Aligning socio-cultural, classroom perspectives on learning with neuroscience perspectives and findings

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Neuroscience perspectives on learning are gaining increasing attention, but the translation of findings of brain-based research to complex classroom environments has received considerable critical attention. The challenges with aligning findings on learning generated from neuroscience with insights from classroom studies, and translating neuroscience findings into recommendations for classroom teachers, include; issues of scale and complexity; vastly different learning paradigms; disparate methodological and epistemological traditions; and disparate theoretical characterizations of learners and learning. Nonetheless, these are research areas that need to speak to each other if we are to develop our understandings of how best to support learning. This paper will explore the nature of the challenges faced in aligning these perspectives, and describe a research program within the newly funded Science of Learning Research Centre, which aims to achieve such an alignment.

The Science of Learning Research Centre

There has been increasing interest by educators and those framing education policy in the findings of neuroscience and what they have to say about effective learning and teaching. Many words have been dedicated to linking our growing understandings of brain form and function to strategies for enhancing quality learning, including classroom pedagogies. The implications and applications of neuroscience research ranges from interventions in medical or genetic related, specific perceptual or cognitive disorders, through techniques to enhance individual learning capability, to the generation of more global principles attending to learning, such as the importance of emotions, the efficacy of hands-on exploration and perceptual stimulation in learning science, or the embodied nature of learning.

Out of this interest has grown a hope that a new inter- or trans-discipline will grow from the intersection of education, cognitive science and neuroscience, to develop more fundamental and certain understandings of learning. A significant Australian report encapsulates this hope:

> Further progress will depend on integrating these disciplines to develop a common, coherent understanding of how learning operates - a new science of learning**”** (PMSEIC report, 2009)

Interest in educational neuroscience has led to a number of research centres being developed internationally dedicated to forging links across these disciplines. The Australian Research Council has recently funded a national ‘Science of Learning Research Centre’ (SLRC: http://www.slrc.org.au/), which brings researchers from these three areas together to develop a range of programs designed to investigate how neuroscience research can inform teaching and learning. The SLRC proposal describes how:

> The needs of teachers in the classroom will be used to drive collaborative discovery, with the expertise of neuroscientists and psychologists being harnessed to design effective and practical learning techniques and assessment tools.

To date, the learning/education areas in which neuroscience has focused its attention have been those where there is already a strong literature in cognitive science. These include social aspects of learning such as imitation and shared attention, empathy and social emotions, links between perception and action, and computational aspects of learning amenable to machine instructional design. This enthusiastic embracing of neuroscience as representing fundamental and reliable insights into learning has led in some cases to the promotion of inferences, taken as ‘findings’ that underpin widespread populist learning approaches, such as ‘brain-based learning’, for which there is little scientific evidence (Howard-Jones, 2013). The popular imagination has embraced a number of pervasive ‘neuromyths’ such as the existence of distinct developmental stages marked by rewiring of brain circuitry, the pervasiveness of learning styles in framing learning, or the idea that coordination exercises can improve integration of left-right brain function (Howard-Jones, 2013)

The SLRC has a number of programs proposed under the broad headings of ‘understanding learning’, ‘promoting learning’ and ‘measuring learning’, including studies of attention, reinforcement, feedback and self regulation, and mathematics anxiety. The particular program this paper is considering is: “Aligning socio-cultural, classroom perspectives on learning with neuroscience perspectives and findings”. This program includes studies of boundary issues in interdisciplinary research, inquiry and problem solving with a representational focus, literacy and dialogic teaching, and dyadic and group interactions.

The SLRC’s research will involve experimental investigations in classrooms, in neuroscience facilities including Functional Magnetic Resonance Imaging (fMRI) and Electro Encephalography (EEG), eye tracking, video capture of real classrooms, and intensive video and audio capture in a specially designed Science of Learning Classroom that extends previous classroom capture technologies developed over a number of Australian Research Council projects (Clarke, Mitchell & Bowman, 2009). Projects include studies of mirror neurons in dyad problem solving and demonstrations, feedback, and small group and whole class talk.

