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Technologies that Aid Learning Partnerships on Real-World, Authentic Tasks

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This is the first of three think pieces written for Ontario school and system leaders to profile key international research findings on teaching and learning for deeper learning, enabled by technology. This think piece addresses two of four areas of focus for the Technology and Learning Fund: 1) Create more teacher-student learning partnerships and real-world, authentic learning tasks enabled by technology and 2) Provide more opportunities in school for peer-to-peer learning enabled by technology.

In its landmark report *Education for Life and Work in the 21st Century*, the U.S. National Research Council (2012) described "deeper learning" as an instructional approach important in preparing students with sophisticated cognitive, intrapersonal, and interpersonal skills. Modern digital tools and media now enable the use of deeper learning strategies in schools (Dede, 2014), including:

- **Connected learning** encourages students to confront challenges and pursue opportunities that exist outside of their classrooms and campuses (Ito et al, 2013);
- **Case-based learning** helps students master abstract principles and skills through the analysis of real-world situations;
- **Interdisciplinary studies** help students see how differing fields can complement each other, offering a richer perspective on the world than any single discipline can provide;
- **Collaborative learning** enables a team to combine its knowledge and skills in making sense of a complex phenomenon;
- **Apprenticeships** involve working with a mentor who has a specific real-world role and, over time, enables mastery of their knowledge and skills; and
- **Learning for transfer** emphasizes that the measure of mastery is application in life rather than simply in the classroom.

Teachers can simultaneously use all these strategies by developing instructional partnerships with people outside of school (e.g. parents, community members) who can play educational roles as mentors, coaches, and tutors about complex real-world problems. In schools, educators then can add learning partnerships that emphasize students and teachers working together to understand and act on these problems in ways that are authentic to the tasks adults perform for problem-solving, but appropriately simplified to reflect learners' developmental level, knowledge, and skills. Peer-to-peer learning is important in this process.

Combined, these instructional strategies and partnerships entail very different teaching methods than the familiar, lecture-based forms of instruction characteristic of industrial-era schooling, with its one-size-fits-all processing of students. Rather than requiring rote memorization and individual mastery of prescribed material, deeper learning involves connected learning about academic subjects linked to personal passions and real-world problems; case-based, interdisciplinary content; authentic diagnostic assessments embedded in instruction and apprenticeships; and peer-to-peer learning that emphasizes transfer from classroom to the real world and mirrors the collaborative nature of 21st century work and citizenship.

Realistically, most teachers will be hard-pressed to get from industrial-style instruction to deeper learning without the help of digital tools, media, and experiences. But adding digital supports and digital learning platforms for instruction will be effective only if this technology is not used to do conventional things better, but instead applied transformatively to do better things (Roschelle et al., 2000). For learning partnerships on real-world, authentic tasks, the most useful digital tools and media are:

- **Collaboration tools** that enable peer-to-peer learning as well as partnerships across distance;
- **Tools that support learners as makers and creators**, which empower students to study real-world problems linked to their personal passions, and to take authentic actions to resolve these problems;
- **Immersive media** that create virtual worlds to situate learning or augment the real-world with an overlay of computational information; and
- **Games and simulations** that are designed to enhance student motivation and learning.

As an example of a simulation-based curriculum in mathematics that embeds collaboration, SimCalc, a well-known and much-studied mathematics curriculum, is configured to enable highly engaging whole class discussions (www.kaputcenter.umassd.edu/products/curriculum_new).

Since representations of student thinking and work can be rapidly distributed in a networked classroom, teachers have the opportunity to direct everyone's attention to specific participants and their contributions. For example, when using SimCalc's Fishy World (see Figure 1), students each "become" a particular fish and learn how the linked graphical representation and symbolic functions relate to their and others' movements. In order to call attention to a particular mathematical concept, the teacher can freeze each student's SimCalc environment, pausing the simulation for a group discussion. Or the teacher can show or hide each student's contribution, in order to have a different *kind* of discussion. For instance, a graph produced by one student group could be made invisible until the rest of the class has had a chance to talk about what they expect it to show, based upon their own work (Hegedus & Roschelle, 2013).

