Higher Education Quality Council of Ontario

An agency of the Government of Ontario

Pitfalls and Potential: Lessons from HEQCO-Funded Research on Technology-Enhanced Instruction

@ Issue Paper No. 22

May 19, 2015

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Published by

The Higher Education Quality Council of Ontario

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Cite this publication in the following format:

Lopes, V., & Dion, N. (2015). *Pitfalls and Potential: Lessons from HEQCO-Funded Research on Technology-Enhanced Instruction.* Toronto: Higher Education Quality Council of Ontario.

Executive Summary

In 2011, HEQCO issued a call for research projects related to technology-enhanced instruction. Part of a broader effort to identify and evaluate innovative practices in teaching and learning, HEQCO's purpose in commissioning these projects was both to inform best practices at the classroom, institution and policy levels, as well as to encourage institutions and faculty members to assess the effectiveness of what they were doing in the classroom.

Now that the technology studies have concluded and that most have been published, this report draws some broader conclusions from their methods and findings. First, it reflects on how certain key terms related to technology-enhanced instruction, such as 'blended' and 'hybrid', have fluid and contextual definitions that can create confusion by disrupting terms of reference that are assumed to be common. Then, it identifies common pitfalls in the implementation of technology in the classroom to consider how new tools might be introduced and integrated more effectively. Finally, it highlights methodological lessons about the challenges of blending research and practice in the classroom.

The report begins by problematizing definitions of 'technology' and 'blended' or 'hybrid' learning. There is no clear definition of what 'technology' means or what it refers to in many studies that investigate its impact on learning. One assumes that the nature of the tools under investigation would have an impact on research design and on the metrics being measured. Yet little attention is paid to this problem, which in turns creates challenges when interpreting study findings. The same could be said of 'hybrid' or 'online' learning, which takes different forms in different institutional contexts. The proportion of online to face-to-face time, as well as the nature of the resources presented online, can both differ considerably. In a policy context, where we may wish to discuss issues across institutions or at a system level, the lack of consensus definitions can be particularly disruptive. In this respect, a universal definition of blended learning, applied consistently to guide practice across all colleges and universities, would be helpful.

Our examination of the HEQCO-funded studies yields several closely related and overlapping best practices for the implementation of new technology in the classroom.

1. Instructors looking to enhance student learning through the use of new technologies should ensure that students are given the required time to become familiar with the technology before it can contribute to their learning.

2. The challenges that students face navigating new technologies can be compounded when instructors run into technical difficulties. For those reasons, instructors and teaching assistants should also be trained on the use and implementation of technology.

3. The simple presence of technology will rarely enhance a classroom. Instead, some thought has to go into integrating it effectively. Technology should be integrated fully and consistently in a manner that is relevant to students and that convinces them of the potential value it holds for their learning experience.

4. Closely related to the point above, new technologies should be implemented not for their own sake but with a specific goal or learning outcome in mind. The integration of the technology should facilitate the pursuit of this goal.

Shifting from practice to research, our examination also yields several opportunities and limitations of doing research in a context that is closely tied to classroom practice.

1. Many of the HEQCO-funded studies, including several of those with complex study designs and rigorous methodologies, concluded that the technology being assessed had no significant effect on student learning. It is difficult to judge whether these findings are genuine or result from the challenges associated with isolating the effects of a specific technological tool in a complex and organic learning environment.

2. Several of the HEQCO-funded studies used subjective measures of student satisfaction, sometimes in combination with more objective measures and sometimes not, to feed into discussions of a tool's effects. Research questions that are addressed with subjective data about satisfaction should focus on technology as a means for learning rather than on technology's direct impact on learning.

3. Researchers in the HEQCO-funded studies faced challenges encouraging student participation, which often led to small sample sizes in situations where classroom-based interventions already limited the potential pool of participants. Retention was also difficult, especially in longer-term studies or ones in which students were asked to complete numerous assessment materials. Issues with recruitment and retention could also be related to many of the other challenges discussed earlier, including the integration of technology: students may have been less likely to participate in a study when the technology introduced did not seem helpful or was poorly integrated into the broader course structure.

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Introduction

In 2011, HEQCO furthered its mandate to examine the quality of postsecondary education in the province by issuing a call for research projects related to technology-enhanced learning. Part of a broader effort to identify and evaluate innovative practices in teaching and learning being implemented at the province's colleges and universities, the goal was to commission research dealing with "pedagogical practices that aim to enhance the quality of student learning through the introduction and integration of new technologies." Eligible courses could be delivered "face-to-face, blended or hybrid," but not "fully online/distance." Proposed initiatives included the use of technology in areas such as course design, assessment strategies or the development of innovative teaching methods. In total, 13 contracts were awarded under this request for proposals. While only some projects assessed the gains in student learning associated with the use of new technologies, all asked research questions that blended technology with teaching practice. As a result, we refer to this cohort of projects as the 'technology-enhanced instruction' projects in this report. These were supplemented by a number of other projects on similar topics awarded under other calls for proposals related to teaching and learning in 2010 and 2011.

