CHAPTER 10

Visions for the Future of Educational Technology

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Educational Technology is in a period of exciting change, with new technologies such as augmented and virtual reality, new techniques to analyse student data, and new pedagogies for learning online at large scale. Universities are entering partnerships with publishers and startup companies to develop teaching and learning online. As the Computer and Learning research group (CALRG) celebrates its 40th anniversary, The Open University (OU) faces challenges and opportunities. The challenges are to find answers to three big questions. How can providers of online courses develop sustainable business models? How can institutions work together to develop courses that attract substantial numbers of fee-paying students and offer transferrable credit? How can course designers offer education that is both engaging and effective? The opportunities include developing new partnerships though the FutureLearn company to offer professional development courses with transferable credit, exploring inquiry learning at scale with the nQuire platform in collaboration with the BBC, and developing mobile technologies that promote broad and deep access to learning. A promising future research agenda is to examine how new educational technology can combine personalized with social learning. A lesson from 40 years of CALRG is that that successful computer-assisted learning involves not a series of exciting prototypes and quick fixes, but a sustained programme of research into the science of learning and the design of effective interventions.

Introduction

The introductory chapter to this book shows an extract from a speech by Lord Crowther, the first Chancellor of The Open University, where he refers to the revolution in communications enabled by computers. Since that speech in 1969, the world has undergone a further technology revolution brought by mobile communications devices: smartphones, tablet computers and wearable communicators.

Equally important is the revolution in education. In 1969, university students listened to lectures, wrote course notes, attended seminars, and sat in exam halls. Many still do. Yet people of all ages and nationalities now learn online. They look up Wikipedia to understand Bitcoin, watch a YouTube video to find out how to bleed a radiator, go to a blog to find a recipe for lasagne, and browse TripAdvisor to plan a holiday. Also, since 2012, Massive Open Online Courses (MOOCs) have allowed anyone with a fast internet connection to study a course in, for example, Mathematics, Machine Learning, or Mindfulness.

The MOOC phenomenon

Many academics at The Open University (OU) were initially blasé about the MOOC phenomenon. Since 1999, we have had our own Open2.net site[1], rebranded in 2006 as OpenLearn[2]. It provides hundreds of hours of free educational content, in collaboration with the BBC. However, in late 2012 the OU made a decision to form the FutureLearn company and build a new platform[3] to offer free online courses from leading universities worldwide. This generated challenges and opportunities.

Project Kyloe

The main challenge was to build a consortium of universities willing to develop free courses, for people from all nationalities with little or no experience of online learning. The opportunity was to develop a new platform that would engage people in sustained, effective, self-managed learning.

In early December 2012, a small group of educational technology experts at the OU were asked to comment on a set of features for Project Kyloe[4], the code name for what was to become FutureLearn. Should the platform have recommendation features, email alerts, ebooks or pdfs, presenters or guest tutors?

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1 https://www.open.edu/openlearn/about-openlearn/frequently-asked-questions/ looking-open2net
2 https://www.open.edu/openlearn/
3 www.futurelearn.com
4 Kyloe is a type of Scottish Highland cattle: Kyloe, cattle, moo, MOOC.

Asking experts to propose a list of features is exactly the wrong way to design a new platform for learning. The right way is to start from the pedagogy. What types of teaching, learning and assessment should be supported? How will people from differing cultures, languages and educational backgrounds be helped to engage and learn? Fortunately, at the end of December 2012, the then Vice Chancellor, Martin Bean, convened a meeting to develop a vision for the new MOOC platform and establish a small team to work with the newly-formed FutureLearn company on pedagogy-informed design of the platform.

Designing FutureLearn

Members of CALRG were prominent in that team, with Sharples as Academic Lead. Together with the software developers, they based design of FutureLearn on a pedagogy of learning as conversation[5]. Conversation is a fundamental process of learning. We converse with colleagues and teachers to share knowledge and coordinate actions. We converse with ourselves to reflect on experience. Conversation can also improve with scale: the more people that take part, the richer and more diverse is the discussion. In FutureLearn, each piece of teaching is linked with a conversation amongst the learners. Conversation for learning has been the guiding principle for designing new features such as peer assessment and online study groups.

