Kinecting in Physics: Student Conceptualization of Motion Through Visualization

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Abstract: The purpose of this study is to share findings associated with using a Kinect® to generate large-scale visualization that served as a mechanism for student learning of physics. We explored the development of student comprehension of motion and examined the development of students' communication of these concepts to others. We examined the affordances of Kinect® in pedagogical practices, looking at how the hardware can be used to better scaffold student learning of physics.

The Major Issue

Secondary students often have ideas about science concepts that are disconnected. One way to overcome these conceptual challenges is through the use of computer games and simulations that have the capability of immersing students in the study of unfamiliar scientific concepts (e.g. NRC 2011). Students often play virtual games and, through their play, develop tacit understandings of topics such as velocity and acceleration. However, gaming practices are not designed to provide opportunities for student articulation of Newtonian Physics or to extend the ideas that emerge. Though this is a challenge, research suggests (e.g. Masson et al. 2011) that the scaffolding of games and simulations can be used to support learning (Gee 2008). These simulations also have the potential to support students in integrating instructed knowledge with their tacit conceptual knowledge (NRC 2011), when the specific design of a simulation allows students to make choices that affects the models or visual images that are being generated. By using visualizations students can begin to integrate discrete ideas, allowing them to begin to make connections (Linn & Eylon, 2006) with complex scientific content that is represented through observable, unwritten representations. Studies, (e.g. Bereiter & Scardamalia, 2010) demonstrate that when instruction includes the students' co-construction of knowledge, students feel empowered to take ownership of their learning. The Xbox Kinect represents a new type of digital tool that can potentially strengthen these social interactions and embodied experiences in physics classrooms (Tolentino et al., 2009). One way in which this can occur is through the representation of dynamic processes at multiple spatial resolutions (Tolentino et al., 2009). By using the Kinect, students can move between multiple levels of abstraction (Megowan, 2007). This study examined the use of 3D simulation to support the teaching of Newton's Laws of Motion in a secondary physics classroom. Recognizing the affordances of embodiment and spatial resolution of this technology, our study aimed to identifying factors that allow Kinect simulations to increase student participation while simultaneously challenging them in their conceptualization of science content. Specifically: *How can the Xbox Kinect be used in pedagogically valuable ways to scaffold instruction in Newtonian physics?*

Context, Methods and Analysis

Using a design based research methodology (Brown, 1992), this study has completed two iterative cycles. These were conducted at rural schools located in the Southeastern United States. Participants included secondary students in a physical science class (n= 24). During each cycle, students were engaged in a unit on kinematics with a specific focus on displacement, velocity, and acceleration. As part of the designed implementation for each iteration, the students received instruction that included a series of stations with inquiry based learning. Each station allowed students to explore specific concepts related to kinematics. These activities encouraged student learning in two ways: 1) understanding of basic concepts associated with kinematics and 2) the transfer of conceptual understanding from one context to another. In addition to these stations, the experimental groups had an additional station that involved using the Kinect. Student transfer of conceptual understanding was then challenged through the use of large-scale visualization and communication to their peers of ideas associated with kinematics. During the first iterative cycle, data was collected from three primary sources: visual data using the Kinect, classroom observations, and interviews with the students. In the second iterative cycle, data was collected from four sources: a kinematic assessment, visual data (both traditional and Kinect generated), observations, and student interviews. The quantitative data was analyzed using descriptive statistics only because of a small sample size. The qualitative data collected to date has been analyzed using naturalistic methods to examine how learning unfolded during the use of the Kinect in the classroom. Using the constant-comparative method (Glaser & Strauss, 1967), researchers generated assertions from the data, consulting field notes and interview data to search for supporting and disconfirming evidence.