HEQCO's purpose in commissioning these research projects on technology-enhanced instruction was twofold. First, we hoped that some of the more rigorous projects might stand the test of peer scrutiny and contribute to the scholarship of teaching and learning, thereby informing best practices at the classroom, institution and policy levels. Second, and perhaps more importantly, we were eager to encourage institutions and faculty members to assess the effectiveness of what they were doing in the classroom, to help foster a 'culture of evaluation' that might lead the sector to reflect on the quality of the education being provided to students rather than focus on innovation for its own sake.

Now that the technology studies have concluded and that most have been published, we can draw some broader conclusions from their methods and findings. Some lead us to reflect on how certain key terms related to technology-enhanced instruction, such as 'blended' and 'hybrid', have fluid and contextual definitions that can create confusion by disrupting terms of reference that are assumed to be common. Other projects help us identify common pitfalls in the implementation of technology in the classroom, allowing us to consider how new tools might be introduced and integrated more effectively. Others teach us methodological lessons about the challenges of blending research and practice in the classroom. These three areas of discussion will make up the substance of this overview. We draw on specific examples from certain HEQCO-funded research projects to illustrate the points discussed above, which our review has shown to be representative of the cohort as a whole.

The Possibilities of Technology

The conditions for learning made possible by new technologies necessitate thought, reflection and research about the impact of these tools. Are they changing how instructors teach and students learn? In what ways do they have a positive impact on learning and how might they constrain it? Are they being used solely to augment conventional practices or have they added new dimensions to the ways of teaching and learning?

Over a decade ago, education scholar Vince Tinto (2002) noted that an extensive body of research has identified the conditions within institutions that best promote student persistence and ultimately student success. The most important of these conditions focused on ensuring that the campus setting fosters learning. He noted that institutions that are successful in creating learning environments that engage students, facilitate contact with faculty and other students, and provide them with support for learning are more likely to retain and graduate their students. As education consultant Tony Bates (2014) notes:

> To enable as many students as possible to succeed given the wide diversity of the student body is a major challenge for institutions. More focus on teaching methods that lead to student success, more individualization of learning, and more flexible delivery are all needed. These developments put much more responsibility on the shoulders of instructors (as well as students), and require from instructors a much higher level of skill in teaching… A different approach to teaching, and a better use of technology to help instructors increase their effectiveness across a diverse student body, are now needed. (Chapter 1, section 1.7)

While attempts to enhance the quality of teaching and learning often drive the integration of technology in the classroom at the instructor level, rarely do instructors make explicit reference to the learning outcomes its implementation is intended to support. There often appears to be an assumption that the simple availability of new technologies will enhance student learning. But the question of technology's effectiveness requires us to think about the learning outcomes that students are to achieve and then to determine what, if any, are the best educational technologies to support these outcomes.

The Myth of the Digital Native

Technology is best viewed as a tool, one that should be deployed with a particular purpose in mind. Students must also be taught how to use it. While the temptation may be strong to assume that today's students, born into the "Net Generation" (Prensky, 2001; Oblinger & Oblinger, 2005), possess an innate ability to orientate themselves to new technologies, both the literature and the experiences of researchers suggest that that is not the case. Nor do these students necessarily demand technology or require it to succeed in an academic context.

A number of recent studies dispute the notion of the 'digital native' and highlight the fact that, in practice, students born after 1982 do not learn in a significantly different way than do those born earlier. Bullen, Morgan and Qayyum (2011), for example, not only find no meaningful generational differences in how learners say they use technology, but they also conclude that postsecondary students typically use only a limited set of technologies for learning. Despite growing up in a digital world and using technology regularly in their personal lives, students do not describe needing technology to learn.

Examining students in South Africa's postsecondary education system, Brown and Czerniewicz (2010) similarly conclude that "Age is not a determining factor in students' digital lives; rather, their familiarity and experience using [technology] is more relevant" (p. 360). They find a wide range of digital skills among

students in the millennial generation, suggesting that the notion of the digital native may be elitist – true of some students who grew up with access to high-quality technology and internet access at home, but not of all students. Despite the geographical context of their study, this argument translates to North America, where internet access is not universal and the quality of technology similarly varies. Students in Waldman and Smith's (2013) study of hybrid learning, which was set at an Ontario college, complained that they could only complete elements of their hybrid course when they had internet access, suggesting that "some students may still not have adequate access to the web to succeed when a large component of a class is delivered online" (p. 24).

A final source of data on students' technological literacy comes from the EDUCAUSE Center for Applied Research (ECAR), which has been studying undergraduate students' use and expectations of technology since 2004 by tracking their responses to questions on an annual survey. The ECAR findings detail students' perceptions of the technology skills they have, how they use them and the benefits that they believe result from technology's use in education. In 2013, over 100,000 respondents at 351 institutions in 13 countries participated in the ECAR survey. For the first time, a consortium of Ontario colleges was included among participating institutions. The differences in the findings across institutions according to size, type, region and most demographic characteristics, including student age, were not meaningful.

The 2013 ECAR survey yielded four main findings. First, students recognize the value of technology in the classroom but still require guidance in the use of technology for academic purposes. The most pervasive technology tools, such as institutional websites and learning management systems (LMS), are also the most valued by students. Second, students prefer face-to-face contact with their professors and continue to choose blended or hybrid courses over fully online instruction, despite the increasing sophistication of the latter. Third, students report being ready to use their mobile devices for academic purposes and look to institutions and instructors for opportunities to do so. Finally, students value their privacy and place limits on the ways in which they are willing to use technology to connect with instructors. Students prefer face-to-face interactions, email and communication through the LMS over social media and other 'recreational' technologies like Facebook or Twitter when dealing with instructors.