The argument for a new 'science of learning'

The hope expressed in much of the writing about an emerging 'educational neuroscience' or 'science of learning' discipline is that by harnessing studies of learning from distinct disciplinary perspectives, and particularly drawing on the 'scientific' evidence now possible through real time brain scanning techniques as participants are enacting thinking and reasoning processes, we will be in a position to develop compelling evidence-based accounts of 'how the brain learns' (the title of a major Australian Council for Educational Research (ACER) conference in Melbourne in 2013) and how we can best support learning. The proposal for an SLRC centre puts it this way:

> Perhaps the most exciting future perspective is that once we understand how learning occurs in the brain and the conditions that optimize this learning, we will be able to develop effective techniques to "teach" the brain to learn effectively in any situation. This can only occur if we have a thorough understanding of the underlying biological aspects of learning, on the neuronal level and on the level of brain networks. This understanding must then be translated into real environments through education research expertise that considers social interactions and digital technologies, leading to a program of comprehensive and long-term research collaboration (SLRC proposal, private communication)

Noticeable in this rhetoric, as in many educational neuroscience writing, is the assumption that fundamental understandings of learning must come from studies at the biological/neuronal level. Classroom research is assigned the relatively modest role of exploring the application of these understandings to 'real environments'. The claims made here are for the ascendancy of 'scientific processes' in developing rigorous evidence based understandings of how learning occurs, with fundamental constructs developed from classroom studies implicitly questioned as capable of providing explanatory power in their own right. In initial discussions between the three disciplines of neuroscience, cognitive science and education, differences have emerged, needing to be negotiated, concerning the relative status of explanatory accounts of learning from education, compared to neuroscience perspectives. Are educational explanations fundamentally reducible to findings at the individual, neuronal level?

Critiquing relations between neuroscience and education

There is in fact a robust literature questioning the relationship between neuroscience and education, and the claims made for neuroscience and its capacity to solve educational problems generally. David Turner (2011) in his provocative review of the default assumptions underpinning typical writing on what neuroscience can offer in understanding learning –"Which part of 'two way street' did you not understand? Redressing the balance of neuroscience and education" – questions the assumption that the scientific methods of neuroscience offer the dominant explanatory paradigm, and that methodological questions attach to education research alone. He closely examines a strongly grounded review in the area to argue that:

- Much interpretation of brain imaging is highly inferential and the claims made are often not sufficiently supported by an evidential chain;
- Brain scans are averaged over many events and multiple subjects so individual thinking is thus far eluding neuroscience studies;
- There is not a one-to-one correspondence between brain regions and mental operations particularly with complex thinking, and claims based on brain scans arguing that activation of particular brain regions unproblematically indicates particular processes are at play – the 'reverse inference' error – are suspect;
- Many claims of neuroscience findings in fact glide into drawing on previous findings from cognitive psychology– thus confusing the nature of the evidential base and over promoting the unique contribution that neuroscience can make; and
- Neuroscience studies can often repeat well-known findings, adding nothing more to our understanding than identifying which brain regions are associated with particular thinking – a descriptive rather than explanatory function.

There thus remains much work to be done on clarifying the relationship between neuroscience, cognitive science and classroom studies in education, and in particular how the insights from each area can inform each other. In a meta analysis of papers discussing the merging of the disciplines, Beauchamp and Beauchamp (2013) use the 'bridge' metaphor to clarify how these disciplinary boundaries might be negotiated. They identify four clusters of themes in these papers: 1) the problem of misapplication of neuroscience ideas to education; 2) the reasons for these misapplications including disciplinary incommensurability and differences in language; 3) possible ways forward including collaboration and appropriate research design; and 4) the value of linking the disciplines. They offer a number of ways of thinking about the relationship between the disciplines, including multi- and inter-disciplinarity, and their preferred trans-disciplinarity which involves "an approach to examining and solving complex problems through the collaborative efforts of multiple diverse partners" with new knowledge stemming from "the interaction of diverse people within an entirely new group" (Samuels, 2009, p. 49).

Thus, it is argued that the disciplines must remain distinct, with partnerships being forged between researchers from each community of practice, with no necessary presumption of an inter-language being developed that pulls the disciplines into a coherent interdisciplinary perspective. The 'new science of learning' thus concerns itself with clarifying productive spaces in the boundary between the disciplines.

