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## LEARNING, SCIENCE, AND CUTTING EDGE METHODOLOGY

### The Cambridge Handbook of the Learning Sciences, Second Edition

*Edited by R. Keith Sawyer. New York, NY: Cambridge University Press, 2014. 784 pp. Paper, $67.*

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 or student learning, or even for building theory that is use-inspired and developed to solve existing real-world problems (Stokes, 1997).

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 National Research Council, 2012). In addition, theorists studying the mind and psychological change have taken a study of learning as part of their purview, often described as the science of learning. Other research fields with disciplinary foci on education include economics, anthropology, and sociology. Each of these fields has different theoretical commitments and methodological priorities, and historically the intersections between these bodies of literature are underdeveloped. Dissatisfied by the existing approaches and lack of convergence across these fields, all purportedly studying the same educational questions, a core set of researchers from across these disciplines have integrated to form a new field, learning science (LS).

So is there a best method 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 methods 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 these methodological approaches must be much broader 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 LS build community and display its commitments broadly. This impressive second edition expands and augments that goal, highlighting the contributions being made by LS researchers across countries and continents, with authors selected by the LS community and including writers from around the world. The editor's decision to draw on the LS community to identify the range of national and international scholars makes this a very rich resource for the LS community and provides a window into it for those not yet within its fold. This book is sure to become a central part of the canon of the new generation of the learning sciences.

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

Because this review is framed for psychologists, I will spend a moment elucidating the challenges to the use of experimentation in educational research. Imagine that an experimental psychologist conducts a series of studies in which a particular psychological finding is borne out repeatedly. Let us imagine it is one that has received repeated tests since before the 19th century yet remains a source of study, such as the finding that repeatedly studying information with temporal spaces in between each study opportunity, also called "the spacing effect," improves learning. More specifically, 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 (1885/1964), revealing that a larger number of study trials were necessary to lead to errorless performance at a delay 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, and that was a pioneering use of scientific experimentation to learn about human cognition (see Roediger, 1985). At the same time, considerations of bias and experimental control, sampling distributions, and placebo effects, many of these issues raised by Ebbinghaus himself, 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 method. Thus, over the century, hundreds of additional studies have been conducted to elucidate 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, with less time needed for relearning (see Cepeda, Pashler, Vul, Wixted, & Rohrer, 2013, for a meta-analysis).

Because of 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 a 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 implemented in some ways. If one examines the timing of classroom instruction, one first notices that children are often learning material for 1 hr a day with 24-hr delays between returning to the material, or perhaps with homework it is two repetitions over 24 hr. These would be fairly long spaced intervals in a laboratory-based experiment. And in many school disciplines such as mathematics, there is an explicit spiral curriculum such that children learn topics in some depth the first year and then return to them the second year in more depth, the third year with further depth, and so on. 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 again not 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. Thus altogether, while improvements might certainly be possible, implications for practice from the broad spacing literature are less clear than at first appearance.

Imagine, though, that our experimental psychologist is not deterred and conducts a classroom-based 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 there was also spacing in the control condition? Or perhaps the experimenter misjudged, and these children's reading levels were too low for the tested materials, which meant they were too slow to benefit from the spaced or massed learning trials, or did not understand the content regardless of times of study. Or perhaps they had learned related content recently (just before the posttest) 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 there are many reasons that the clear assumptions invoked for hypothesis testing and falsifiability in at least the idealized laboratory may not be able to be applied as uncritically in classrooms.

Dempster (1988) once called the spacing effect a case study in the failure to apply psychological research to learning contexts, and although 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), with reflection one can see that the matter of drawing relationships between the experimental results and classroom practice is challenging, and the lack of application is not simply a matter of educators not realizing the utility of the psychological findings. The spacing effect is just one example, of course, but 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 although 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, although experimentation is synonymous with scientific discovery in many fields, LS has taken a conscientious step to make the scientific method not a core method to its scientific practice, and potentially not even one viewed to be within its disciplinary purview. As reviewed in the handbook itself, many of the founders of the field began in psychological and experimental traditions, and they made the decision to turn instead to new methods. 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 LS. In the current version, the introduction states that experimentation is not described as a method because 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, whereas elemental approaches are about taking a phenomenon or context and separating it into elements, which can then be studied rigorously. The latter is a common strategy used in experimental or quantitative analyses, but it is generally not part of the LS methods. The importance of systemic research is then reiterated in multiple chapters throughout the handbook, as is the utility of capturing learning as it unfolds, rather than a more standard experimental design capturing learning at the conclusion of a study.

That being said, I cannot help but note that experimentation does not have to be elemental, it can capture variations between learning based on a specific change that happens in a rich context, and outcome measures can be rich and varied. Both experimental contexts and iterative LS design-based research in fact share that they are both studying learning in settings that have been designed by a researcher, such that one explores the nature of learning in relation to a carefully considered context. One might consider an iterative design similar to experimentation but just on a sequential time scale between conditions and with a broader lens used to capture learner data than is typical in experimental methods (including non–a priori specified learner indicators such as gesture, vocalizations, and affective responses). It is worth considering, though, that these methods are not as far apart as they have been construed.