The recently released 2014 ECAR findings corroborate the 2013 findings. While technology is deeply embedded into students' lives in general, it has only a moderate influence on their active involvement in particular courses or as a connector with faculty and with other students. Students still report wanting guidance on how to use the technologies they are familiar with from their personal lives in the classroom. Overall, they report considerable breadth but little depth in their use of technology. The report concludes by suggesting that, instead of assuming widespread competency and familiarity, instructors should consider assessing incoming students' technological literacy as it applies to their institution and guide those who require it to sources of extra help.

The literature makes clear the dangers of assuming students' familiarity with technology and emphasizes that they require guidance concerning its best and most appropriate use in an academic context. As Ng writes, even 'digital natives' "need to be taught about these technologies, just like people born into a community need to be taught how to speak the language or use tools and equipment that are available to

the community" (p. 1065). Similarly, ECAR results should lead us to question any suggestion that students 'crave' technology in the classroom or that its simple presence will solve pedagogical problems. We can observe this in the HEQCO-funded study by Burk et al. (2013), which presented students in a large, first-year chemistry course with a variety of electronic resources, including recorded lectures, electronic tutorials and a homework management system offered by the textbook's publisher. Despite the wealth of options, students reported that the most helpful tools provided were the LMS and bank of questions on the publisher's website, which allowed students to practice solving problems similar to those presented in class.

Theoretical Obstacles: Problems of Definition

'Technology'

The use of technology in an education context provides students and instructors with access to a breadth of intellectual and cultural resources; to constantly changing, sophisticated and customizable tools for inquiry and investigation; and to modes of interaction, communication and collaboration not previously possible. When the word 'technology' is used in relation to education and its purported enhancement of learning, it now often refers specifically to digital computer technology. Over the years, this category has included a vast and varied selection of hardware and software: presentation software, content ware, course management systems, e-textbooks, the World Wide Web, multimedia, DVDs, videos and MP3s, video and or audio conferencing, discussion forums, wikis, blogs and podcasting, simulations, games and automated testing systems, computer labs, networked classrooms, wired campuses, laptops, desktops, tablets and smartphones are all included under the umbrella of 'education technology.'

The shifting definition of 'technology' constitutes a fundamental challenge for research that focuses on technology-enhanced instruction and one that is most often ignored in the literature. There is no clear definition of what 'technology' means or what it refers to in many of the studies that investigate its impact on learning. One assumes that the nature of the tools under investigation would have an impact on research design and on the metrics being measured. Little attention is paid to this problem, which in turns creates challenges when interpreting study findings. The ECAR study provides an interesting example of this. There is no clearly stated definition of what 'technology' means in the findings, nor is a definition provided to students in the survey. Do the students and researchers assume the same definition? If not, how might this confuse our interpretation of the findings?

'Hybrid'

The same could be said for 'hybrid' or 'blended' learning, which is defined in a variety of ways both in the literature and in the HEQCO studies. Sana, Fenesi and Kim (2011) document a variety of definitions for blended learning, ranging from "the combination of tradition face-to-face instruction of classroom teaching with online learning materials" to "combining technologies from online learning materials exclusively in a web-based learning environment" (p. 4). Other definitions take a position between these two extremes by

prescribing a ratio of online time to face-to-face time for hybrid instruction.[1] While there is no universal definition — in the literature or among institutions — of what exactly constitutes a blended or hybrid course, it involves the 'replacement' of traditional class time with out-of-class learning and assessment activities, thus reducing the face-to-face time that students spend with their instructors.

A quick scan of the colleges reveals that one college uses the term 'blended' to describe a course that combines online/e-learning and classroom delivery. Substantial parts of the content are delivered online, replacing face-to-face time. Another college defines blended learning as combining in-class and online learning activities and integrating both face-to-face learning and online learning in the delivery of a course. The term 'hybrid' is used at another Ontario college when delivery is mixed, blending face-to-face instruction with online facilitation of discussion. The inconsistent uses of these terms, both with respect to the time spent online and the kinds of materials presented there, result in further challenges for those seeking to measure the impact of online learning.

The inconsistent use of definitions can also be observed in the HEQCO-funded reports that deal with hybrid learning. Each situated in their own institutional contexts, researchers organically adopt the definition of online learning commonly accepted at their college or university. So, for Waldman and Smith (2013), hybrid or blended learning involves "partnering traditional classroom-based teaching with additional independent online learning components" (p. 5) and requires one hour of online work for every two hours of class attendance per week, instead of three hours in class for courses delivered traditionally. In contrast, Maclachlan et al. (2014), operating in a different institutional context, use blended learning to refer to the relocation of an entire module of course material usually presented face-to-face to an online environment.

