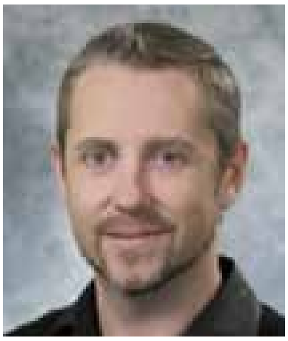
FROM THE LABORATORY TO THE CLASSROOM:

TRANSLATING THE LEARNING SCIENCES FOR USE IN TECHNOLOGY-ENHANCED LEARNING



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Dr Jason Lodge is a psychological scientist and lecturer in technology-enhanced learning at the Griffith Institute for Higher Education, Griffith University, Brisbane. Jason's research concentrates on the application of the learning sciences to education. Specifically, he is interested in the cognitive and emotional factors that influence learning and behaviour and how research findings from the learning sciences can be better used to enhance instructional design, teaching practice and education policy. Jason is also interested in the ways technology is influencing learning, particularly in terms of the impact of technology on the development of metacognition, critical thinking and expertise. Jason is a team member on a national Office of Learning and Teaching project; he is the chair of the Queensland branch of the Higher Education Research and Development Society of Australasia and is currently serving as a member of the New Media Consortium Horizon Project Australasia Advisory Board.

ABSTRACT

The learning sciences including neuroscience and cognitive psychology provide abundant opportunities for enhancing teaching, particularly as technology plays a greater role in education. But the translation of research conducted in the laboratory for use in the physical or virtual classroom is difficult. Studies examining the mind and brain cannot be easily converted into simple formulae or algorithms for learning. What is required is translation through a network of enabling disciplines for supporting teachers to enhance student learning, as it enables medical practitioners to improve health. The aim of this presentation is to outline the possibilities for the use of the learning sciences for enhancing learning with technology. In doing so, examples of the use of principles developed in the learning sciences applied to teaching practice will be explored. It is hoped that these examples will help teachers and learning scientists to understand what is required to translate research into technology-enhanced learning and teaching practice.

The evidence underpinning teaching practices at all levels of education has come under increasing scrutiny for several decades. The foundations of teaching practice have been described by Slavin (2008, p. 5) as 'driven more by ideology, faddism, politics and marketing than evidence'. While Slavin's commentary represents one end of the spectrum of criticism of educational research and is not representative of all views, this scrutiny has nonetheless prompted policy responses in a number of countries. For example, the 'No Child Left Behind' policy of the US government (US Department of Education, 2001) in the early 2000s contained within it a concerted push for what became known as the 'what works' agenda. A similar policy discussion paper has recently been issued by the Department of Education in the UK (Goldacre, 2013). The theme in both of these policy documents is similar: that education should be informed by rigorous scientific evidence including randomised control trials.

The alternative viewpoint to the criticism of current educational research and the resulting policies is that the rigorous approaches such as those used in cognitive psychology and neuroscience are too rigid and reductionist for practical use (Oliver & Conole, 2003; Smeyers & Depaepe, 2013). In other words, what happens in a laboratory or randomised control trial is not necessarily indicative of or generalisable to a physical or virtual classroom. The upshot of the debate about the 'what works' agenda is that rigorous studies examining fundamental learning processes are very difficult to translate so that teachers are able to use the findings in practice. Reeves (2011) suggested that getting the maximum benefit from research into learning and teaching will only occur when the difficult balance between rigour and relevance is achieved. This remains one of the major ongoing challenges for educational research: laboratory and imaging studies are simply not readily applicable to teaching practice without substantial translation and interpretation.

While debates about the virtues of rigour and relevance for teaching have continued, advances in technology have fundamentally altered learning and teaching at every level of education. The last decade in particular has seen an explosion in availability, power and capacity of digital technologies that have outpaced the development of effective pedagogy for using these new tools (Beetham & Sharpe, 2013). At the same time, research on the use of educational technology has faced criticism for failing to inform the implementation and development of technologies for learning in education and beyond. Selwyn (2012, p. 1) argued that 'educational technology certainly suffers from a lack of rigorous and sustained inter-disciplinary exchange' and as a field of research has therefore become overly insular, providing little of use outside the educational technology community. It would appear that although educational technology has had an increasing impact in the classroom and beyond, research into the ways in which technology can be used to effectively enhance learning has not kept pace.

