A Challenge to Enhance the System of Education—a Comment from a Researcher Perspective

Book Section

A Challenge to Enhance the System of Education

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Technology and educational transformation

Technology enhanced learning is a complex system that consists of much more than a set of research-informed products (TELRP, 2013). It encompasses a dynamic interaction between communities, technologies, and practices, informed by pedagogy. Some aspects of this dynamic system are very difficult to change because they are bound together in a mutually reinforcing mesh. Formal education consists of an interlocking set of curricula, standards, examining processes, and teaching practices that are very difficult to shift. Similarly, commercial educational publishing of textbooks and journals has been slow to respond to external pressures for interactive media publishing and open access.

For the past hundred years, grand predictions have been made about the future of education. Looking back, they appear to overstate greatly the power of technology to change this super-stable system. In a magazine article published in 1913 Thomas Edison was quoted as saying "Books will soon be obsolete in the public schools. … It is possible to teach every branch of human knowledge with the motion picture. Our school system will be completely changed inside of ten years." Over the succeeding decades similar predictions have been made about the transformative power of educational television in the 1960s, language labs in the 1970s, computer based instruction in the 1980s, integrated learning systems in the 1990s, virtual worlds for learning in the 2000s, and Massive Open Online Courses (MOOCs) in the 2010s.

It seems clear that no injection of technology alone will transform education, in the way that a driverless car may transform road transport. So what should be the grand challenges for TEL? Arguably, the nearest to transformative technologies for learning to date have been flipped learning (Hamden,McKnight & Arfsrom, 2013) and the MOOC. Neither of these arose from a Grand Challenge or a major research programme, but rather they emerged from individual initiatives (by Salman Khan, Dave Cormier, George Siemens and Stephen Downes, the latter three inspired by the Open Educational Resources movement). Flipped classrooms and MOOCs are both combinations of technology and pedagogy, they bridge the gap between formal and informal settings for learning, and they address the affective aspects of learning, motivating people to learn through attractive media and inspiring teaching. They also have broad applicability across ages and sectors, their reach is global and, most important, they don't seek the permission and purchasing power of formal education.

Smart cities

Taking these aspects as indicators of possible success (combining technology and pedagogy, bridging formal and informal settings, addressing affective aspects of learning, broad applicability, and ability to grow outside the formal education sector), how do the Grand Challenge Problems measure up? Perhaps the closest match to these criteria is in the GCP1 Smart City Learning challenge. The opportunity here is to extend a city infrastructure to enable learning. Just as cities are places for living, working, shopping and travelling, so they can be sites for learning. To some extent they already are, but the learning has tended to be confined to specific locations (libraries, museums, galleries) or to learning about the city itself through information boards and signage. The opportunity is to extend the city as a site for learning: about its inhabitants, its structure, its history, and about the fabric and dynamics of cities in general. Major tourist destinations such as London and Florence are obvious candidates. The Streetmuseum smartphone app by the Museum of London provides an augmented reality tour of the streets of the city, with the ability to hold the camera up to a present-day street scene and see how it looked in the past, accompanied by information about historical events[1].

But as the grand challenge indicates, all cities could become "inclusive and supportive of the whole complexity of human learning". Just as many bus and tram stops offer dynamic information about the next arrival, so buildings could inform about their energy usage, or streets about their levels of carbon monoxide and other pollutants. Residents in a city could create stories, trails and language resources for visitors. Art and culture can be taken onto the city streets through augmented reality graffiti. The learning can be enabled by self-directed interaction with resources *in situ*, by enhancing meaning-making through annotation of places and artefacts, by making connections between people in actual locations and online ones, and by creating storytelling trails that lead visitors and new residents through enriched paths around a city. The challenge is how to make this work in a way that informs, enlightens and inspires, creating a greater affinity with the living city, not just a new electronic cacophony of city noises and images.