Leger et al. (2013) evaluate three different ratios of online to face-to-face time in their study, examining models that progressively reduce face-to-face time. Interestingly, when participants in the Waldman and Smith (2013) study were asked to identify the optimal blend of online and class time, most study participants emphasized that the 2:1 ratio employed at Sheridan (2 hours in class, 1 online) was ideal, with 25% of students requesting that the course be delivered entirely face-to-face and only 3% of students requesting a course entirely online (p. 18). At the very least, this suggests that these participants felt comfortable with the blend of online and face-to-face time adopted by their institution.

This echoes the findings of the ECAR study as well, in which almost 85% of Ontario participants wanted more face-to-face interaction with their instructors; only 7% wanted less. At the same time, almost 60% believed that they tended to learn more in courses with some online components, suggesting that the desires for interaction and online learning need not be mutually exclusive. Students value highly the time spent with their instructors and want even more face-to-face time with them. The blended learning environments that students prefer are those that combine classroom instruction with online activities and resources, rather than those that sacrifice face-to-face time for online learning.

[1] For further discussion and alternative definitions, see Swenson & Evans (2003), MacDonald (2008) and Kanuka & Rourke (2013).

Yet many colleges and universities push to develop an increasing number of fully online courses and to offer courses in hybrid or blended formats that reduce contact time with the instructor. Findings from the literature and the HEQCO-funded studies suggest that these moves at best are contrary to student preferences and at worst may threaten the academic achievement of already lower achieving students. At the same time, the lack of a universal or at least consistent definition of what constitutes hybrid or blended learning makes any inter-institutional conversation difficult, as the terms of reference are not shared. In this respect, a universal definition of blended learning and clear guidelines for its use, applied across all colleges and universities, would help eliminate much confusion.

The Effective Implementation of Technology

The HEQCO-funded studies yielded several lessons for those working with technology in the classroom, including many concerning how it should be implemented effectively. In this respect, the challenges that some studies faced were often more instructive than their findings. As Paré et al. (2015) observe, instructors often worry about introducing new technologies into the classroom due to the confusion and frustration that technical issues, for example, can cause students. The HEQCO-funded studies yield some best practices to minimize these risks. As discussed previously, instructors assume intuitive knowledge of technology at their own peril. Instead, students benefit from extensive training on how to use and troubleshoot the new technology being introduced. The same is true for instructors and teaching assistants. Furthermore, integration is key. Technologies should be integrated into the course and the classroom fully, consistently and in a manner that is obviously relevant to students. They need to be sold on the technology's value and 'buy in' to its use before it can make a real contribution.

Training for Students

The HEQCO-funded studies highlight that when technology tools are introduced into the classroom, both faculty and students have to be adequately trained in their use. This reflects the literature on the topic, which concludes that the assumption that students innately know how to approach new technologies is mistaken.

In their study, Ghilic et al. (2014) assessed the effectiveness of iclickers compared to a traditional lecture and to the pen and paper method of testing student knowledge and gathering student feedback. The students in the course were not familiar with the use of iclickers and only used them once in the course. As a result, the iclickers only proved to be a distraction. Reflecting on their methodology, the researchers recommend that students spend time in class becoming familiar with the technology, pointing out that the manufacturer suggests that students use the devices three to five times per hour of lecture. Teaching assistants in the course similarly had difficulty working the iclicker base station that collects feedback from the individual student devices, which resulted in frustration for all parties involved. Ghilic et al. (2014) conclude that "when students are unfamiliar with the learning technology being implemented, focus can shift from understanding the concept [being taught] to the technology itself" (p. 18). This situation is clearly not conducive to enhanced learning.

Reflecting on their study, which used interactive planetariums to enhance student engagement in a large first-year science course that primarily enrolled non-science students, Reid et al. (2014) write that:

> One of our main conclusions is that first-year non-science students are not well equipped to manage their own learning in a planetarium environment without a lot of scaffolding. The 'wow factor' of being in a planetarium does not necessarily draw them in quickly or deeply enough to overcome the technical difficulties of operating the planetarium. (p. 4)

Students in the course experienced two different conditions: a TA-led planetarium experience, in which the teaching assistant narrated a tour of the planetarium's features and used it to demonstrate themes addressed in the course, and a student-led experience, in which students were asked to complete an assignment in groups while working the planetarium without TA assistance. As in the Ghilic et al. study, students needed considerable time to become familiar enough with the controls to work the planetarium on their own and the prospect of doing so without guidance provoked considerable anxiety. The researchers conclude that the planetarium experience is most beneficial for students when they are taught at length how to use the machine, when the self-directed experience is heavily scaffolded and when considerable time is allotted to the planetarium throughout the semester.

These conclusions are also reflected in the qualitative portion of the study findings. While students provided moderately positive feedback on the TA-led planetarium experience, they reported lacking the skills to work the planetarium properly on their own. They also suggested that the planetarium is likely more useful as an engagement tool than as one that facilitated learning. Students reported not learning anything from the planetarium experience that they had not already grasped from the course readings, though some found it helpful to see these notions illustrated in person.

Waldman and Smith (2013) uncover similar findings in their study of hybrid learning. They close their report by emphasizing that qualitative student feedback on surveys and in focus groups highlights the need to orient students to the web-based tools used in a hybrid course before expecting them to use them effectively. Suggestions from students and faculty for improving the hybrid experience included "providing additional technical support for students and faculty, mandatory tutorials introducing students to online tools, and hybrid course development training for faculty" (p. 4).

