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by Annick Janson and Robin Janson

Despite increasing interest in technology-assisted education, technology-based instructional design still lacks support from a reliable body of empirical research (Wiley 2002). This dearth of reliable information hampers its integration into mainstream school systems. In fact, many teachers remain resistant to using technology in the classroom (Johnson 2003; Shayo and Olfman 2003; Koohang and Harman 2007). In order to encourage uptake of new educational technologies, Roblyer (2005) argues that fundamental research on the potential impact of technology on school life must be conducted. This line of inquiry needs to offer a clear research agenda and provide evidence that will help drive effective classroom practice; indeed, in Roblyer's view, it is only when the impact of technology on school life is clearly articulated and demonstrated that educators will start to adopt technology widely.

In order to overcome teacher resistance to technology in the classroom, we have sought to follow a process described by Friesen (2004) to evaluate the advantages and disadvantages of the educational use of digital learning objects (DLOs) from the teachers' point of view. This article explores the opportunities and challenges inherent in using digital learning objects and reports on the impact of DLO use at both the classroom and school levels. By providing research that links students' use of DLOs with the development of key competencies, we hope to sharpen instructors' vision of how DLOs can help them achieve their educational goals and to encourage DLO uptake among teachers. Finally, we envision a DLO that can assist school principals in the facilitation of educational leadership and help transform teachers' attitudes toward technology-based teaching.

Digital Learning Objects in the Classroom: Opportunities and Challenges

A digital learning object is "any digital resource that can be reused to support learning" (Wiley 2000, 7). DLOs, like these examples from the Le@rning Federation, can be used in a variety of ways to support learning in every discipline: in mathematics, to help students rehearse long multiplication or equation solving; in science, to help students understand tectonics and other complex concepts; in language arts, to guide creative writing and critical thinking exercises; in social studies, to illustrate concepts in civic education and complex decision-making processes. Myriad examples of DLOs can also be found at the Multimedia Educational Resource for Online Teaching (MERLOT).

Teachers in primary, secondary, or tertiary education use DLOs in a variety of ways to meet curriculum needs and address different learning abilities among their students. DLOs enable students, both individually and collaboratively, to work hands-on with complex content and ideas. Students can, for instance, manipulate and experiment with variables, carry out simulations, prepare exhibitions with authentic artifacts, and explore new concepts in game formats. DLOs challenge students to question, investigate, analyze, synthesize, problem solve, make decisions, and reflect on their learning. Finally, DLOs enable students to work at their own pace and can provide scaffolded learning tasks that offer real-time feedback on performance in a variety of supportive and engaging ways.

That said, DLO integration inevitably creates challenges; teachers need to invest extra time and energy learning about and implementing DLOs (Wetterling and Collis 2003) and overcoming the technological challenges that come with any innovation (Freebody 2007). Our previous research demonstrated that complex factors affect the learning value derived by students from DLOs (Janson, Janson, and Falloon

2007). Once DLOs are integrated into the classroom, how they are used and what benefits they provide are shaped by the teacher's technological competency and preferred teaching modes.

Digital Learning Objects' Classroom Impact

In this study, our research objective was to explore the impact of DLO integration into classroom activities for both individual teachers and the school at large, thereby broadening the scope of our research from students to educators. The project involved five schools over four years of work; other portions of the project are reported elsewhere (Falloon, Janson, and Janson 2008). In each school, the research team allowed participating teachers to guide the choices of topic and particular DLOs used. This article presents the experience of 8 teachers and 200 students (aged 8-10) in a small primary school in Wellington, New Zealand. The school joined the program after its principal answered a call for research participants; her intention was to use the opportunity to expose her staff to new ideas and teaching tools. Teachers had varying backgrounds and skill levels in the use of information communication technologies (ICTs). While one teacher had a university degree in ICT, others started with only a rudimentary familiarity with Microsoft Office applications. None of the teachers had any former experience with DLOs.

First, we briefed the teachers who volunteered to participate and trained them in DLO use. The briefing included a discussion with teachers about their upcoming teaching interests and challenges and a discussion of DLOs available at the Le@rning Federation that met the teachers' needs. The teachers expressed an interest in using DLOs to teach science as the science and technology fair was approaching and selected a subset of three DLOs that were made available to the experimental classes (Exhibit 1).

