FROM EXPERIMENTAL PSYCHOLOGY TO A SCIENCE OF LEARNING

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His research is concerned with human emotional learning and the interrelation between human emotion and attention. He has published more than 100 papers in international peer-reviewed journals and has obtained more than $1.2 million in research funding. He is currently the editor-in-chief of the journal *Biological Psychology*.

His teaching covers the areas of associative learning, emotion and psychophysiology. His efforts in undergraduate teaching and postgraduate supervision were recognised with teaching awards at the university and national level. In 2004–05, he led a discipline-based project to review the teaching of psychology in Australia. Since 2009, he has acted as one of the co-directors of the University of Queensland's Science of Learning initiative.

SACHA DEVELLE

Dr Sacha DeVelle has an extensive teaching and research background in educational assessment and psycholinguistics gained from working in Australia, the UK, Latin America and East Africa.

Her undergraduate degree in psychology and Spanish at the University of Queensland was the impetus for further postgraduate study into language processing. It was there that she coordinated the psycholinguistics laboratory within the linguistics program, and lectured on a range of linguistics, Spanish and ESL subjects for a number of years.

In 2007 she joined the Research and Validation Unit, University of Cambridge ESOL, where she was responsible for the IELTS research agenda and language-testing projects across the organisation. Since then she has managed projects in Uruguay, Brazil, Uganda, Ethiopia and Rwanda, and has specific expertise in advising on education programs within developing contexts.

Dr DeVelle has a particular interest in how the brain processes language at the semantics–pragmatics interface. She has presented and published extensively on this topic. Her more recent research has extended this work to deaf communities in Uganda, East Africa.

ABSTRACT

Human learning has been one of the core topics of psychology since its inception as an independent discipline in the late 19th century. Nevertheless, if one were to tally the contributions that experimental psychology has made to enhance learning in practice, only a rather brief list would emerge. This rather disappointing picture is slowly changing. By drawing on recent developments within experimental psychology and cognitive neuroscience, it is possible to highlight a number of promising approaches to the development of a translational educational science that connects basic psychological research and educational practice. Phenomena like the testing effect or the practice of interleaved training hold considerable promise to support enhanced learning across various settings and content areas, through building on strong empirical evidence. But the challenge remains to bridge the gap between the research laboratory on the one hand and the classroom on the other. The concept of the experimental classroom that affords the level of control required for the systematic study of human learning as well as the realism of a 'live' teaching and learning setting is proposed as an answer to this challenge.

INTRODUCTION

Recent discoveries in cognitive neuroscience, experimental psychology and education (Goswami, 2006; Howard-Jones, 2011; Roediger, 2013) have raised new questions about how learning takes place, and further emphasised the need for interdisciplinary collaboration, for a new 'science of learning'. But, as in most cross-disciplinary settings, such a dialogue is not easy and the science of learning is no exception. The Science of Learning Research Centre (SLRC) was recently established to provide a base for the cross-disciplinary study of human learning, and brings together researchers in education, neuroscience and cognitive psychology from three lead institutions – the University of Queensland, the University of Melbourne and the Australian Council for Educational Research (ACER) – plus a number of partner institutions (Macquarie University, the University of New England, Deakin University, Charles Darwin University and Flinders University). Two experimental classrooms, one at the University of Queensland and one at the University of Melbourne, will be at the core of the centre. Importantly, any successful bridge between the laboratory and the classroom will depend on, firstly, a common language and, secondly, a joint ownership of the research that is beneficial to such interdisciplinary collaboration (Howard-Jones, 2011). This session outlines how research from the Science of Learning Research Centre can contribute towards a translational educational science, allowing educators to select evidence-based learning methods (Roediger, 2013). The discussion starts with a brief description of cognitive neuroscience and experimental psychology to highlight their similarities and differences. We then turn to two results from experimental psychology research that hold considerable promise for the classroom. We finish with more detail about the Science of Learning Research Centre and the experimental classroom environment.