The distance between rigour and relevance in educational research, educational technology and teaching practice is a fundamental issue for enhancing education at all levels. Bruer (1997) famously argued that the gap between studies examining the brain and educational practice is a 'bridge too far'. While there may never be a simple process for translating highly controlled experimental or imaging studies to classrooms, there might be possibilities for learning from other disciplines and industries where such a leap has been made. The most obvious case of basic research developing a comprehensive evidence base applied successfully to practice is in medicine (Goldacre, 2013). Chemistry and biological science, among other enabling disciplines, are translated for use by biomedical science, which is then developed into evidence-based treatments for use by medical practitioners. The ecosystem of enabling disciplines in medicine provides one way of understanding what is possibly lacking in the quest to enable teachers with a rigorous scientific evidence base.

For technology-enhanced learning, the situation is made more complex in that there remain many unanswered questions about the effectiveness of using technology as opposed to more traditional learning and teaching approaches (Selwyn, 2011). Another allegory may be useful in understanding and enabling technology-enhanced learning, that of molecular gastronomy. Although cooking, as a practice, has existed for millennia, it has only been for the last few decades that food science has had a major impact on established cuisines and traditional cooking approaches (Vega & Ubbink, 2008). Rather than force a complete rethink of the way that food is prepared, molecular gastronomy has involved a deconstruction of techniques and a tweaking of these approaches through test kitchens or laboratories relying on food science to inform incremental improvements in cooking practices (This, 2006). In a similar manner, it is possible that technology-enhanced learning could be enriched through a process of deconstructing established approaches to instruction and educational design, rapid prototyping and small-scale, rigorous testing before innovations based on the learning sciences are applied to classrooms (see also Reeves, McKenney & Herrington, 2011).

While examples of overcoming the gap between rigour and relevance are uncommon, there are some cases where a deconstruction of technology-enhanced instructional approaches has occurred. For the purpose of this paper, I will discuss these examples as 'easy' or 'hard' problems. Easy problems are those that lend themselves to relatively straightforward solutions provided by the learning sciences. One example of this is provided by Smyth and Lodge (2012). In this case, the problem was a pastoral care (that is, co-curricular) issue. When students first begin university, many feel overwhelmed with the amount of information they are asked to deal with (Kift, 2008). Sweller's (1988) cognitive load model provides a suitable approach for understanding this issue. In this case, the information provided electronically to students about admission, enrolment, financing their studies and so on is mostly essential, so there is high intrinsic cognitive load (Sweller, 1994). The approach taken by Smyth and Lodge was to reduce this cognitive load by making the orientation process 'longer and thinner' through the creation of an online portal for vital information that is self-paced and can be completed in a time frame that allows students control over when and how they consume the information. The design of the site was also based on principles of visual attention (for example, Wolfe, 1998) so, not only was the information presented in smaller chunks to reduce cognitive load, visual cues were added to guide attention to relevant important information. Sections of the site were also colour-coded to allow a simple visual indication of progress through the site. Students to whom a pilot of the site was made available used the site extensively and the number of enquiries these students had after completing the orientation were fewer than those who had completed a more traditional orientation. It would appear that cognitive load theory and principles gleaned from rigorous research on visual attention were useful in dealing with a co-curricular issue through a deconstruction of the approaches being used.

As opposed to easy problems, hard problems are those that require a deconstruction of a broader pedagogical approach or problem. Understandably, there are fewer examples of curriculum deconstruction in the literature. The example of a co-curricular problem described above in molecular gastronomy terms is akin to deconstructing one element of a dish. On the other hand, deconstructing a curriculum to increase the chances of students meeting an intended learning outcome is like attempting to deconstruct an entire dining experience of several courses including the environment in which the meal is consumed. The context in which the learning experience takes place, the nature of the students in the physical or virtual classroom and the limitations and affordances of any technology being used, among other factors, are all essential elements to consider if any enhancement is to be effective (see also Goodyear, 2005).