Connecting learning in formal and informal settings

Other Grand Challenge Problems explore the connections between learning in formal and informal settings. The GCP5 and GCP6 grand challenges envisage vocational education students as 'connectivist' learners, bridging the divide between the workplace as a site for acquiring procedural knowledge and skills, and the classroom as a place for sharing and reflecting on situated experience and for refining skills. For this to happen, schools in the vocational education and training (VET) sector must be more tightly connected to the world of work. Technology can assist by allowing learners to capture workplace incidents as video clips, to explore simulations of their real work settings, and to take their reflective practice back into the workplace through mobile devices. In the Dual-T project Motta and colleagues (Motta, Cattaneo & Gurtner, 2014) equipped apprentice cooks, pastry cooks and car mechanics with headband cameras or smartphones to capture workplace incidents on video that provided resources for discussion in the classroom. They conclude: "Capturing visual materials through mobile devices on activities experienced at the workplace and using them at school to promote specific learning activities can constitute an effective way to give apprentices the chance to learn and reflect on their own professional background" (Motta, Cattaneo & Gurtner, 2014, p. 176).

But for this to happen on a large scale, teachers need to extend their practices to embrace not only the new technologies but also the new connections to the workplace that these enable. As GCP5 indicates "schools must be reorganized as a learning community that shares and connects experience among itself and with the workplace". However admirable the aspiration, it is unlikely to be realised, at least in the short term, within the constraints of current vocational education. There are no incentives within the current over-stretched system for teachers and learners to share

[1] http://www.museumoflondon.org.uk/Resources/app/you-are-here-app/home.html

experiences or exploit technology to connect with workplaces. Perhaps the best hope for the future lies in new industry-education partnerships, such as the University Technical Colleges in the UK that offer partnerships with companies to undertake project-based vocational learning enriched by technology.

Technology-enhanced science inquiry

A similar systemic resistance to change is faced by attempts to empower science teachers with technology-enhanced scaffolding to improve inquiry learning (GCP3). The curriculum may require students to understand science inquiry, and individual teachers may be inspired to adopt inquiry methods for science education. But factors including timetabling, health and safety regulations, lack of equipment, and a reluctance to allow students to user their own smartphone devices as tools for data capture mean that it is difficult, if not impossible, to enact a full cycle of inquiry-based learning within the classroom. There are opportunities to extend inquiry learning beyond the classroom, with the teacher and students deciding an inquiry question in class, then the students using mobile devices to collect data at home or outdoors, and then sharing and presenting the results back in class (Anastopoulou et al., 2012). However, this requires a teacher who not only understands the methods and practices of 'extended inquiry learning', but is capable of managing the disciplined improvisation needed for a classroom lesson to integrate the data collected by twenty or more learners on mobile devices, and bring the inquiry process to a satisfying conclusion.

Providing a teacher with a 'virtual assistant' (GCP3) to analyse and respond to individual learners may seem like a means to address this problem by reducing the burden of classroom management. But this raises a classic problem of artificial intelligence for the real world. The nature of genuine scientific inquiry is that it may produce unpredictable findings, so either the inquiry activity must be constrained to fit the limitations of the virtual teaching assistant, providing simulated results within narrow parameters, or the human teacher will need not only to manage a class of human students but also to interact with a virtual assistant when it fails to cope with the complexities of real data, and explain its limitations to the students. Injecting virtual teachers into real classrooms is likely to increase, not reduce, the complexity of science teaching.