In what to me was a very useful chapter, Sasha Barab (chapter 8) presents a cogent and informative description of the method of design-based research (DBR). DBR is the method 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 gain insight both into mechanisms of interplay between environment and the learner and into improving the efficacy of the designed learning context itself.

This is a chapter I encourage experimental psychologists interested in LS (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, because 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.

Although DBR is a focal method 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. Methodology is a key theme highlighted in many of the chapters. In part this is because the LS 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, which is a topic of increasing focus for educators, psychologists, and economists who have identified this as a key "21st-century skill" (see Partnership for 21st Century Skills, 2009). In contrast to those approaches, which tend to treat this as an individual difference that is important based on its ability to predict other skills or workplace successes, this chapter epitomizes the breadth of LS research by providing a careful analysis of four different methodological treatments of collaboration. Specifically, 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 (e.g., a posttest), collaboration for proximal outcomes including gains in abilities that foster collaboration (e.g., 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, and 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, and it 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 the increasingly novel ways it is being used to study teacher learning using interactive prompts, to conduct observations, and to design learning materials. This is something I 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 methods and empirical advances building on novel technologies, such as virtual worlds (Kafai and Dede), mobile learning (Sharples and Pea), and the use of technologies within disciplinary instructions such as science education (Songer and 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 also forges connections and boundaries to make it a coherent field, while doing the explicit work of displaying the depth and range of research being conducted in the LS community. I would highly recommend this book to those interested in education and its study in broad terms and to those seeking a strong empirical basis for improving educational practice.

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## IS FIGURATIVE LANGUAGE THE FINAL FRONTIER OR A PIT STOP ALONG THE WAY?

### Bilingual Figurative Language Processing

*Edited by Roberto R. Heredia and Anna B. Cieślicka. New York, NY: Cambridge University Press, 2015. 418 pp. Paper, $45.99.*

One of the most interesting aspects of human communication is that people do not always mean what they say. Indeed, a big part of a listener's job is to understand an utterance even when its literal meaning is false. How do people do that? Nonliteral expressions are an important part of everyday language. Therefore, the mechanisms and processes involved in the processing of nonliteral language have attracted increasing study over the past several decades. Not surprisingly, the breadth of the topic has motivated researchers to move beyond the general matter of figurative language to focus on specific subtopics (e.g., idioms, metaphors, hyperbole, irony) or on specific subdomains of language users (e.g., clinical populations, children). The collection of research reviewed here represents the current state of work on one such subdomain: bilinguals.

This is the fifth edited volume that Roberto Heredia has been a part of and the first to focus entirely on bilingual figurative language processing. His co-editor, Anna Cieślicka, is a colleague at Texas A&M International University and fellow language researcher. Between the two of them, they have notable expertise on bilingualism (in general) and figurative language (in particular). Their view is that research on figurative language processing by bilinguals and second language learners will bring us closer to answers to questions that have long vexed those pursuing them from a monolingual perspective. To that end, Heredia and Cieślicka have brought together an international team of researchers whose work covers a range of topics, from idioms and metaphors to humor and irony, specifically as occurs in bilingual or second language learning situations. The resulting volume provides a fresh perspective on the production and comprehension of figurative language and how people acquire, store, and process it in multilingual settings.

#### *What Is Figurative Language?*

We often use the word *literal* to refer to the meaning of a word stored in the lexicon (e.g., "context-free"). This definition is based on the work of Searle (1978, 1979), who argued that the components of sentences carry their literal meanings individually. But how do listeners differentiate between the meaning of an entire utterance and the single words within it? One way to approach this question is by appealing to the principle of compositionality, by which the meaning of a complex expression, whether mathematical or linguistic, is determined by the meanings of its constituent expressions and the rules used to combine them. In the case of a linguistic expression, if the core lexical components are removed from the sentence, what remains will be the rules of composition. This issue of compositionality is at the heart of the debate over how figurative language is processed (Gibbs, 2002; Recanati, 1995). How does combining literally represented individual words into an utterance lead to a nonliteral interpretation? Are literal and figurative meanings binary, in the sense that everything that is not literal is figurative? Or are literal and figurative meanings better thought of as endpoints on a scale along which the different figurative phenomena (e.g., metaphor, metonymy, irony, idioms) are arranged? Suffice it to say that answers to these questions are hard to find. One might imagine they would be more so when bilingualism is added to the mix, but that has not prevented the emergence of a subfield of research focused on just that.

#### *Understanding Idioms Across Languages*

A good portion of the early work on figurative language processing focused on the most canonical of figurative forms, idiomatic phrases (or idioms). That research pointed to what seemed like straightforward answers along the lines of idioms being nondecomposable (fixed) phrases and thus exceptions to the principle of compositionality. In the process, however, the many other forms of figurative language—and the different varieties of idioms themselves—were noted for challenging any one-dimensional, nondecomposable explanation (e.g., Cutting & Bock, 1997; Gibbs & Nayak, 1989; Gibbs, Nayak, Bolton, & Keppel, 1989). Some idioms are frozen, some are flexible, and ultimately, compositionality appears to be a matter of degree. It was this variability that prompted Wulff (2008) to develop a quantitatively oriented approach for determining degrees of compositionality of different phrases by working across large text corpora. The research questions have likewise broadened to include various other ways people do not mean what