INTERDISCIPLINARY RESEARCH: A SCIENCE OF LEARNING

There is a plethora of experimental psychological research on human learning, considering issues such as working memory, motivation, attention and emotion, language development, learning difficulties or child development. Much of those findings have implications for all levels of education, from the learner and teacher to the policy adviser. Experimental psychologists traditionally use behavioural measures such as response times or response accuracy. In recent years measurement of brain function has complemented these behavioural measures. (These methods of measurement include electroencephalography – EEG – and event related potentials – ERPs – as well as functional magnetic resonance imaging – fMRI. Such methods are complementary in the aspects of brain activity they reflect – electrical versus brain blood flow – and the information they provide – high temporal resolution versus high spatial resolution.) Cognitive neuroscience aims to explore the neural bases of cognitive and behavioural phenomena using these brain-imaging methods. Much has been achieved in this field to answer the 'where' question – which are the brain areas that contribute to the behaviour in question? Of more interest is the 'how' question: how does the brain solve a particular task placed in front of it? The field overlaps with experimental psychology to the extent that it asks very similar questions, and many cognitive neuroscientists have a background in experimental psychology. Let us now look at two findings from experimental psychology that hold considerable implications for learning in the classroom. These are the stability bias in memory and the testing effect.

STABILITY BIAS IN MEMORY

Students are expected to take some responsibility for their own learning. But to carry this out successfully they must possess the metacognitive skills that support the learning process. Predicting how further practice can strengthen memory is a crucial skill, particularly when making decisions about the content and extent of future study. Kornell and Bjork (2009) carried out a series of memory experiments to assess students' ability to make this judgement. Having studied a set of easy and difficult items once, students were asked to predict their level of performance immediately or after 1, 2 or 3 additional study sessions. Although the students held the metacognitive belief that studying enhances learning and thus performance, they underestimated the performance gain due to further study by up to 33 per cent. Thus, having completed additional study sessions, students performed significantly better than they had predicted after the initial study session. This finding is complemented by the observation that students systematically underestimate the extent to which they will forget materials that they have studied previously. Koriat, Bjork, Sheffer and Bar (2004) asked students to learn a list of easy and hard items and informed them that they would be tested either immediately, a day or a week later. Students were very good at predicting performance in the immediate test. They were woeful in anticipating the detrimental effect that the passage of time would have on their performance. Taken together, these results provide evidence for a stability bias in the evaluation of memory performance (Kornell & Bjork, 2009). Students underestimate the benefits of additional study and overestimate the stability of memories that they have acquired. These findings are based on standard memory paradigms as used in experimental psychology research. There is no research that examines whether the stability bias scales up from the simple experimental paradigms employed in the laboratory to the more complex classroom environment. The question of particular relevance to researchers at the Science of Learning Research Centre is how to overcome this bias so that students become better predictors of their own performance, either as a function of additional practice or as a function of forgetting.

TESTING EFFECT

There is a vast literature showing that practice testing improves learning. This work has highlighted the importance of dosage (more is better) and time interval between tests (longer is better) among other factors (Logan & Balota, 2008). More recently, Roediger and Butler (2011) reviewed literature on the testing effect, which suggests that having a test on particular material enhances performance more than rereading or having no re-exposure. Students who received repeated testing were shown to outperform students who had only one test before a delayed final examination one week after study. In contrast, the number of study trials completed in the two testing conditions did not seem to affect performance at test. The effect of testing can be enhanced if feedback is provided as to accuracy. Interestingly, delayed feedback seems to be more beneficial than immediate feedback. Moreover, it is thought that repeated testing enhances transfer and the flexible use of acquired information. The testing effect is thought to reflect on the benefits of repeated retrieval practice, and the notion that effortful retrieval of a memory and its reconsolidation will strengthen retention. Less is known about the role of other processes such as self-generated feedback or the correction of memory biases (see above) in mediating the testing effect. The testing effect has clear implications for student learning but it is necessary to broaden the paradigms and contents currently used in its investigation so they become more relevant for educational practice.

We have reviewed as examples two findings from basic experimental psychology research that have clear implications for the enhancement of student learning (for further elaborations and examples, see Dunlosky, Rawson, Marsh, Mitchell & Willingham, 2013). The next step is to involve settings and materials that resemble those used in the classroom, while maintaining the strengths of the experimental approach – control and reproducibility. This is where we see the role of the experimental classrooms that form the core of the Science of Learning Research Centre.

THE SCIENCE OF LEARNING RESEARCH CENTRE

The research centre is funded under the Australian Research Council's Special Research Initiatives scheme. It brings together researchers from the areas of neuroscience, cognitive psychology and education to perform research on human learning. Bringing together such a diverse group of researchers, who differ widely in theoretical background and methodology, is challenging. Moreover, the centre will engage with stakeholders in government and with educational practitioners. Engaging with educational practitioners is of vital importance for two reasons. First, it will help the centre to perform research that is of practical relevance. We have no doubt as to the importance of basic research, as illustrated by the examples cited above that emerged out of basic research. However, if the centre is to achieve its objectives it must align the research with the requirements of educational practice. Second, early engagement with educational practitioners can only help facilitate the implementation of research outcomes. The platforms that will permit us to realise this ambitious collaboration (between researchers from very different backgrounds and between researchers and practitioners) are the experimental classrooms: one at the University of Queensland and one at the University of Melbourne. The classrooms will serve as conduits that connect laboratory-based research with educational practice in a two-way street of information exchange (see Figure 1).