In May 2015, 270,00 people started the FutureLearn course 'Understanding IELTS' from the British Council. The biggest-ever online MOOC course, it attracted learners from 190 countries notably in the Middle East and Eastern Europe. For many, it was their first experience of online learning. 25% accessed the courses on mobile devices. The first video in that course (asking participants how they feel about taking exams) attracted 65,000 comments. By the time the course had ended, over 35% of the participants had contributed to the online discussions and many more had learned from viewing the peer contributions alongside educator-designed content. This and subsequent courses have shown how well-conceived social learning can be a basis for open education at scale.

FutureLearn Academic Network

Perhaps the greatest opportunity afforded by FutureLearn has been for academics and educational technologists from 120 institutions to explore new ways to teach online. The FutureLearn Academic Network (FLAN) was set up

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5 Conversation Theory was developed by Gordon Pask and extended by Diana Laurillard, both of whom worked with The Open University. Laurillard was a former Pro-Vice-Chancellor (Technology Development). Pask obtained the first Open University DSc.

in 2013 to connect academics and research students based in FutureLearn partner institutions. FLAN is coordinated by Eileen Scanlon and Rebecca Ferguson from CALRG. Through quarterly meetings, comparative research studies, joint research bids and collaborative publications, the network has examined successful ways to teach, learn and assess online. Two reports, authored by members of CALRG, surveyed 66 publications on MOOCs from The Open University (Ferguson, Coughlan & Herodotou, 2016) and then 109 publications by FutureLearn partners (Ferguson, Coughlan, Herodotou & Scanlon, 2017). The two reports identify priority areas for universities investing in MOOCs, including: develop a strategic approach to learning at scale, identify and share learning designs, support discussion more effectively and widen access.

The pedagogy of learning through conversation at scale has also posed new questions for educators. What makes a good question to prompt discussion? What should be the role of educators in facilitating conversation – should they ask open questions, offer hints, answer queries, encourage peer discussion, lubricate social interactions? Can learners be trained and supported to act as peer facilitators? How should courses be designed to engage and retain students?

A journey from MOOCs to micro-credentials

FutureLearn, in common with other MOOC platforms, is now on a long-term journey away from a focus on free courses for leisure learners, towards accredited programmes for professional development and lifelong learning. Figure 1 shows the trends, from 2000 to 2020, of open and distance education. In the early 2000s, some universities including The Open University made educational resources such as course notes and recordings of lectures free to browse online.

In the first experiments with MOOCs, from 2008 onwards, learners constructed free online resources into personalized courses and discussed their learning with other participants. In 2012, the major MOOC platforms of Coursera and EdX were established, followed in 2013 by FutureLearn. The courses that run on these platforms, along with others including OpenLearn, have generated rich data on student learning. The fields of social learning analytics, predictive analytics and analytics for learning have sprung up to inform new methods of teaching and learning at scale.

A combination of business imperatives (MOOC companies have belatedly realised that it's hard to sustain a business based on free courses), entrepreneurship, and greater understanding of the needs and profiles of adult learners, have resulted in clusters of courses, dubbed 'nano-degrees'. Each of these nano-degrees provides a credential certified by the providing institution. Combine these clusters, sometimes from multiple providers, and you have a hybrid degree course. Merge them with campus teaching and you get blended courses that can be taken on campus, online, or in combination.
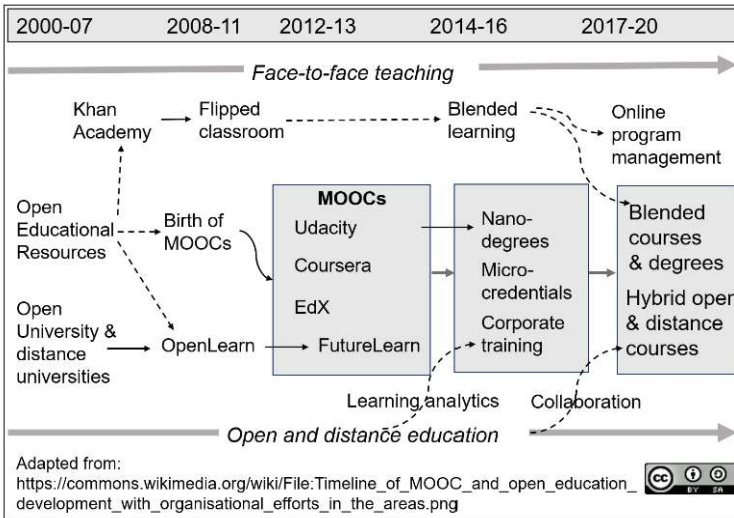
Figure 10.1: Trends for open and distance education from 2000 to 2020.

