Learning, Science, and Cutting Edge Methodology: A Review of the Cambridge Handbook of the Learning Sciences, Second Edition

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Internationally, one of the most consistently pressing societal, political, and social science research goals is the improvement of modes for supporting youth in learning and developing skills needed for successfully navigating their future worlds. The crucial yet highly unconstrained nature of this problem (e.g. what is the nature of knowledge to be taught, what is the goal for 'successful navigation of future worlds') means that many different traditions of research in this vein have emerged, with there being no clear resolution regarding a model that is most effective or efficient at producing changes in formal educational outcomes, student learning, or even for building theory that is use-inspired and developed to solve existing real world problems (Stokes, 1997).

Being so important, many fields have developed their own lines of research to study education, such as within disciplines of knowledge (e.g. Mathematics, Science, and Engineering: see NRC, 2012). In addition, theorists studying the mind and psychological change have taking a study of learning as part of their purview, often described as the Science of Learning (not to be confused with the Learning Sciences). Other research fields with disciplinary focus on education include economics and sociology. Each of these fields has different theoretical commitments and methodological priorities, and historically the intersections among these bodies of literature are under-utilized.

So is there a best methodology for the study of learning? How does one conduct educational research that has the best chance of building a theory base for improving children's long-term outcomes? Are these aims best approached through what has been traditionally the coin of scientific research – the scientific method – or can we capitalize on the growing technological resources available

to design creative new methodologies for assessing learning? These questions are themes grappled with throughout the Cambridge Handbook of the Learning Sciences, with the most important common insight from this collection of chapters being that this theory base and methodological approaches must be much more broad than emerges from simply one discipline. In particular, fields such as the science of learning are deeply committed to experimental designs, yet that methodology figures not at all into the research reviewed in the Handbook.

The first edition of the Handbook of the Learning Sciences did more than simply present a review of educational insights from the field; rather, the handbook became in some ways a centering artifact to help the emerging field of Learning Sciences build community and display its commitments broadly. This impressive second edition expands and augments that goal, highlighting the contributions being made by Learning Science researchers across countries and continents, with authors selected by the learning science community and writers from around the world. The editor's decision to draw on the LS community to identify the range of national and international scholars make this a very rich resource for the LS community, and provides a window into it for those not yet within its folds. This book is sure to become a central part of the cannon of the new generation of the learning sciences.

The first two sections of the book describe methodological and foundational commitments of the learning sciences as a field. These are commitments to going beyond the scientific method through the use of innovative methodologies and research approaches, following dissatisfaction with the ability of the scientific method to develop insights with the potential to change educational practice meaningfully.

Since this review is posed for psychologists, I will spend a moment elucidating the challenges to the use of experimentation in educational research. Imagine an experimental psychologist conducts a series of studies in which a particular psychological finding is born out repeatedly. Lets imagine it is one that has received repeated tests since before the 19th century yet remains a source of

study – the finding that repeatedly studying information with temporal spaces in between each study opportunity, also called “The Spacing Effect.” Practicing retrieval of some information repeatedly with no intervening time (massed practice) improves performance in the short term, but spacing out opportunities to practice leads to ultimately better retention of the learned content over time. This cognitive phenomenon has been well studied, with early evidence by Ebbinghaus (1885), revealing that a larger number of study trials were necessary to lead to errorless performance when all study was successive repetitions, when compared with distributing study over several days. Ebbinghaus conducted this work on himself as a sample of 1, which was a seminal work that has been foundational to many lines of educational research. At the same time, considerations of bias and experimental control, sampling distributions and placebo effects have led to increasingly detailed requirements necessary for ensuring commitment to the scientific method and its aims to improve the generalizations that can be made through this methodology. Thus over the century, hundreds of additional studies have been conducted to better understand this phenomenon of the “Spacing Effect,” revealing that, much as Ebbinghaus determined, massing practice leads to more rapid success on a task in the short term, but when tested at a delay, spaced repetitions are more efficient and lead to greater retention over time (see Cepeda, Pashler, Vul et al, 2013 for a meta-analysis).