A key question is whether classroom education insights can be reduced to biological processes. This presumption underpins enthusiastic advocacy of the new collaboration, such as:

> A particular challenge of this research is that it requires educational and psychological theories, which specify cognitive processes that are detailed enough to be examined by neuroimaging. This will be of crucial importance not only for interdisciplinary research in neuroscience and education, but also

> for educational research in itself in order to fully understand complex mathematical skills. (De Smedt et al., 2010, p. 102)

Yet:

> More than seventy years ago Vygotsky was arguing the exact opposite, that the reason that the psychology of education was failing was that it insisted on treating higher mental functions as nothing more than a collection of simple processes that could be understood in purely physical terms (Rieber, 1997 p. 48, quoted in Turner, 2011, p. 229).

We would argue, in looking to forge new knowledge drawing on socio-cultural and neuroscience perspectives, that there are explanations of aspects of classroom learning that are fundamental in their own right and not reducible to biology. As Clarke and Hollingsworth (2013) argue:

> A challenge for any research project seeking to connect sociocultural research with neuroscience is how to interweave the complementary accounts provided by each analytical approach. We suggest that, in the same way that the unit of analysis is different between sociocultural and neuroscience research, so the nature of the explanations provided will be fundamentally different, offering not different explanations of the same phenomenon but explanations of related phenomena that are different in scale, in complexity and in the relative prominence given to the individual as cognising agent or as participant member of a social group. We anticipate drawing on the findings of one discipline to explicate, elaborate and explain learning as it is conceived in the other discipline.

Methodological challenges

The challenge of aligning findings from neuroscience with those from classroom studies has at least four distinct dimensions:

- Scale and complexity: The challenge of scaling up from studies of single individuals to the complexity of interactions in classrooms
- Learning paradigms: The challenge of aligning findings concerning relatively simple and uni-dimensional learning behaviours to the complex higher order reasoning capabilities that are the proper focus of education programs
- Epistemological/methodological: The challenge of alignment of the disparate methodologies that characterize neuroscience, cognitive science, and education studies, which represent disparate epistemologies
- Theoretical: The challenge of aligning the different models of the learner and learning implied in these fields, from information processing models to socio-cultural perspectives focusing on the role of language and human interaction.

As an example of the practical and methodological difficulties involved, Dalgarno, Kennedy and Bennet (2006, p. 193) describe their exploration of the effect of interactivity on learning, using fMRI technology:

- The complex physical interaction in the simulation condition could confound the results because it would be difficult to differentiate between brain activation associated with the motor tasks and brain activation associated with the cognitive task.
- The visual differences between the simulation and tutorial conditions could confound the results because it would be difficult to differentiate between the brain activation associated with attending to the rich multimedia content in the simulation condition from the activation associated with the cognitive task.
- It would be difficult to provide a regular baseline or rest stimulus within the simulation condition if we allowed complete learner control.

Despite these challenges, there is widespread agreement that we have much to learn about learning in classrooms from the growing insights forged by neuroscience. How to deal with these challenges in bridging between the disciplines is a key question occupying SLRC researchers.

Designing the research

In the SLRC research program bridging between neuroscience and socio-cultural views of classroom learning, the science of learning classroom being developed at the University of Melbourne is seen as key. This classroom will have 8 separate video and audio streams that can focus in closely on the interactions and work of individual groups and the teacher, operated by remote control. This facility will enable a very close monitoring of individual and group interactions, including dialogue and representation construction, in pre-designed classroom experiences. A number of projects are planned in this ambitious program:

1. Meta analyses/research syntheses of the literatures.
2. The development of a methodological perspective that can guide the process by which the perspectives from the three different fields can be appropriately aligned.
3. Naturalistic classroom studies to explore in sharper detail the features of teacher-student-artefact interactions that lead to productive learning.
4. Refined investigations using the Science of Learning Classroom with the capability of both a) controlled investigative designs that focus on particular features of learning interactions, b) close video and audio tracking to identify key features of learning, and c) stimulated recall investigations to explore personal interpretations of the learning process.
5. Investigations in the neuroscience laboratory that explore neurological correlates of the learning settings and behaviours identified in the classrooms.

It is envisaged that movement will occur in the directions 3-5 and 5-3 in refining our understandings of learning, and validating these refined findings back in real classrooms. The approach was articulated in the SLRC proposal and is shown in Figure 1.