This complex net of partnerships, providers and pedagogies is still under development, not least at The Open University. A postgraduate degree in Online and Distance Education has been developed by faculty associated with CALRG and now runs on the FutureLearn platform. This degree is both a way to apprentice students into e-learning and a means to research the delivery of accredited courses on a MOOC platform.

The adult learning dilemma

Such courses expose a central dilemma of adult learning: what students like most is generally not what is best for them. In 2016, Rienties and Toetenel, from CALRG, published two papers that analysed student satisfaction, retention and performance for over 150 degree modules offered by the OU (Rienties & Toetenel, 2016; Toetenel & Rienties, 2016). To develop an OU undergraduate module, the course team follow a process of learning design that involves predicting the percentage of different types of student learning: assimilating delivered content, finding information, communicating with other students, producing assignments, experiencing, interacting, and taking assessments.

When the module runs, the university gets data on student satisfaction, retention and exam performance. Thus, for each OU module, we can investigate what type of course design produces what outcomes. In brief, students prefer modules with plenty of delivered content (videos, texts) and some interaction. But the modules best at retaining students are those with communicative and

collaborative learning. And student exam performance is *worst* on those modules that are heavy on delivered content.

The future of distance education rests on finding answers to three big questions. How can providers of online courses develop sustainable business models? How can institutions work together to develop courses that attract substantial numbers of fee-paying students and offer transferrable credit? How can course designers overcome the adult learning dilemma to offer education that is both engaging and effective? For The Open University, as one of the largest distance learning universities in Europe, addressing these questions is central to its strategy and future direction.

Inquiry learning at scale

FutureLearn has shown that a platform based on a pedagogy of learning as conversation can be both engaging and effective at massive scale. What other methods of teaching and learning can run at scale? Since 2007, CALRG has designed a series of technologies, collectively named nQuire, to investigate inquiry learning, initially in classrooms then from 2013 for self-directed learning online. The approach of pedagogy-led design is the same as for FutureLearn: start from theory and practice of inquiry learning; let this inform design of a demonstrator system that is tested with learners; apply findings from the system in use to inform both design of the next version and to refine the pedagogy.

Personally meaningful inquiry

nQuire has gone through three main phases, each offering insights into inquiry learning with technology. The first was to explore 'personally meaningful inquiry'. School students investigated topics that had personal significance, such as 'Are animals in cities affected by pollution?' and 'How noisy is my classroom?'. Each student had a computer-based toolkit to guide an entire inquiry process that connected structured learning in the classroom with discovery and data collection at home or outdoors. A visual map of the inquiry process, enacted on a portable computer, was successful in guiding students. However, this schools' version of nQuire placed demands on the teacher to orchestrate the process, particularly for the classroom activity that integrated data collected by all the students into a satisfying conclusion.

Citizen inquiry

The second phase, described in Chapter 9, was to explore how inquiry learning could be managed online, without the guidance of a classroom teacher. The structured inquiry process from the first phase proved too complex and

tedious for self-managed inquiries, so we have explored how to implement a new pedagogy of 'citizen inquiry' (Herodotou, Sharples & Scanlon, 2017). This fuses the mass participation of citizen science with the question-led investigation of inquiry learning. In effect, it flips the roles of citizen science. Instead of a scientist designing an investigation to which members of the public contribute, in citizen inquiry any person or group can design an inquiry and then recruit other people, including scientists, to help with carrying it out. The key is to keep each inquiry clear and focused, with an initiating 'big question', a structured activity to investigate it, data that can be collected by members of the public on mobile devices, a way to publish results on the platform, and a conversation between participants to provoke interest and guide the unfolding investigation.

The nQuire-it platform was open to anyone to develop a new inquiry, called a 'mission'. An authoring tool on nQuire-it assisted in designing the mission. Once the mission had been built, it was published on the site for anyone to contribute. Each contribution was visible and, as with FutureLearn, each mission and contribution had a linked discussion. Over the five years that the platform ran, some 150 inquiry missions were developed, ranging from an investigation of noise levels in school classrooms to observations of the impact of flooding on homes and roads in Vietnam's Mekong Delta (Figure 10.2).

Figure 10.2: A contribution to an nQuire-it mission to log and discuss flooding in Vietnam.