Due to the extraordinary experimental and laboratory-based support for this cognitive phenomenon that provides a clear educational recommendation, the spacing effect has received the attention of researchers who state an explicit goal to improve educational practice by drawing on psychological research. The recommendation to space practice is part of the practice guide developed by the Institute of Education Sciences (Pashler et al, 2007), and many research papers begin or conclude with the admonition that the educational community should increase its spacing between study opportunities.

At the same time, the relationships to classroom practice are more difficult to consider. First – spacing may in fact be already unintentionally implemented in

some ways. If one examines the timing of classroom instruction, one first notices that in fact children are often learning material for one hour a day with 24-hour delays between returning to the material, or perhaps with homework, it is two repetitions over 24 hours. These would be fairly long spaced intervals in a laboratory-based experiment. And, in many disciplines like mathematics, there is a spiral curriculum such that children learn topics in some depth the first year, and then return to them the second year in more depth. An expert in the spacing effect might protest that these are not direct repetitions, but at the same time an educator might respond that the final test goals are not again direct repetitions but transfer, so it seems reasonable that students should be learning the material in ways that build in complexity and with expanding focus rather than spending a large amount of time repeating the entire curricular content of a year exactly on multiple occasions. So, structurally modifying spacing is challenging and may not be directly applicable.

Imagine though that our experimental psychologist is not deterred, and conducts an experiment in which instructional repetitions of some key curricular information are massed versus spaced, but then at a final test there are null results. Does this mean that we should abandon the practice of recommending that educators use spacing in classroom contexts? Or, might the null results reflect that the experimenter misjudged and these children's reading levels for example were too low, which meant they were too slow to benefit from the spaced or massed learning trials. Or perhaps they had learned related content recently and were at ceiling. Or perhaps the final test was administered on the day yearbooks were handed out (this happened to me once!), so student attention spans were severely compromised. In any case the point is that experimentation in classrooms is very messy and may not be able to be used in the way, at least idealized in the laboratory, that we hope to be able to make falsifiable claims about improving learning in classrooms.

Dempster (1988) has called the spacing effect a case study in the failure to apply psychological research to learning contexts, and while progress has been made in this regard with improved materials and research conducted in

actual everyday learning contexts (e.g., see Sobel, Cepeda & Kapler, 2011), this is clearly not simply a matter of educators not realizing the utility of the psychological findings. The spacing effect is just one example of course, and it is an area with better experimental support than many others in which psychologists have aimed to test learning principles in classrooms. Thus it is clear that while experimentation may have an important role to play in educational research, it cannot provide all insights needed to make real world gains in educational practice.

Importantly, while experimentation is synonymous with scientific discovery in many fields, the Learning Sciences has taken a conscientious step to make the scientific method not a core methodology to its scientific practice, and potential not even one viewed to be within its disciplinary purview. The introduction to the prior edition of the Handbook of the Learning Sciences included a strongly worded statement that experimental designs were not part of the learning sciences. In the current version, the introduction states that experimentation is not described as a method since it is already described adequately elsewhere.

Instead, many of the chapters of the handbook not only review the literature in their focal area, but also highlight the methodological commitments or foundations of the work. This engenders therefore a much more purposeful and interrogated approach to methodology than is typical in a scientific handbook. Nathan and Sawyer (Chapter 1) highlight the distinction between “elemental” and “systemic” research approaches (Nathan & Alibali, 2010), which means that systemic theories study phenomena in context, without separating them from their environment, while elemental is about taking a phenomenon or context and separating these phenomena into elements, which can then be studied rigorously. This is a common strategy used in experimental or quantitative analyses, but the learning sciences community generally rejects the assumption that contexts may be thus separated into elements. The importance of systemic research is then reiterated in multiple chapters throughout the handbook, as is

the utility of capturing the learning as it unfolds, rather than a more standard experimental design capturing learning at the conclusion of a study.

