dummer, N. M. Seel (Eds.), Computer-based diagnostics and systematic analysis of knowledge, New York, NY: Springer-Verlag.

Torres, R. J. (2009a). *(Dissertation) Learning on a 21st century platform: Gamestar Mechanic as a means to game design and systems-thinking skills with a nodal ecology*. Ann Arbor: UMI ProQuest.

Torres, R. J. (2009b). *Learning on a 21st century platform: Gamestar Mechanic as a means to game design and systems thinking within a nodal ecology*. New York University: ProQuest Dissertations.

White, H. C. (2008). *Identity and control: How social formations emerge*. Princeton, NJ: Princeton University Press.