Although nQuire-it demonstrated that people worldwide could design and run investigations, most missions were short-lived with few contributions. A study by Aristeidou with amateur meteorologists (Aristeidou, Scanlon & Sharples, 2017) found that extrinsic factors, such as a well-designed site and thought-provoking questions, attracted and activated participants, but intrinsic factors such as personal interest in the topic and support from the community crucially determined whether the community of inquiry developed and sustained.

Inquiry learning at scale

The new nQuire platform[6] is a collaboration with the BBC. The aim is to demonstrate scale and sustainability in learning by inquiry. Promotion through BBC broadcast media provides the initial recruitment (a mission on nQuire to survey UK gardens has attracted 230,381 responses), but to be successful nQuire must address three challenges: engage participants in valid and meaningful scientific inquiry; provide reward for taking part; enable individuals, groups and organisations to design and run missions on the platform. Some methods we are exploring to meet these challenges include: framing each mission within a scientific process that includes informed consent and ethical scrutiny; offering intrinsic rewards through personalized feedback; giving powerful yet easy-to-use tools to author new investigations; and providing a guided process to design, preview, pilot and launch a mission.

The nQuire project offers an object lesson in developing education technology beyond prototypes (Scanlon, et al., 2013). The persistence has lasted over twelve years and four major versions of the platform. Each iteration of pedagogy and technology has produced a site for bricolage through playful experiment. For example, the Noise Map mission on nQuire-it started as a demonstration of how a mobile phone could capture sound data to the platform, then was taken up by a teacher in Argentina who used it with students to explore environmental noise, then it spread to schools in Hong Kong, Taiwan, China and New Zealand where they compared noise levels in classrooms, labs and school cafes:

> "Our MindLab Manurewa recorded a sound level of 44 to 68dB. While this seemed somewhat reasonable, I think this was a little loud for groupwork indoors. At a high of 68dB we struggled to hear each other or follow the conversation." ejenkins@ormiston.school.nz

Each iteration of the nQuire project has produced evidence of the value to learners of engaging in inquiry learning, both to investigate personally-meaningful

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6 www.nquire.org.uk

issues and to understand how to be a scientist. It has also raised issues – such as teacher orchestration, self-managed inquiry, and inquiry at scale – that have been examined by successive iterations. However, if this suggests a smooth path of design-based research, it certainly does not feel that way to the research team. Each version of the project has involved debate about the value and direction of the research and a continual struggle to get funding.

Inquiry, like conversation, is a fundamental process of learning. Through inquiry learning students learn to pose thoughtful questions, make sense of information, and learn about the world around them. They develop the skills and attitudes needed to be self-directed, lifelong learners (National Library of New Zealand, n.d.). Citizen inquiry learning that is online, open and scalable offers new opportunities for people to learn by investigating themselves and their environment.

Mobile and accessible learning

Personal investigations require mobile technologies to record and share data. Members of CALRG have been active since the early 2000s in development of mobile technologies for learning. Sharples held the first international conference on mobile and contextual learning, to become the mLearn conference series, and both Sharples and Kukulska-Hulme have served as Presidents of the International Association for Mobile Learning[7].

Learning and context

The large European MOBILearn project, which ran from 2002–2004, developed an architecture for mobile learning. As with FutureLearn and nQuire, the focus was not on the technology alone, but the combination of pedagogy and technology. One important legacy of MOBILearn is a theory of mobile learning as a contextualised practice (Sharples, Taylor & Vavoula, 2016).

As learners, we are always immersed in a context. For traditional education, this is the classroom, managed by a teacher and mediated by familiar tools such as blackboards and textbooks. When education is taken beyond the classroom, the context becomes more fluid and unpredictable. As well as being *in* a context, as learners we also *create* context out of our available resources of location, technology and social setting. For example, a family standing before an exhibit in a museum is creating a context for learning out of the exhibit and its labelling, the route through the museum to reach that exhibit, existing knowledge

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7 https://iamlearn.org/

brought by each family member, mobile devices including handheld museum guides and mobile phones, and the conversation amongst the family members.

Since people have a diversity of needs and cultures, own a range of technologies, and move through varying locations and social engagements, it follows that researching mobile learning is complex and challenging. To design mobile technologies involves either adapting them to rapidly changing contexts or providing a generic aid to learning that will offer useful learning despite context (Sharples, 2015). To evaluate the effectiveness of mobile learning requires new methods for understanding how knowledge is created within and across contexts.