Overall, then, findings from the HEQCO-funded studies support those from the ECAR project: while students may be very comfortable with many forms of technology in their personal lives, this familiarity does not always translate into the classroom. Instructors looking to enhance student learning through the use of new technologies should ensure that students are given the required time to become familiar with the technology before it can be expected to contribute significantly to their learning.

Training for Instructors and Teaching Assistants

The challenges that students face navigating new technologies can be compounded when instructors run into technical difficulties or integrate tools into their courses in less than optimal ways. For those reasons, instructors and teaching assistants should also be trained in the use and implementation of technology.

Waldman and Smith (2013) describe the challenges that some instructors faced moderating their hybrid courses. For example, some became disorganized and failed to post material online at the right time or in manners that made its link to the syllabus clear. Others lacked the technical expertise to troubleshoot the online infrastructure and to provide students with guidance in its use. Some instructors "found working with less technologically able students to be particularly challenging" and spent such time directing "students who seemed to be overwhelmed by the technical requirements of the course" that they "expressed concern about the suitability of hybrid courses for first-term college students" (p. 28). In each case, instructors suggested that the college could improve the hybrid experience by providing added support to both students and faculty.

Reid et al. (2014) similarly conclude that "the value of a rigorous TA training program cannot be understated" (p. 31). The instructor found it difficult to effectively train teaching assistants on the use and implementation of the planetarium in the time allotted under the teaching assistants' collective bargaining agreement, such that many TAs had to perform with very little training. Those TAs who had added training through the teaching and learning centre, not only with respect to technology in the classroom but especially with respect to the particular inquiry-based techniques used in the planetarium exercise, were able to make much better use of their time and students benefited as a result. In many cases, students surveyed in the study commented on the under-preparedness of some TAs for the planetarium session.

Ghilic et al. (2014) also ran into issues with their use of iclickers that could have been resolved with better TA preparation and training. Iclickers in adjacent rooms interfered with each other and confused the base stations that tabulate student votes, which could have been handled had rooms been better selected or had TAs been trained to change the frequencies of the base stations. Many TAs who had not previously tested the compatibility between the iclickers and their personal computers also arrived at the lecture only to discover that their computer did not recognize the iclicker software. Others took lengthy periods of time at the beginning of lecture to set up the base station and make the system operational, which could have been avoided had TAs been asked to practice setting the system up ahead of time.

When Elliott and Colquhoun (2013) measured the effects of learning studios on student success and satisfaction and surveyed both students and faculty on their appreciation of the space, they found that many of the technologies integrated into the enhanced classroom were not utilized due to a lack of training. "Compared to a classroom, a learning studio offers the teacher and students a greater choice of available technologies, greater flexibility in the furniture and room arrangements, and ultimately greater choice in how the class is delivered" (p. 7). Yet students reported that their preferred 'technology' the classroom offered was the moveable furniture, in part because many of the other options went unused by instructors.

If we cannot assume a high level of comfort with technology from students, it should come as little surprise that we cannot expect it of instructors or teaching assistants either. They would benefit from extensive training on both the functional and pedagogical aspects of new technologies. At many institutions, these resources are available through the teaching and learning centre or through IT services. The challenge is in making instructors aware of their existence and in findings ways to encourage them to access training.

Integrating Technology

The simple presence of technology will rarely enhance a classroom. Instead, some thought has to go into integrating it effectively. Technology should be integrated fully and consistently in a manner that is relevant to students and that demonstrates the added value it offers their learning experience. As Grajek (2015) recommends:

> It is important to view technology as a supporting tool, similar to earlier tools such as blackboard/chalk. Technologies need to be carefully scrutinized for their pedagogical implications. The real value of technologies is in how faculty integrate the technologies into their teaching and learning and how they use the technologies to further refine their course delivery and student engagement. (p. 19)

When Ghilic et al. (2014) integrated iclickers into their lectures, not only did they find that the tools did not improve student learning, as measured by student performance on a quiz, but the students did not report enjoying the iclickers either. The authors conclude that the tools might have been more effective with regular use, as students only used them once throughout the semester. This might constitute an example of a poor integration of technology into a classroom setting. As discussed earlier, various technical difficulties also played a role in disrupting the student experience. Ultimately, the researchers recommend "the complete integration of the iclickers into the course design, or at least their regular use" (p. 19) in order to properly gauge their effectiveness.

Leger et al. (2013) redesigned a first-year human geography course as a blended course. Three different models were tested: one with three 50-minute lectures per week (the traditional model); one with three online lectures per week and an interactive 90-minute class per week (the intensive blended model); and one with less frequent online lectures than the intensive blended model and four three-hour interactive classes over the course of the semester (the reduced resources blended model). Students in the intensive blended model had the highest engagement scores, as measured using the Classroom Survey of Student Engagement (CLASSE), while students in the third model were least satisfied, citing unclear course structure and the infrequency of meetings with the instructor. Both students and instructors in the intensive blended model also reported higher workloads. While students in the second model enjoyed the flexibility of having course components online, they also suggested that these various components did not always feel like they were integrated into a cohesive whole, leading the researchers to identify this as an area for future improvement.