One way in which I have explored a pedagogical problem at the level of intended learning outcomes is the way in which academics are introduced to technology-enhanced learning in a graduate certificate program in higher education. One of the main intended learning outcomes of the technology-enhanced learning unit within this program is for students (that is, academic staff of the university) to understand the issues faced by students as they attempt to develop the literacies required to be successful in programs or units that use online or blended learning approaches. The pedagogical principle underpinning the approach used to achieve this learning outcome is experiential learning (Kolb, 1984). Despite the solid theoretical grounding behind the approach being used to help academics meet this outcome, many have not gained a grounded understanding of the difficulties faced by students adapting to online and blended learning and hence do not completely understand the importance of educational design in this context.

In order to overcome this problem, possible solutions provided by the learning sciences were considered. One phenomenon that has been researched extensively in psychology laboratories and might prove useful in this situation is 'desirable difficulties' (Bjork, 1994). Desirable difficulties are deliberate strategies for disrupting the learning process and making the learning situation more challenging. For example, Diemand-Yauman, Oppenheimer and Vaughan (2011) found that presenting participants with material in a 'disfluent' or hard-to-read font was enough to create additional 'cognitive burdens' that result in improved learning compared to when material is presented in familiar fonts. Applying the notion of a desirable difficulty to a live classroom setting is difficult as the focus of studies of the effect is low-level cognitive processes, not high-level subjective experiences of learning. In a recent study Carpenter, Wilford, Kornell and Mullaney (in press) found that, while a more fluent instructional video (that is, clear and easy to process) led to more confidence that the material had been learned, there was no difference in performance between groups exposed to a fluent or disfluent (that is, difficult to process) video. While it is therefore challenging to directly translate desirable difficulties research to the classroom, these studies provide clues as to the ways in which teaching practice can be tweaked to create conditions more likely to result in students meeting desired learning outcomes.

In the case of experiential learning for academics, desirable difficulties do not provide a straightforward enhancement but the idea that making a learning experience more difficult or disfluent to improve learning does allude to a possible solution when incorporated into established approaches. The traditional design of transformative learning experiences often involves the idea of 'scaffolding' (Pea, 2004) in that support is provided so that students are able to construct their knowledge incrementally in alignment with Vygotsky's (1978) notion of the zone of proximal development. Alternatively, the notion that more challenging learning experiences can lead to better outcomes suggests that there may be some benefit in deliberately removing some of the scaffolding. In this case, a form of 'experiential disfluency' (as per Carpenter et al., in press), as opposed to low-level cognitive disfluency (as per Diemand-Yauman et al., 2011), was hypothesised to lead to a greater likelihood that the learning outcome would be met with better retention of the learning over the longer term. The feedback from academics completing the unit suggests that, although they found the experience of being an online student difficult and at times frustrating, they had a deeper appreciation of what it takes to design effective technology-enhanced learning as a result. While the results of this tweaking of the unit using principles from the learning sciences requires further investigation, it remains plausible that a translation of the notion of desirable difficulties to an experiential situation might have helped consolidate learning in this case.

Teachers cannot simply translate research conducted into low-level cognition and brain processes for use in real-life physical or virtual classroom settings but the two examples discussed here do give an indication as to possible avenues for allowing this type of translation to occur. Research on visual attention and desirable difficulties is predominantly conducted in highly controlled laboratory settings. While these sorts of studies emulate those found in the 'hard sciences' such as physics and chemistry, the process of attempting to apply this research beyond the laboratory requires a level of deconstruction, translation and interpretation similar to that in medicine and now common when chefs in the world's top restaurants apply food science to modern cookery. Translating the learning sciences will require a level of cooperation between neuroscientists, cognitive and educational psychologists, instructional designers, educational technologists and teachers beyond what is currently common. If the rapid growth of molecular gastronomy is any indication, should this collaboration be successful, the opportunities for advancing education at all levels through technology-enhanced learning will be both countless and potentially revolutionary.

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