In each lesson, the teachers introduced the topic under study and presented the material via a data projector so the whole class could see some examples of DLO work and understand the possibilities offered by the learning objects. The students then worked in pairs, as is customary in the school for in-class assignments with the teachers available for further clarification. Students worked with the DLOs according to their level of proficiency and rhythm, with each allowed to work at a pace that supported their learning needs (Exhibit 2). All DLO work was carried out during class time within the same yearly study block as students prepared their science and technology fair presentations. This procedure was standardized across classes as far as possible to ensure that all students experienced the same experimental conditions with the differential impact of DLO use for students who, as described above, worked at their own pace.

Students used DLOs for two school terms while the teachers recorded their reflections on students' learning in reflective journals. We also interviewed the teachers and members of the school leadership team before and after the experiment. We then analyzed data from these interviews and reflective journals for recurring and common themes (Geertz 1983). The results of these analyses suggested that there are three levels at which DLOs can have significant impact.

Impact on Student Learning

The teachers with whom we worked integrated DLOs into their lesson plans to address different teaching challenges, starting with the preparation of students for the science and technology fair. The greatest challenge inherent in this project was that teachers were only allotted 12 weeks in which to coach their students. In this time, teachers had to introduce and teach the concept of fair testing and then encourage students to come up with their own experimental designs, test their hypotheses, reach conclusions, and construct visual displays to present their experiments and results. The sooner students mastered the concept of fair testing, the more time they had to invest in designing their own experiments. The laboratory facilities used to carry out the fair-testing demonstrations varied widely across schools, disadvantaging smaller and less well-equipped schools like the primary school in which our study was carried out.

A complex chain of thinking skills fuels students' process of presenting a science project, from mastering fair-testing concepts to applying those concepts in crafting new hypotheses and finally to designing ways to test those hypotheses. Students use prior knowledge and then interpret, implement, analyze, and evaluate to create a new product. To borrow Anderson and Krathwohl's (2001) categories, this process involves moving from lower-order thought processes (for example, remembering, understanding, and applying) to higher-order ones (for example, analyzing, evaluating, and creating). Guided by their teachers, students working on fair-testing DLOs from the Le@rning Federation completed the science fair learning process and entered display boards in the regional competition. They then produced digital stories to describe their uses of DLOs (Exhibit 3).

Our analysis of these projects suggests that students' motivation to engage with the DLO tasks was high; additionally, teachers reported achieving the learning outcomes they had set for these units (Falloon 2006). Teachers felt that the DLOs allowed them to overcome significant difficulties presented by the lack of science laboratories in the school, which had hampered previous efforts to teach fair testing. Teachers' postintervention evaluations showed that they thought that the use of DLOs was equivalent to having a virtual lab and that DLOs made fair-testing teaching more efficient (Exhibit 4). They attributed their success in preparing students for the science fair to the unique learning scaffolding afforded by the DLOs and described class examples where learning had taken place and was being transferred into other activities (Exhibit 5).

Impact on Teacher Practice

Through this project, teachers became involved in building their knowledge bases. They engaged in testing various DLOs against their teaching objectives and compared the relative advantages and disadvantages of specific DLOs for their specific student populations. In doing so, they also brought into question teaching methods that had been constrained by the school's physical facilities, such as the lack of a science laboratory, which had limited the number of students who presented projects to the national science fair competition. The expansion of this knowledge base helped teachers craft expanded teaching objectives, which led to a significant increase in submissions. This progress was further recorded when teachers, after adopting DLOs, seized the opportunity to expand on their managerial skills or risked venturing into new territory by mastering new educational software. One of the teachers reported that working as a team leader for this project helped her expand her managerial skills by providing novel situations for the team to identify, discuss, and solve the teaching challenges they experienced. She reported that her role as team leader was strengthened by these positive experiences and that word of the project and her team's work had spread through the school, raising other teachers' interest in the intervention.

The research situation had opened a window of time and energy, enabling the additional training that allowed for exploration and mastery of novel education software and tools to complement DLOs. The teachers described this as significant because there was too little time for them to engage in such exploration in the course of their usual teaching routine. In shaping their own professional development, the participating teachers displayed self-leadership (Bryman 2004) as exemplified in the team leader's account; this self-leadership formed the basis for their reaching out to other teachers later, thus spreading the impact of their experience from individual and team levels to the school as a whole.