Samuels, McDonald and Misser (2013) provided students with an online tool that was designed to help them better plan and structure writing assignments. They then gathered student feedback on its usefulness. Both instructors and students noted difficulties integrating the tool into classes. Students felt that they received little guidance or support in its use, while instructors had different expectations of student writing that led them to implement the tool in a variety of ways, some more effective than others. "Comments from professors suggest that they felt very much like novices trying to integrate the [writing tool] – a new resource – into their classes and that encouraging the use of the [tool] was only one element that needed to be balanced in teaching their classes" (p. 20).

Martini and Clare (2014) reached similar conclusions when they provided psychology undergraduates who were nearing graduation with an e-portfolio assignment to help them reflect on the transferable skills they had developed during their degree and how these might be useful on the labour market. Presenting students who were near graduation with a tool that asked them to reflect on the entirety of their learning, the researchers suggested that "for true value to be derived from an e-portfolio it must be developed over the course of the entire degree program" (p. 34). This level of integration could have led to deeper and more detailed reflection that could in turn have produced a more helpful final product. "Its use in a 'one-time only situation such as this project (or a 'last minute' effort at the end of a degree) is unlikely to have the impact on students' understanding of transferable skills, their knowledge of how these skills are fostered by curricular and co-curricular learning experiences, or their ability to articulate those skills in job-relevant settings" (p. 34).

Clear Rationale for Use

If the clear and consistent integration of a new technology is important, so too is the manner in which the instructor deploys it in the classroom. We learn from the HEQCO-funded projects the importance of implementing technology for a particular purpose. The new tool should clearly add something to the course, which will in turn help instructors demonstrate the value of the tool to students and encourage them to use it.

For example, Martini and Clare's (2014) e-portfolio project provided students with an opportunity to reflect on the transferable skills they had developed as undergraduates, which could help them integrate into the labour market more effectively and thus address a key point of anxiety for many students who are about to graduate. The e-portfolios also addressed a need that was unlikely to be met by course instructors, who in the researchers' estimation tend to communicate with students about course content rather than about the skills they wish students to develop. Similarly, undergraduate students are rarely assessed with regard to transferable skills across individual courses, much less over the course of their degree. The e-portfolios provided an opportunity to fill this gap which many students could have found to be valuable.

Pretti, Noel and Waller (2014) attempted a similar experiment that provided co-op students with a series of online modules designed to build their employability skills while on work placement. The program was created in response to employer criticism about the inadequate essential skills students brought with them to the workplace. While the benefits of the modules should have been clear to students who understood

employer concerns, participants in the study suggested that module content was common sense and that they did not feel their employability skills to be lacking. Despite this, students still self-reported that they felt their skills had improved in areas in which they had taken courses and that they felt better prepared for the workplace. When researchers aggregated employer evaluations of co-op students, they also found that students who had completed the online modules received better evaluations than those who had not.

In some cases, the benefits to students can also come in the form of enhanced student experience rather than enhanced learning. Paré et al. (2015) focus on the value of peer assessment technology to enhance students' sense of community in large classes. The use of technology to increase student engagement in large classes is a common goal, whether it be through tutorials, iclickers, discussion boards or other tools made available through the learning management system. Peer assessment technology works in much the same way by breaking large classes down into smaller groups, within which different interpersonal dynamics and modes of learning become possible. While students who participated in the study described enjoying the peer assessment technology and the assignments it made possible, psychometric assessment of their sense of community also showed an increase for those who had used the tool. In this case, the researchers present peer assessment technology as a way to solve the logistical constraints imposed by the large class format while also supporting deeper student learning.

Methodological Observations: Conducting Research on Technology

While the previous section dealt with practical lessons that emerged from the HEQCO-funded studies and addressed how technology might be implemented effectively in the classroom, the following paragraphs present observations on methodology and reiterate certain best practices when conducting research about the effectiveness of introducing new technologies.

As mentioned earlier, one of the primary motivations in HEQCO's decision to fund a cohort of projects on technology-enhanced learning was to encourage instructors to reflect on and assess the effects on the tools they were using in the classroom. The goal here was to foster a 'culture of evaluation' in which the effects of pedagogical changes on the quality of teaching and student experience would become top of mind.

As a result, and as is typical of scholarship in the field of teaching and learning, primary investigators were often course instructors. This reality often placed constraints on what was possible in any given research project. For example, the use of control groups and random assignment was often very difficult if not impossible, making true experimental conditions unachievable. Implementations of technology were often carried out and conditioned by specific institutional contexts, which made terms of reference difficult to translate and made the generalizability of findings a challenge. At the same time, these constraints are frequently encountered by many who blend research with practice.

We highlight three observations about performing research within these constraints. First, null findings are common, in many cases resulting from variables affecting learning that cannot be controlled. Second, many

studies assess student satisfaction with the technology being implemented, sometimes but not always in combination with other, more objective metrics of student learning. Finally, studies regularly encounter challenges with student recruitment and retention, engagement in the study and tracking of student activity.

Null Findings

Many of the HEQCO-funded studies, including several with complex study designs and rigorous methodologies, concluded that the technology being assessed had either no or only a small effect on student learning that was not statistically significant. It is difficult to judge whether these findings are genuine or result from the challenges associated with isolating the effects of a given technological tool in a complex learning environment.