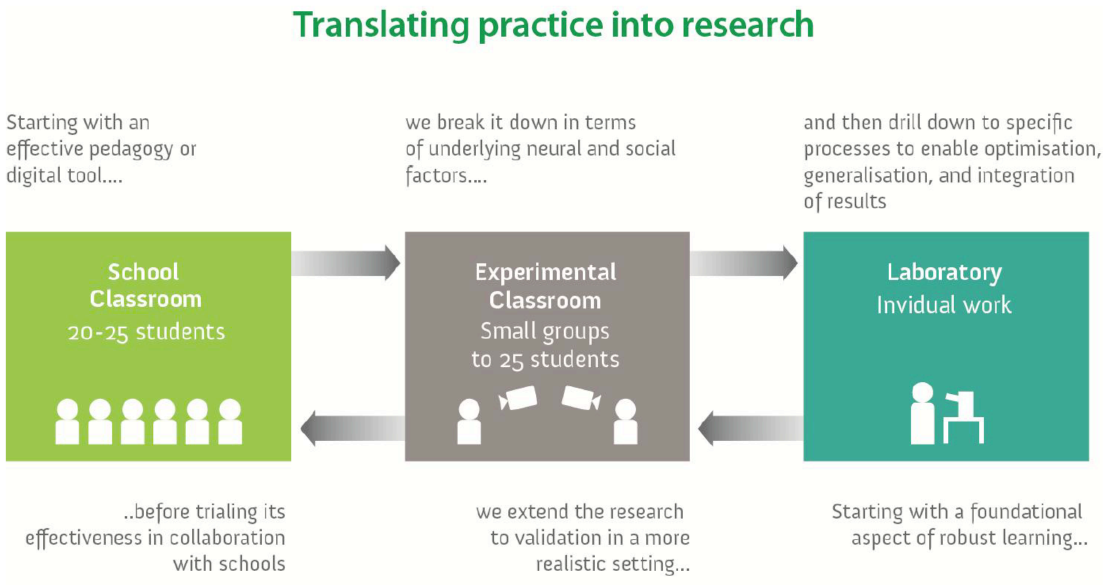

Figure 1: Methodological approach to aligning neuroscience with classroom learning

As an example of how this might work, we take the research question: "What advantage is conferred by constructing representations in a guided inquiry process, compared to direct instruction in representational form and function?". Already we have evidence from classroom studies of the power of representation construction (e.g. children drawing as part of a challenge to explain). There is literature and theory to support this, but we propose to further explore the relative advantage of students constructing as distinct from interpreting teacher-generated representations, using an experimental design. Close video monitoring will enable us to examine the explicit interactions and production work of students in each condition, with a view to refining our understanding of what core processes might be at work during construction.

Exploration of the core nature of these learning processes will lead to hypothesis generation enabling experimental designs involving brain scanning techniques. In some cases eye-tracking hardware will be used to further refine our understanding of 'what is going on'. We anticipate that the rigor of clarifying the particular interactions that are productive for learning, in order to subject these to refinement for neuroscience investigation, will produce new insights. The brain imaging will provide verification of patterns of behavior associated with effective learning, and provide clues, and an evidential base, for further explorations of classroom processes in both the science of learning classroom and school classrooms, leading to the development of explanatory paradigms at the classroom level. Thus, in Figure 1 above, the two-way arrows should be taken to represent interactivity at the level of research design and theory generation, and not simply a broader logic of how the sites might interact.

Conclusion

In much writing on the insights of neuroscience applied to education, there is an implicit assumption that explanation is the province of investigation of biological processes, and classroom practices are reducible to brain function. Thus, the relationship between education and neuroscience is seen as that of a handmaiden to the aristocrat, or the technician to the research scientist. We argue, on the contrary, that the bringing together of neuroscience and education should be seen as a partnership involving explanatory paradigms that are complimentary but fundamentally distinct. Sociocultural constructs such as 'communities of practice' or 'distributed cognition' or 'inquiry' cannot be re-interpreted either in practice or in principle as the sum of a set of neurological parts. They might be considered, from a complexity theory perspective, as distinct phenomena that emerge from the complex interactions between teacher, setting, artefacts, histories, and individual cognizing. This implies a methodology that involves a two-way and iterative conversation between members of the two communities, clarifying and exploring emerging conceptual categories within distinct disciplinary frameworks. The task will be to develop not a new biological explanation of classroom learning, where the interaction of a community of learners is re-interpreted in terms of the operation of the individual brain, but rather new insights into how to productively link socio-cultural and neuroscience perspectives and practices.

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