Learning analytics

An alternative approach to virtual assistance is to empower the human teacher to make appropriate decisions, based on rich data about student learning, whether that occurs within the classroom, outside it, or online (GCP4, GCP7, GCP8, GCP11, GCP12). This approach of providing 'teacher dashboards' of real-time information about learners' knowledge, activity and emotion has much appeal as a grand challenge. It attempts to empower rather than replace the teacher. It is based on a theory and practice of visible learning that is shown to be effective in improving learning outcomes (Hattie, 2009). It recognises the real or online classroom as a site of complex cognitive, social and emotional interactions. And it can be extended to a large scale – for example, the STEMscopes online science curriculum can provide visualisations of the activity of 50,000 teachers and over a million students[2]. The most effective approaches so far are beguilingly simple. The Purdue Signals system (Pistilli & Arnold, 2010) provides an early warning system of problems with a course or with individual students by automated analysis of performance data into a 'traffic light' visualisation. A

[2] http://stemscopes.com

green signal shows that the work is progressing smoothly, amber indicates areas of concern, and red flags up significant problems. These signals can be shown to the teacher or to students, and the teacher can intervene by contacting students at risk of failure to offer support. Analysis of outcomes for courses that have used the Signals system, show a consistently higher level of exam grades (Pistilli & Arnold, 2010).

So, analytics for learning can work. The irony is that it does so by reducing the dynamic complexity of learning to three colours: green, amber, red. But that apparently reductive simplicity belies the sophistication of the approach. It can provide similar information to both teacher and students, leading to a convergence of understanding and goals for improvement. It can be applied dynamically, providing timely feedback on performance. It can reveal problems with a course, with groups of students, or with the performance of individual learners. And it can provide a basis for action, by identifying a source of difficulty and an opportunity for focused teacher intervention.

We should also be aware of the limitations of this approach, since analytics is not a panacea: it is no substitute for an inadequate curriculum or weak teaching. A dashboard can only reveal what can be measured. Currently, this is largely based on when the student has completed an activity, such as viewing a page of online material or contributing to a forum, or has taken a test.

A grand challenge is to extend this to other kinds of learning and interaction, such as self-regulated experiential learning in groups (GCP2). The signals from learners could include facial expression, speech patterns, eye movement and physiological data such as heart rate. There may be a temptation to dismiss this emotional data as pseudo-science: measuring how much children fidget as an indicator of their boredom. But emotional self-regulation based on bio-feedback from heart rate and skin conductivity has been shown to help financial traders improve their decision-making – particularly, in addressing a key problem known as the 'disposition effect' whereby investors in a volatile trading market hold on to losing positions for longer than to winning positions (Peffer & O'Creevy, 2012). Can similar methods be used to assist classroom or online learning by helping learners, individually or collectively, understand and manage their emotions?

For learning analytics to be extended across formal education does not require the wholesale reform of schools or universities, Indeed, a criticism levelled at learning analytics is that the collection and analysis of educational data reinforces traditional teaching practices and sustains inequalities, providing more opportunities for testing and number-crunching rather than innovations such as project-based learning that may be harder to measure. As GCP8 indicates, ethics and social responsibility should be at the core of learning analytics, not only in setting boundaries on what data should be collected, but also questioning whether data collection leads to greater accountability, or to teaching by numbers.

Where learning analytics can work well, is when the data can be visualised in ways that provide immediate feedback to learners on how they are progressing in relation to goals they have set themselves, to teachers on where to intervene and support, and to policy makers in exploring opportunities for re-designing education. These feedback loops then may enable an educational system that is dynamic as well as complex, working to achieve goals rather than stifling change, and empowering innovators not just satisfying administrators.

A challenge to create dynamic and innovative systems of education

Thus, an overarching challenge is to employ technology in ways that create dynamic and innovative systems of education, where teachers, learners and policy makers are enabled to explore new methods based on combinations of powerful theory and sound evidence. For this to happen educational institutions need to become learning systems, with educational technology as the mechanism for institutional development as well as for enhancing learning. We can picture this, in Figure 1, in terms of the organizational double loop learning of Argyris and Schön (1974, 1987).