Waldman and Smith (2013) assessed the impact of hybrid course delivery on student learning and course withdrawal rates, in addition to collecting faculty experiences with the blended mode. The researchers conclude that:

> students achieved slightly lower final marks in hybrid courses as compared to the face-to-face control courses offered in the previous year, though the magnitude of this effect was very small, in the order of -1%. Further analysis revealed that students with high academic standing were successful regardless of the course mode, while students with low GPAs performed slightly worse in hybrid classes. Course mode did not have an effect on withdrawal from the course, suggesting that the format does not impact course completion. (p. 4)

The authors are careful not to draw a causal link between student performance and course delivery due to the observational nature of the study, suggesting that a variety of uncontrolled student characteristics, such as engagement, academic readiness or level of comfort with technology, may also have played a role. They recommend further exploration of their findings in subsequent research.

Other HEQCO-funded studies similarly showed little effect from the intervention being studied. Elliott and Colquhoun (2013) found that using learning studios to increase student engagement had no significant effect on grades, though it did increase students' reported level of satisfaction with the course. Reid et al. (2014) end their study with a suggestion that researchers focus on the effects of planetariums on student engagement, pointing out that "conceptual gains are either difficult to demonstrate or non-existent" (p. 31).

Cowan et al. (2014) tested the use of engagement strategies to teach undergraduate students critical thinking skills in a large history class. The course employed engagement strategies, such as online quizzes and iclickers, which had been shown to be effective in the physics teaching and learning literature to determine whether they could be transferred to a humanities context. The course was taught in consecutive terms by the same instructor, with the fall section of the course serving as the intervention group and the winter section serving as control. The authors conclude that while some students learned better with the tools in the short term, there was no difference in long-term recollection of material. The strategies were

most beneficial for those students who performed slightly above the average academically. While the top students performed well in both conditions, they did best without the strategies. Overall, Cowan et al. suggest that while the tools did help develop the critical thinking skills of some students, even they did not perform significantly better than students taught with more traditional approaches to instruction.

Findings from these and other HEQCO-funded studies demonstrate that the question of technology's impact on student learning cannot be answered easily because the use of the tools under investigation usually interacts with many other variables that also impact learning. Even seemingly innocuous factors such as the time of day can determine the way that a tool or teaching strategy is perceived both by faculty and students. A given tool will perform differently in different contexts. Both excellent and flawed learning experiences can be designed with technology and without it. In the final analysis, whether learning occurs or not will be determined by a very complex set of interactions.

Student Feedback and Subjective Measures of Enjoyment

Several of the HEQCO-funded studies used subjective measures of student enjoyment, sometimes in combination with more objective measures and sometimes not, to feed into discussions of a tool's effects. In these cases, student feedback was usually gathered through focus groups, interviews, or through open-ended questions on a survey. These qualitative measures of student appreciation of a tool can be very helpful or less so depending on the context.

Research questions addressed using student feedback must be crafted carefully. For example, student use of a tool or preference for that tool over a traditional way of teaching tells us nothing about the effects of that tool on learning. These data view students as technology users rather than as learners engaged in a process of knowledge construction, such that research questions that are addressed with subjective data about enjoyment should focus on technology as a means for learning rather than on technology's direct impact on learning.

When Maclachlan et al. (2014) examined the possibility of using an online module to replace course material on geospatial and information literacy that had traditionally been offered face to face, they observed no change in student performance in the subject matter. However, student feedback allowed them to identify at least one major factor that contributed to student satisfaction with the online module – it remained available for students to use several times and to consult later in the semester, such as when they were writing end-of-term assignments.

Martini and Clare (2014) asked students to evaluate their experience with the e-portfolios at the end of the process. Students indicated that "the sessions have been helpful in giving them some broad skill-based terms to organize their learning" (p. 34) and that they found it to be a useful exercise overall. This information could then be used by researchers to shape future iterations of the e-portfolio exercise – a valid and helpful use of student satisfaction data. In other cases, as with Ghilic et al.'s (2014) intervention involving iclickers, students expressed a clear dislike for the tool. This provided a clear flag for researchers

that they should reconsider either the use of the tool itself or the way in which it was implemented in the study.

Reid et al. (2014) make a clear and helpful distinction between students' satisfaction with the planetarium experience and its actual effectiveness for teaching purposes. While the 'wow factor' of being in a planetarium was supported by the comments of several study participants, the authors emphasize that "the planetarium does not automatically increase students' conceptual gains" (p. 4). Cowan et al. (2014) make a similar point after their attempt to develop students' critical thinking skills through technology:

> The study also found that there was no relationship between students' evaluations of the engagement strategies and individual student learning outcomes. Students who liked the strategies were neither more nor less likely to improve than those who did not like them. This finding has implications for the development of education quality indicators, as it suggests that student experience or satisfaction measures do not necessarily relate to academic success or student learning, and thus should be considered separately from, and should not be mixed in with nor substituted for, assessment of learning outcomes. (p. 7)

While student satisfaction with a tool or teaching technique may be a valuable metric to consider for a number of studies, researchers should be careful not to confuse satisfaction with effectiveness. As stated above, the two need not be related and can often be assessed in quite different ways.