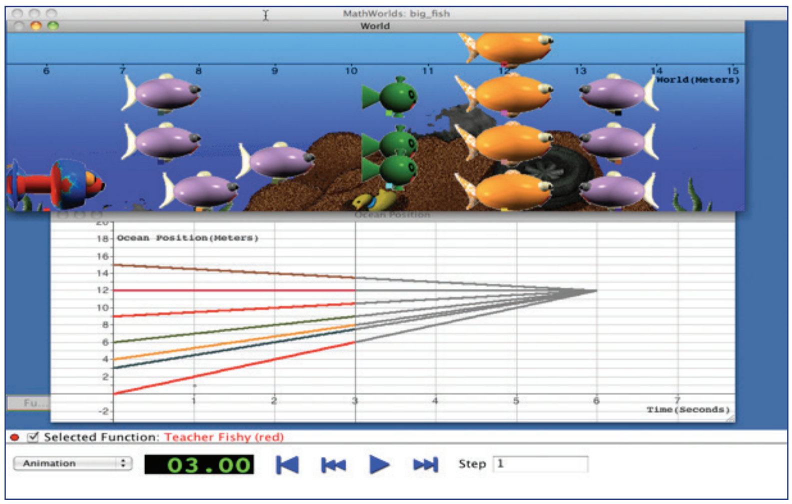

Figure 1. SimCalc's Fishy World

In short, much of the pedagogy in SimCalc classrooms involves the teacher facilitating discussions among students about what they learn from the dynamic representations on their computer screens. Substantial research has shown that these mathematical dialogues tend to involve almost everyone in the class, are highly engaging, and lead to deep understandings of the why behind mathematical formulas and theorems. And this form of collaborative discussion and debate – stimulated and grounded by the technology – prepares students well for the types of mathematics they will encounter in algebra.

If used in concert, all the deeper-learning technologies listed earlier can help prepare students for life and work in the 21st century, mirroring in the classroom some powerful methods of knowing and doing that pervade the rest of society. Further, they can be used to create a practical, cost-effective division of labor, one that empowers teachers, instructional partners outside of school, and students to collectively perform sophisticated authentic tasks. In addition, these media can address the learning strengths and preferences of students growing up in this digital age, including bridging formal instruction and informal learning. And, finally, these technologies can provide powerful mechanisms for teacher learning, by which educators deepen their professional knowledge and skills in ways that mirror the types of learning environments through which they will guide their students.

For reasons of space, this thought piece focuses on just one way among many of combining these technologies to aid learning partnerships on real-world tasks: immersive authentic simulations. Without using media as sophisticated as those described below, educators can take important first steps with collaboration tools, media that support maker/creator activities, and games and simulations.

Immersive Authentic Simulations

Experiences such as internships in 21st century workplace settings offer potential benefits for student motivation, academic learning, and mastery of skills for the global, knowledge-based, innovation-centered economy (Dede, 2012). However, providing extended, mentored real-world activities outside classrooms is difficult, particularly for younger students. Moreover, internship/apprenticeship models are hard, if not impossible, to bring to scale, partly because the number of workplace sites willing to accept mentoring responsibilities for students is limited, and partly because teachers accustomed to conventional classrooms often struggle to adapt to this form of education. Fortunately, virtual worlds and augmented realities now offer ways for students to experience simulated internships without leaving classrooms.

Two types of immersive media underlie a growing number of formal and informal learning experiences:

- **Multiuser virtual environments** (MUVEs, or "Virtual Worlds") offer students an engaging "Alice in Wonderland" experience in which their digital avatars in a graphical, virtual context actively participate in experiences with the avatars of other participants and with computerized agents (Ketelhut et al., 2010).
- **Augmented reality** (AR) enables students to interact—via mobile wireless devices – with virtual information, visualizations, and simulations superimposed on real-world physical landscapes. This type of immersion infuses digital resources throughout the real world, augmenting students' experiences and interactions (Klopfer, 2008).