Results

Iterative Cycle I: Observations of activity with the Kinect revealed that students had basic understandings of kinematics with one and two objects. Though comprehension was present, interviews revealed that the graphs being generated during the exercise resulted in some confusion. For example, when plotting acceleration, the Kinect® registered acceleration of the body movement. Because the visualization extrapolated information from multiple data points, the students had difficulty unpacking what was occurring. Their discourse also did not reflect that they were making sense of their observations. Instead of trying to understand the zig-zag lines generated by the multiple data points the students often stopped. For example, Brad, in the post interview stated the following: "*I was like, why is it doing this? It doesn't look like a graph for velocity should."*

Iterative Cycle II: Data and observations from this iterative cycle demonstrated that students have a preference for visual learning. In the interviews, one student noted, *"I feel that seeing is the best way to learn. I would like to see it and then learn it."* This was a common theme throughout the interviews. Students made sense of their data through their comparisons of the Kinect data with graphs generated in the inquiry stations. The differences found in the graphing mechanisms seemed to contribute to students' lack of conceptual understanding. This was supported by the quantitative findings that showed the experimental group scoring lower than the control group. This indicates that further scaffolding and support structures are needed in the next design cycle that will help students to work through the visualization and eliminate the potential misconceptions.

Conclusions

The use of the Kinect® did generate large-scale visualizations and hands-on interactions that served as a mechanism for student learning, and an analysis of the data demonstrated rudimentary evidence of the development in student comprehension of motion. The students were also engaged in recursive activities associated with design-based learning and specific learning objectives, and, as a result of the structure of the activity, were beginning to develop a level of communication related to the concepts being taught.

The Kinect® presented numerous possibilities for learning, yet initial results have revealed that a high degree of scaffolding is still relevant to student success with conceptualization and communication of the data. We believed that the Kinect® afforded a number of opportunities for the development of knowledge construction. Yet, because of the challenges associated with presenting understandings that the students were not fully comfortable with, we did not see major advancements in student learning that we had hoped to see. However, we do believe that given the right scaffolding in the next iterative cycle, the Kinect® can be used as a way to encourage student learning by focusing on conceptual understanding through the use of content. The initial efforts of the students showed the beginning of this idea as the students were challenging their academic peers to solve problems in reverse, e.g. "*What does this image represent*?" or "*Can you emulate it*?" Where this activity fell short was that students' were not asking their peers to make connections between established learning goals and what they were observing and doing. Though we have not yet established ideal use, we believe these findings will continue to refine the practices and implications of digital gaming and simulations, such as Kinect®, as an instructional tool for the development of student comprehension in kinematics

References

Bereiter, C., & Scardamalia, M. (2010). Can children really create knowledge? *Canadian Journal of Learning Technology/La revue canadienne de l'apprentissage et del la technologie, 36*(1).

Brown, A. (1992). Design experiments: Theoretical and methodological challenges in creating complex interventions in classroom settings. *Journal of the Learning Sciences, 2*(2), 141–178.

Corbin, J., & Strauss, A. (2008). *Basics of Qualitative Research: Technique and Procedures for Developing Grounded Theory* (3rd ed.). Thousand Oaks: Sage Publications, Inc.

Gee, J. P. (2008). *Learn and games*. Cambridge, MA: MIT Press.

Glaser, B.G. & Strauss, A.L. (1967). *The discovery of grounded theory.* Chicago, IL: Aldine Publishing.

Linn, M., & Eylon, B. (2006). Science Education: integrating views of learning and instruction. In P. Winne (Ed.), *Handbook of educational psychology* (2nd ed.). London: Lawrence Erlbaum Associates.

Masson, M., Bub, D., & LaLonde, C. (2011). Video-game training and naive reasoning about object motion. *Applied Cognitive Psychology, 25*(1), 166-173.

Megowan, C. (2007). Framing discourse for optimal learning in science and mathematics. Ph.D. Dissertation, College of Education, Division of Curriculum and Instruction, Tempe, AZ.

NRC. (2011). Simulations and games in the classrom. In Honey, MA, Hilton, M. (Eds.) *Learning science through computer games and simulations*. Washington, DC: National Academies Press.

Torentino, L., Birchfield, D., Megowan-Romanowicz, C., Johnson-Glenber,M.C., Kelliher, A., & Marinez, C. (2009). Teaching and learning in the mixed-reality science classroom. *Journal of Science Education and Technology,* 18:501-517