The two experimental classrooms will be set up to complement each other and will leverage existing expertise in cognitive neuroscience (Queensland) and observational classroom research (Melbourne). The Queensland classroom will permit the monitoring of electrocortical activity, eye movements and peripheral physiology while small groups of learners engage in a variety of different tasks. This will enable the online assessment of cognitive processes as well as of performance measures. It will provide insights into the manner in which, for instance, the attentional engagement with study material changes as learners become more proficient at a given task or the manner in which different types of feedback enhance learning. The Melbourne classroom will permit the audiovisual monitoring of teacher–student and student–student interactions as they occur in a realistic classroom setting. This will enable the fine-grained analysis of both social

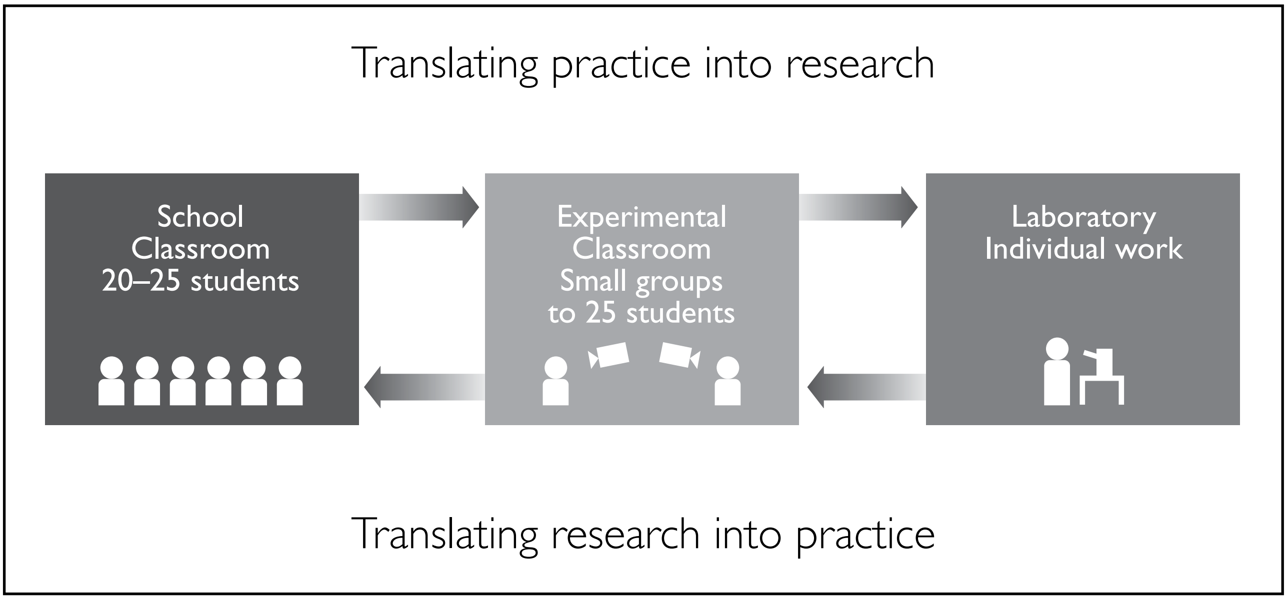

Figure 1 The experimental classroom as the connection between classroom and laboratory

interactions that characterise a learning situation and those that influence the learning process. It will provide insights, for instance, into the manner of how teachers and students respond during what they respectively perceive as the most critical moments of a particular lesson. It will also provide the opportunity for immediate feedback to teachers and students for a more in-depth gathering of information about the role of social interactions in class.

CONCLUSIONS

Education is about enhancing learning – experimental psychology and cognitive neuroscience investigate the mental processes involved in learning. 'This common ground suggests a future in which educational practice can be transformed by science just as medical practice was transformed by science about a century ago' (Royal Society, 2011). The Science of Learning Research Centre is designed to provide the platform to make this vision a reality. It will provide opportunities for research that will enhance our understanding of human learning and the factors that promote it and that will provide the base for a translational educational science.

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