Mobile support for migrants

Of all the contexts for mobile learning, perhaps the most difficult to research and design involve support for migrants. Immigrants to a country bring their own knowledge, language, technologies, expectations and concerns to a new setting. Just providing migrants with a mobile visitor guide in their own language in by no means sufficient. They have needs to gain work, find friends, understand cultural norms and expectations, and learn how to survive and prosper in the new environment. CALRG, led by Agnes Kukulska-Hulme, has had a central role in the European MASELTOV project to support immigrants in cities through mobile technologies. Its aim has been to understand the changing contexts of the immigrants as they go about their daily lives and how combinations of mobile technology and peer support can give help when needed (Kukulska-Hulme, et al., 2015).

Accessible learning

Viewing learning as a mobile and contextualised activity prompts us to rethink accessibility. As Chapter 4 discusses, allowing people with a broad variety of abilities and disabilities to enter online learning is necessary but not sufficient. We must also support them to stay and learn. Each person has a different context for learning – with unique needs, barriers, resources, culture, and social network. This context frames how that person understands what it means to learn, what will be gained from engaging in education, and how the learning activity will progress. The implication is that we must look for new ways to support the resourcefulness of students from their contexts, not just provide our resources.

As an example, members of CALRG have been exploring the value of predictive analytics. Computational techniques can analyse the online interactions of students on a course and predict, with high accuracy, which students are at risk of failing. What then? One use of such methods is to alert teachers to

poorly-performing students. Another is to let the students themselves know what they could do to get back on track – such as join a discussion forum or read a supplementary text. However, this is analytics seen from the perspective of the course provider. To the student, being given yet more resources is unlikely to help if they are already overloaded, or if they view learning as a process of trying to digest everything they are given. Understanding students' context, history and culture may contribute more to effective learning than diagnosing failure – but that is hard to program into software. A better approach may be to offer analytics that empower teachers to understand not just which students are at risk, but the contextual factors involved (Herodotou, et al., 2019).

Merging personal and social learning: a research agenda

It is an exciting time for educational technology. There's a plethora of new tools for learning: virtual and augmented reality, chatbots, predictive analytics, personalized learning systems. The Bill and Melinda Gates Foundation has teamed up with the Zuckerberg Initiative (founded by Facebook CEO, Mark Zuckerberg) to promote and invest in personalized technology for classroom instruction (New Profit, 2017).

However, technology alone will not transform education. An analysis of 40 years of research into the impact of educational technology on educational performance shows only a small to moderate effect size of 0.33 (Tamin, et al., 2011). The successes in computer-assisted learning come from understanding how to use technology effectively in the classroom and online. Future research must explore good combinations of technology and pedagogy. For example, a RAND study of personalized learning in schools showed that it could be effective, but only if students learn in groups, the classroom is re-designed to accommodate the new way of learning, and the students are given opportunities to discuss their performance with the teacher (Pane, Steiner, Baird & Hamilton, 2015).

A promising research agenda for educational technology is to examine how personalized and social learning can fit together. Personalized learning offers content and activity that is matched to the needs, abilities and context of each learner. It can drive mastery learning where the student continues with a topic until it is well understood, and cognitive tutoring that diagnoses each student's knowledge and gives remedial help to correct misconceptions.

Social learning is a great success of educational innovation (Johnson & Johnson, 2009). When students cooperate in small groups of between four and eight people, this results in greater creativity and better outcomes than working alone. Over the past 40 years, hundreds of studies in labs, classrooms and online, have uncovered conditions for successful cooperative learning. For groups to work well, they need to have shared goals, each person should know how and when to contribute, and everyone should make an appropriate

contribution. They should share rewards such as group marks in a fair way, and members of a group should all have opportunities to reflect on progress and to discuss contributions. For many students, learning in groups is not a natural process, and they need to learn how to cooperate by arguing constructively and resolving conflicts. The key phrase is *positive interdependence* – everyone sees the benefits of learning together and works to achieve the group's goals. Social learning platforms such as FutureLearn are starting to show how positive inter-dependence can enhance learning online at large scale.

How can personalized and social learning be made to work together, so that they compliment rather than conflict? It means designing learning environments that encourage students to examine their personal learning goals and work to achieve mastery of a subject, not alone but alongside others with similar aims and contexts. Successful learning environments of the future will be based on a deep understanding of the science of learning, support students to set and meet their goals, offer a combination of personalized tuition and social learning, harness predictive analytics to assist teachers and students, and provide a delightful experience.