By immersing students in authentic simulations, MUVEs and AR promote two deeper-learning strategies, apprenticeship-based learning and learning for transfer, that are very important for education.

EcoMUVE as an example of multi-user virtual environments

The EcoMUVE middle grades curriculum teaches scientific concepts about ecosystems while engaging students in scientific inquiry (both collaborative and individual) and helping them learn complex causality (http://ecomuve.gse.harvard.edu). The curriculum consists of two MUVE-based modules, allowing students to explore realistic, 3-dimensional pond and forest ecosystems. Each module consists of ten 45-minute lessons and includes a complex scenario in which ecological change is caused by the interplay of multiple factors (Metcalf et al., 2013). Students assume the role of scientists, investigating research questions by exploring the virtual environment and collecting and analyzing data from a variety of sources over time (Figures 2, 3). In the pond module, for example, students can explore the pond and the surrounding area, even venturing under the water; see realistic organisms in their natural habitats; and collect water, weather, and population data. Students visit the pond over a number of virtual "days" and eventually make the surprising discovery that, on a day in late summer, many fish in the pond have died. Students are then challenged to figure out what happened – they travel backward and forward in time to gather information to solve the mystery and understand the complex causality of the pond ecosystem.

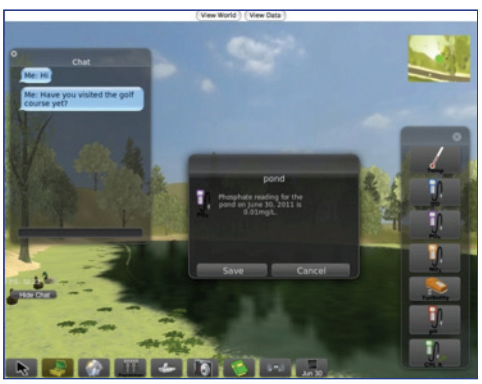

Figure 2. Students can collect pond and weather data

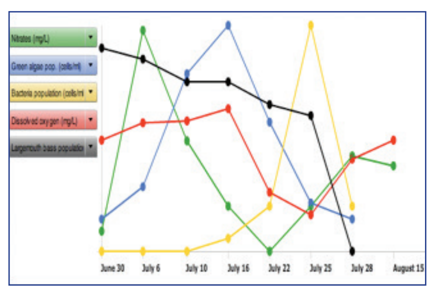

Figure 3. Summarizing and interpreting data

The EcoMUVE curriculum uses a "jigsaw" pedagogy, in which students have access to differing information and experiences; they must combine their knowledge in order to understand what is causing the changes they see. Working in teams of four, students are given roles that embody specific areas of expertise (naturalist, microscopic specialist, water chemist, private investigator) and that influence how they participate and solve problems. Using the differing methods of their roles, students collect data, share it with teammates via tables and graphs that they create within the simulation, and then work collaboratively to analyze the combined data and figure out how a variety of inter-connected parts come together to produce the larger ecosystem dynamics. The module culminates with each team creating an evidence-based concept map – representing their understanding of the causal relationships at work in the ecosystem – which they present to the class.

EcoMOBILE as an example of augmented realities

Designed to complement EcoMUVE, the EcoMOBILE project explores the potential of augmented reality (as well as the use of data collection "probeware," such as a digital tool that measures the amount of dissolved oxygen in water, to support learning in environmental science education (http://ecomobile.gse.harvard.edu). The EcoMOBILE curriculum is a blend of the EcoMUVE learning experiences with the use of digital tools that enhance students' real-world activities, as illustrated by a 3-day project that has been field-tested successfully (Kamarainen et al., 2013): During one class period, a group of middle school students participated in an EcoMUVE learning quest, completing a 5–10 minute on-line simulation in which they learned about dissolved oxygen, turbidity, and pH. The following day, the students went on a field trip to a nearby pond, in order to study the relationship between biological and non-biological factors in the ecosystem, practice data collection and interpretation, and learn about the functional roles (producer, consumer, decomposer) of organisms in the life of the pond.