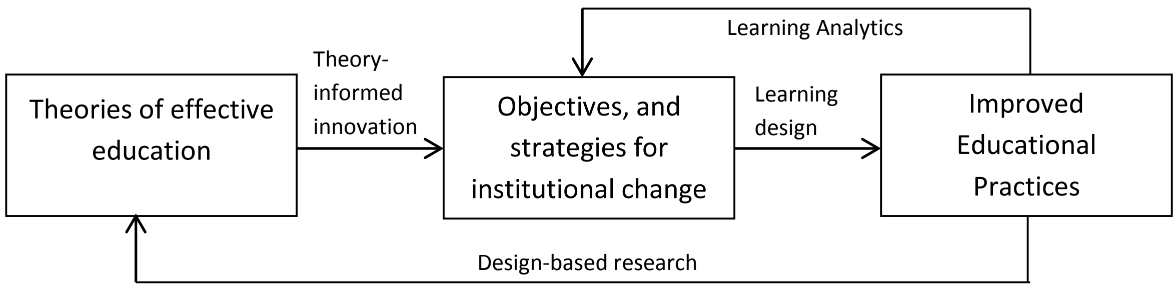

Figure 1. Double-loop organizational learning for educational change.

An effective learning organization is not only able to adjust to changes in the external or internal environment, but also to reflect on the process of change and thus change its objectives and strategies to enable more effective working. The system of education now has both the methods and the technologies to put this into practice. Innovations in pedagogy (Sharples et al., 2014) and studies of the relation between learning theories and effective practices (e.g. Hattie, 2009) can provide guides to theory-informed educational innovation. These can inform a productive cycle where analyses of current practices, using learning analytics, provide grounds for changed objectives and strategies that are put into practice through a process of technology-enhanced learning design. The larger cycle of organizational change comes through a process of design-based research where "insights from many different fields are converging to create a new science of learning that may transform educational practice" (Meltzoff et al., 2009).

MOOCs are the new proving ground for this organisational double-loop learning. They offer what was previously missing from an effective learning system: the ability to carry out research based on rapid cycles of learning design and analyses of large-scale data, leading to development of new theories of effective online education innovation, that inform further practice. As an example of the new science of learning in action, the FutureLearn platform (www.futurelearn.com) to support MOOCs from 50 partner institutions, is being developed by incremental Agile software methods (Rubin, 2012). Each two-week cycle of development includes a 'pedagogy scrum' that sets objectives to develop major educational functions for the platform and proposes how to re-conceive the underpinning theories for massive-scale online learning. Data from learner activities on each course are continually analysed and fed into the pedagogy scrum to improve functioning of the platform. The data also informs research into the emergence of a new pedagogy of massive online social learning, explored by a research network of FutureLearn partners.

This iterative pedagogy-informed process of learning design is far removed from the typical process of educational technology innovation in schools, universities or workplaces, where "if there's any change it's very slow. I don't think the educational establishment has really embraced these ideas [of creative and collaborative learning]" (Resnick, cited in TELRP, 2013). The easiest and most commercially viable use of technology enhanced learning is for it to reinforce traditional education by providing more efficient methods of teaching, tracking and testing. The alternative – to challenge educational inequalities (GCP9) by devising new forms of technology enhanced learning that empower and emancipate – requires a "vivid network and community of practice" (GCP10) that coordinates research labs and schools capable of enacting large scale, sustainable innovation. The network must itself adopt agile methods of research, implementation and dissemination, to experiment with new forms of learning for a digital world. The ultimate goal is a pan-European TEL network, similar in scope and ambition to those of particle physicists[3] or climate scientists[4], which organises large-scale design research projects, provides an international forum to align efforts of thousands of learning technologists and educational practitioners, interprets findings from a wide variety of educational experiments within and beyond classrooms, and provides policy makers and education leaders with the best possible evidence of successful innovation.

The quest to improve education for all, enhanced by technology, is at least as important to society as finding the Higgs Boson and or investigating climate change. To coordinate this effort requires a shared vision and the collective exercise of ambition by researchers, practitioners and policy makers.

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[3] http://home.web.cern.ch/
[4] http://www.wcrp-climate.org

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