That being said, experimentation does not have to be elemental, and can capture variations between learning based on a specific change that happens within a rich context, and outcome measures can be rich and varied. Also fully departing from the scientific method within a science field (Learning Sciences) raises questions about the nature of science itself. Both experimental contexts and iterative research designs more common to LS research are designed learning settings in which one explores the nature of learning in relation to a carefully considered context,. One might consider an iterative design similar to experimentation but just in a longer time scale. It is worth considering that these methodologies are not as far apart as one might imagine.

In what to me was a very useful chapter, Sasha Barab (Chapter 8) presents a cogent and informative description of the methodology of Design-Based Research (DBR). DBR is the methodology of designing an intervention context and studying the learning that emerges by the intended participants. As defined by Nathan and Sawyer (Handbook Chapter 2), the model is systematic, such that one studies not only one component of the learning context or of the learner themselves, but the intersection and the complexity of this interaction. Perhaps most importantly, this model of research is also iterative, such that one studies the designed context and learning that emerges, then adjusts the learning intervention and again examines the emergent learning, enabling one to both gain insight into mechanisms of interplay between environment and the learner and into improving the efficacy of the designed learning context itself.

This is a very useful chapter and one I encourage experimental psychologists interested in the Learning Sciences (perhaps those invested in Science of Learning research) to read in order to provide a framework for understanding the field. I also recommend this chapter to DBR practitioners, since it provides a cogent model for thinking through the utility and conceptual framing for research designs in a way that can facilitate scalable, use-inspired research – as DBR is intended to accomplish. The challenge often posed to

DBR is that deep insights may be gained, but only for the particular context in which it emerged. Barab raises this challenge himself, highlighting the importance of focusing on "returns to investment," as a way of stating that the research insights must be scalable and meaningful beyond the context of derivation. He concludes the chapter with a list of practical steps to support high quality DBR.

While DBR is a focal methodology used regularly by LS researchers, the Handbook also highlights the wide range of research designs used including microgenetic methods, digital video, learning progressions and assessment models, educational data-mining and learning analytics, among others. Methodology is a key theme highlighted in many of the chapters. In part this is because the Learning Sciences as a field is pushing the boundaries of technology, traditional research designs, and traditional questions about education. This is a key element of this field.

As an example, Enyedy and Stevens (Chapter 10) present a topic based chapter, on Collaboration, but their approach epitomizes the breadth of LS research by providing a careful analysis of four different methodological treatments of collaboration, in which they describe four dimensions along which the bodies of research on collaboration may be distinguished: collaboration as a window into individual cognition, collaboration for distal outcomes as a mode for improving learning on measures external to the learning event (such as a posttest), collaboration for proximal outcomes including gains in abilities that foster collaboration (such as intersubjectivity), and collaboration as a focal process and the learning outcome itself. Analyzing these literatures together provides structure for considering their interrelationships and formulating a broader insight into the frameworks themselves.

Goldman, Zahn & Derry (Chapter 11) similarly review the literature, historical and emerging, on research using digital video, highlighting the ways that digital video technology has become integrated into many different areas of study. Digital video has revolutionized observational and ethnographic studies of everyday learning environments such as museums or classrooms, as well as has

been used with cognitive designs to study strategies for supporting and studying learners in making connections between problem solving within context and abstract reasoning. Again, this chapter describes a cutting edge technology and ways that it is being used in increasingly novel ways to study teacher learning using interactive prompts, to conduct observations, and to design learning materials. This is something I personally find extremely compelling, using interactive digital videos of classroom lessons as part of experimental designs myself (Begolli & Richland, 2015).

Many other chapters also address key methodologies and empirical advances building on novel technologies, such as virtual worlds ((Kafai & Dede), mobile learning (Sharples & Pea), and the use of technologies within disciplinary instructions such as science education (Songer & Kali).

Overall, the Handbook of the Learning Sciences is a rich and dense treatment of a discipline that is expanding across schools of education internationally, providing a window that is open to those both within and without its borders. The book is thought provoking and generative in conceptualizing the fields of both learning and sciences. The handbook as well does the work of displaying the depth and range of work being conducted in the LS community at the same time that it forges connections and boundaries to make it a coherent field. I would highly recommend this book to those interested in education and its study in broad terms.

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