At a number of spots around the pond, students' handheld devices showed them visual representations – overlaid onto the real environment – of the natural processes at work in the real environment, as well as interactive media including relevant text, images, audio, video, 3D models, and multiple-choice and open-ended questions. Students also collected water measurements using Vernier probes (Figures 4, 5). On the next school day after the field trip, back in the classroom, students compiled all of the measurements of temperature, dissolved oxygen, pH, and turbidity that had been taken during the field trip. They looked at the range, mean, and variations in the measurements and discussed the implications for whether the pond was healthy for fish and other organisms. They talked about potential reasons why variation may have occurred, how these measurements may have been affected by environmental conditions, and how to explain outliers in the data. Our research shows that virtual worlds and augmented realities are powerful complements to enable learning partnerships for real-world, authentic tasks.

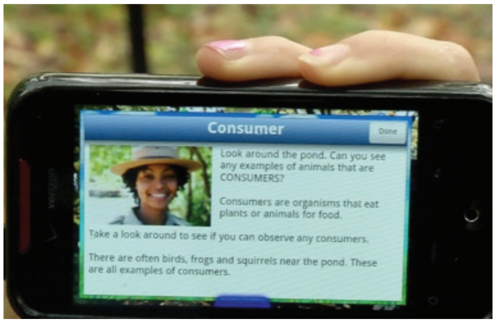

Figure 4. Handheld device delivering information

Figure 5. Collecting water data on turbidity

Developing an Action Plan for Deeper Learning

Educators do not have to begin implementing deeper learning by using media as sophisticated as immersive authentic simulations. Teachers and administrators can take important first steps in a progression of technology implementations from collaborative media and simulations to maker/creator tools to immersive experiences as a pathway to achieve learning partnerships on real-world tasks. The Ontario Technology and Learning Fund Action Plan report provides an excellent template for doing this type of progressive planning. The examples in this paper are middle-grades; excellent digital curricula are available across the developmental spectrum.

Steps in the template include:

- deciding what evidence-informed innovative technology-enabled practices to scale,
- developing inquiry questions and theories of action for answering those questions,
- formulating measures of success to track progress along the implementation pathway,
- forming a team that involves instructional and change leaders at every level and across departments in the system, plus a range of stakeholders in education, and
- preparing a budget and timeline.

Ontario district school boards, provincial schools and school authority boards are all part of the province-wide collaborative Technology and Learning Fund Innovation Research effort and related professional learning community. This presents a valuable opportunity to build on others' successes and insights, while also making your unique contributions to improving education across the province, and potentially in the international arena.

Summary

Overall, immersive media can be used in a number of ways to promote deeper learning, such as by facilitating case-based instruction, peer-to-peer collaborative activities, simulated apprenticeships, and the development of inquiry skills (Dede, 2014). Simulations allow students to learn skills under controlled conditions that may be difficult to replicate in the real world (Dawley & Dede, 2013), but which convey some degree of authenticity, allowing what is learned in one setting to transfer to the other. And Augmented Realities embed learning in the real world, giving students a deeper understanding of the immediate environment (Dunleavy & Dede, 2013). On their own, each of these approaches has important benefits for students; and blending them together presents even greater opportunities for deeper learning, student collaboration and partnerships on authentic real-world tasks. There is evidence from the reports of phases of the Ontario Technology and Learning Fund that significant progress has been made in adapting technology-assisted practices to student success in learning. The current report provides a practical template for planning initiatives. Directors and system leaders would be well served to share best practices and results within and across boards in order to capitalize on the good work that has been done.

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