Student Recruitment, Retention and Engagement in Research

Researchers in the HEQCO-funded studies often faced challenges encouraging student participation, which often led to small sample sizes in situations where classroom-based interventions already limited the potential pool of participants. Retention was also difficult, especially in longer-term studies or ones in which students were asked to complete numerous assessment materials. Issues with recruitment and retention could also be related to many of the other challenges discussed earlier, including the integration of technology: students may have been less likely to participate in a study when the technology introduced did not seem helpful or was poorly integrated into the broader course structure.

When Martini and Clare (2014) reviewed students' e-portfolio submissions, they concluded initially that "the quality of student responses was somewhat poor, with more than half of students falling in the 'benchmark' or 'emerging' categories for each of the three skills examined" (p. 29). Upon further reflection, they wondered whether students' responses truly reflected their underdeveloped ability to articulate their skills or rather "a lack of motivation to complete the task" (p. 29), which required a substantial time commitment. They relate that "some students may not have been particularly motivated to expend a great deal of time or energy on the tasks that comprised this study" (p. 34), as the assignments were not incorporated into a course curriculum and may not have been viewed as necessary or relevant to their studies. While they admit to having no specific reason to suspect that this was the case, they do raise the possibility as a potential limitation of their study and of student-centred research in general.

Not surprisingly, Samuels, McDonald and Misser (2013) suggest that students may be more likely to use a tool if marks are assigned to it. Their evaluation saw an online essay-planning tool be made available to students in certain courses, but instructors were free to integrate and use it as they saw fit. Overall, the researchers found that very few students used the tool regardless of the way in which the instructor had chosen to integrate it into the course. While the tool was made available to both first- and fourth-year undergraduate students, Samuels et al. found that fourth-year students in particular tended to see the tool as one that was destined for struggling students or those who had poor writing skills. As a result, they tended not to use it. Both the researchers and the instructors who participated in the study disagreed with the students' assessment of the tool's audience. When asked what could motivate them to use the tool, students said that marks should be assigned to it.

Discussion and Conclusions

The integration of technology in postsecondary education has progressed to such a point that we no longer need to ask whether we should use technology in the classroom, but rather which tool to use and how. In this light, lessons from the HEQCO-funded studies become particularly illuminating. Implementations of new technologies in the classroom are more likely to be beneficial to student learning if they are rooted in a vision that emphasizes learning with technology rather than learning from technology. New technologies are thus best positioned as tools, as means to an end rather than as ends in themselves. As such, they will often be accompanied by different learning environments to best exploit their unique capabilities.

There is no single, unified, universally accepted model or theory that could be applied to ensure optimal learning in all educational settings. That which constitutes effective and enhanced teaching and learning practices depends on the content and the desired learning outcomes. This report has taken but one approach to the issue, one framed by the methods, challenges and findings of the HEQCO-funded studies on technology-enhanced instruction.

First, we note problems of definition, which are especially prominent with terms like 'technology', 'blended' or 'hybrid.' Scholars deal with problems of definition all the time and consensus definitions are rarely found in academic literature. The primary task is, first, to be aware of the different definitions that exist and, second, to understand the differences that exist between them. In a policy context, however, where we may wish to discuss issues across institutions or at a system level, the lack of consensus definitions can be particularly disruptive. In this respect, a universal definition of blended learning, applied consistently to guide practice across all colleges and universities, would be helpful.

Our examination of the HEQCO-funded studies yields several closely related and overlapping best practices for the implementation of new technology in the classroom.

1) Instructors looking to enhance student learning through the use of new technologies should ensure that students are given the required time to become familiar with the technology before it can contribute to their learning.

2) The challenges that students face navigating new technologies can be compounded when instructors run into technical difficulties. For those reasons, instructors and teaching assistants should also be trained on the use and implementation of technology.

3) The simple presence of technology will rarely enhance a classroom. Instead, some thought has to go into integrating it effectively. Technology should be integrated fully and consistently in a manner that is relevant to students and that convinces them of the potential value it holds for their learning experience.

4) Closely related to the point above, new technologies should be implemented not for their own sake but with a specific goal or learning outcome in mind. The integration of the technology should facilitate the pursuit of this goal.

Shifting from practice to research, our examination also yields several opportunities and limitations of doing research in a context that is closely tied to classroom practice.

1) Many of the HEQCO-funded studies, including several of those with complex study designs and rigorous methodologies, concluded that the technology being assessed had no significant effect on student learning. It is difficult to judge whether these findings are genuine or result from the challenges associated with isolating the effects of a given technological tool in a complex and organic learning environment.

2) Several of the HEQCO-funded studies used subjective measures of student satisfaction, sometimes in combination with more objective measures and sometimes not, to feed into discussions of a tool's effects. Research questions that are addressed with subjective data about satisfaction should focus on technology as a means for learning rather than on technology's direct impact on learning.

3) Researchers in the HEQCO-funded studies faced challenges encouraging student participation, which often led to small sample sizes in situations where classroom-based interventions already limited the potential pool of participants. Retention was also difficult, especially in longer-term studies or ones in which students were asked to complete numerous assessment materials. Issues with recruitment and retention could also be related to many of the other challenges discussed earlier, including the integration of technology: students may have been less likely to participate in a study when the technology introduced did not seem helpful or was poorly integrated into the broader course structure.

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