Ethical EdTech

Yet even an environment for successful learning is not enough, if it fails to reach the standards expected of ethical research and development. Too many educational technology studies in the past have treated students as if they were subjects in a laboratory experiment. That is no longer acceptable. The new direction is not to claim that the outcomes of an educational intervention justify the means, nor to rely on an ethical review board to police educational research, but for the researchers themselves to engage actively in a process of ethical research design (Head, 2018).

The first consideration is whether it is ethical for any piece of educational research to take place at all. Researchers should engage in questioning the assumptions of their research from the outset. Part of developing as an educational researcher is learning how to work with participants, to be sensitive to their needs and contexts, and to address and resolve ethical dilemmas. "Becoming an ethical educational researcher, then, is a matter of pedagogy." (Head, 2018, p.11). The CALRG is contributing to that pedagogy of ethics for fields that include mobile learning (Lalley, et al., 2012) and AI and education (Holmes, Iniesto, Sharples & Scanlon, 2019).

It is not possible here to summarise the rich ongoing discussions about ethics for educational research. Instead this chapter ends with some provocative guidelines framed as a mnemonic: MISSION.

Multiple media, devices, partners
Independent verification

Secure environment
Support for learners
Inquiry process
Open access
aNalytics for learning

Educational technology requires understanding the *multiple media* and devices that people use in their everyday lives and designing new ways to augment their learning across contexts. It also involves multiple partners as design informants, including learners, teachers and policy makers.

As design of an educational technology progresses, there is increasing need to bring in *independent verification* of the educational need, the user experience, the validity of the learning and its ethical soundness. For CALRG projects, this has included expert testing of early prototypes, recruiting teachers as experts in educational effectiveness and curriculum relevance, and commissioning independent reviews of data security.

A *secure environment* for learning covers not only ensuring security of data produced by learners, but also providing safe and enjoyable places to learn online. For example, the FutureLearn and nQuire sites provide ways for users to report inappropriate comments, checked by moderators.

Support for learners starts from their first engagement with the educational technology. For our projects, we put great effort into designing the 'first five minutes experience' so learners know how to take part, what to expect, and what to do first. On nQuire, users can view content without registering for the platform, so they know what to expect before providing personal data. Support for learners can extend to recruiting expert and peer facilitators and embedding effective pedagogies into the learning experience, such as formative testing with immediate feedback.

An *inquiry process* is central to active learning. It involves learners setting personal goals and asking questions to themselves that require investigation and reflection. The teacher becomes a partner in the learning process, guiding students to create knowledge. Good teachers and researchers inquire into their own practices and share knowledge of what works.

For ethical education, *open access* should be the norm, not only to enter education but to profit from the full richness of the experience. That means designing for cultural, physical and mental diversity and providing ways for like-minded students to share their knowledge and experience. It also means giving students access to the process and results of their unfolding study, through techniques such as dynamic knowledge maps, skill charts and open learner models (Bull & Kay, 2010).

Learning online creates a rich seam of data that can be mined to show progress and performance. An ethical approach to educational technology harnesses that data to provide *analytics for learning*. This could take the form of predictive analytics to guide students in what to do next based on their performance, or it

could assist teachers and course designers to understand which topics students find difficult and how to improve the course quality and access.

CALRG at 40

As the Beyond Prototypes framework indicates (Scanlon, et al., 2013), technology enhanced learning is a complex system of technologies and practices, developed and embedded over many years. We are fortunate to be part of a research group that has prospered for 40 years and is still thriving. Some themes that influenced the formation of CALRG, such as designing and testing open and accessible educational technologies, are as important now as then. Some themes have come to prominence more recently, such as developing learning environments that are scalable and sustainable. And some themes set an agenda for future research and development, including analytics for learning and how to combine personalized with social learning online. Over the years, PhD students have made a major contribution to CALRG, opening new areas of research and bringing their personal and cultural perspectives. So too have the system developers and programmers – they have built the technologies and platforms, sometimes through many versions, that support the learning and test the theories.

We now know for certain that successful computer-assisted learning involves not a series of exciting prototypes and quick fixes, but a sustained programme of research into the science of learning and the design of effective interventions. Continued support for research and development in education technology is essential for the next generation of students to benefit from the current advances in educational technology and pedagogy.

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