Schoolwide Impact

Observing that some of the main challenges she faces relate to the slow uptake of technological innovation by her staff, the school's principal saw participation in the research as an opportunity to open the topic for discussion in the school among all teachers, rather than leaving it as primarily her responsibility. As the study progressed, the principal concluded that her leadership role was one of facilitation (Exhibit 6). Rather than taking a top-down approach, she attempted to facilitate technology adoption among teachers in a way that gave them ownership of the transition.

The impact of this intervention registered at the school level, changing pedagogical practice and raising organizational awareness of the effect of technology on learning. Participant teachers discussed, both formally and informally, their experiences in the experiment with their colleagues, who reacted positively and showed interest in being involved. During the school review of yearly teaching activities, the teachers who had participated in the research led the movement to adopt the practice of DLO-enabled fair-testing teaching for the following year as a schoolwide policy. As a result, the school's teachers decided as a group to implement DLO use schoolwide. The team leader for the teachers who had participated in the research presented the results of the intervention to the school's Board of Trustees and discussed the technological issues that needed to be addressed to enable schoolwide application of this new pedagogical tool. This presentation prompted the Board of Trustees to approve funding for additional technology to facilitate adoption of DLOs, including interactive white boards to supplement the data projectors that teachers had been using to present DLOs to their classes. This change across the administrative levels of the school resulted from the early adopter group sharing their experiences and the positive results of DLO-facilitated learning with their peers during a formal presentation to the teaching staff and in informal conversations. Thus, the educators involved displayed leadership in transforming organizational culture, extending the effect of their experience beyond the level of their personal development to create change at the school level.

Sharing the Learning

In order to capitalize on these successes, our next step has been to develop a DLO for professional development within a school system. This new DLO, Microsoft E-leadership Learning Object (MELLO), currently in prototype, will assist school principals nationwide in facilitating the transformation of teaching practice in their schools. The rationale for the MELLO is that peer information combined with a hands-on approach to learning can play a significant role in encouraging uptake of new practices. The MELLO prototype platform integrates

- Video interviews with the early-adopter teachers and school principals regarding their experiences;
- Video clips of student-teacher interactions;
- Screenshots and multimedia submissions of student work, including e-portfolios;
- Text documents delineating the rationale for using a technology-enhanced methodology; and
- Footage of teachers relating how they overcame initial resistance to technology-rich learning environments.

The platform is designed to allow for the addition of material relevant to different school environments or other educational contexts and is structured to organize material thematically with searchable categories with an architecture supporting Web distribution via a SharePoint server on the Australia New Zealand Innovative Teacher Network. The prototype will be tested with school principals and teachers so that its impact on educational leadership development can be evaluated. Following proof of concept, the MELLO pilot will be broadened and tested as a means of facilitating innovation uptake; this effort will involve dissemination via Windows Mobile platforms.

Since the MELLO is programmed to tailor information to participants' specific questions or concerns, we hope to decrease the likelihood of user resistance (Koohang and Harman 2007). The MELLO guides transformative practice and records evidence of learning by

- Capturing participants' existing knowledge and new questions as they arise;
- Offering a series of learning activities;
- Recording participants' rating of each activity;
- Capturing post-learning reflection;
- Encouraging sharing of select elements with peers or other interested parties via onsite e-mail functionality; and

- Scaffolding a change process that encourages users to articulate new personal aims and delineate an action plan to put necessary changes in teaching practice into place.

In order to encourage multiple learning experiences with the MELLO, participants' data is recorded in the database as a "learning journey" (with users' consent). With each use, the participant can either print or save his or her learning journey for future reference or share it with peers and mentors, allowing refinement and deepening of professional development. This capability ensures that the database grows with each use, adding multiple perspectives on the issue under scrutiny.

Conclusion

Results from this study support Freebody's (2007) assertion that DLO integration in schoolwide learning activities requires different types of school leadership at different uptake stages. These results are also consistent with the three years of research we have conducted with Microsoft New Zealand's Partners in Learning Programme. The ripple effect of intervention on pedagogical practice and learning outcomes spread to the school as a whole, reinforcing Joel Barker's assertion that "information technology in education has a transforming effect on the setting or institution itself" (Morrison, Barker, and Erickson 2006, ¶19). Moreover, DLOs have another unique role to play in educational leadership development. DLOs can be designed to help educators overcome their initial resistance to innovation uptake and understand the powerful teaching potential technology-rich learning environments represent. School principals wishing to build collective capacity and develop staff members are already experimenting with the unique e-learning models facilitated by DLOs. In this way, early adopters of educational technology can display leadership in facilitating transformational e-learning experiences for their peers.

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