chapter i

Introduction

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The learning sciences (LS) is positioned as an interdisciplinary approach to the study of how children and adults learn. Generally working outside of a laboratory setting, learning scientists attempt to conduct research in authentic settings to test iteratively designs for new learning environments that results in theoretical insights as well as instructional improvements. The focus of LS research has progressed beyond a sole emphasis on individual cognition to include social and cultural considerations as well as the role of the environments in which learning takes place. LS is marked by collaborations among instructional technologists, educational psychologists, content area educators, anthropologists, computer scientists, linguists, philosophers, and many more. LS is, then, an interdisciplinary approach to the study and facilitation of learning in authentic settings.

The first LS program was formed at Northwestern University in 1991 – so the field will have existed close to a quarter century as this book goes to press. Yet, in all of this time, no book has been published that analyzes "learning sciences" itself. There are now LS programs in at least thirty-five US universities and in several countries around the world, and new programs are being created as we write. Two journals dedicated to LS have been founded (*The Journal of the Learning Sciences* and *The International Journal of Computer-Supported Collaborative Learning*), and an international association, the *International Society of the Learning Sciences* (ISLS), holds annual meetings. An original focus on classroom learning has been supplemented by a growing interest in learning in "informal settings" such as museums, after-school programs, and the home. At the same time, LS is having an increasing impact on policy in areas such as mathematics (National Council of Teachers of Mathematics), science (National Science Education Standards), and engineering education (*The Engineer of 2020: Visions of Engineering in the New Century*). In addition, LS has been changing in important ways over the course of its existence and continues

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to do so. This book is the first to document, explore, and extrapolate from these characteristics of LS.

It is true that articles have appeared that reflect on the history of LS as a whole and of the *Journal of the Learning Sciences* in particular (e.g., Kirby, Hoadley, & Carr-Chellman, 2005; Kolodner, 2004). In addition, two editions of a massive *Handbook* have summarized the state of the art (Sawyer, 2006, 2014). LS is indeed "growing up" (Kolodner, 2004), but of course it is not a person. It is many individuals and groups working together, a field of study, an academic discipline, a community of practice, and so forth. But what is it, exactly? What kind of organization is LS itself? How have its members learned to be learning scientists? What implicit understandings are shared by learning scientists about how to do research, how to improve education, and what counts as knowledge? In other words, what is the "paradigm" or "discourse" of LS? The time is ripe to ask key figures within LS – individuals who created the field and individuals who are transforming it – to answer these questions for us.

This book originated in a well-received symposium at the 2010 meeting of the ICLS, held in Chicago. M. A. Evans, M. J. Packer, and R. Stevens presented papers while R. K. Sawyer served as commentator (Evans et al., 2010). The session was well attended and gave rise to much debate and discussion during and after, encouraging us to prepare this book. It was clear that the issues delved into during the symposium warranted further exploration. Consequently, we decided to invite leading learning scientists (as well as select scholars with related interests) to engage in a reflexive examination of their field. This book is not a simple description of a state of affairs, because the questions we raise are contested within LS itself. No doubt partly because of its interdisciplinary nature, members of the field hold competing understandings and participate in subtly different discourses and practices. As a result, the field itself is dynamic and fluid. Perhaps this is what is driving LS forward into maturity, or perhaps this situation is holding LS back from truly "growing up." It will be evident to readers that the opinions of the authors of the chapters in this book differ to noticeable degrees.

Through a significant period during the twentieth century, the term "the science of learning" was associated with behaviorist psychology in the West, particularly in the United States. Nevertheless, this behaviorist paradigm was the exact opposite of the cognitive approaches that underlie LS. Consequently, how did learning scientists reclaim the term "learning" and re-form it to align with a cognitive paradigm? Throughout this book, contributors explore key terms, including "learning," and explore

how these terms help to define LS as a paradigm. Terminology is particularly important because LS is a project that requires collaboration among researchers and technologists from various disciplines, each with its own vocabulary. It seems likely that a common language is necessary for them to work together, even when it contains terminology with which they can disagree.

This book is divided into three main sections, followed by a conclusion that reviews what has been covered and considers what further issues LS needs to address. Part 1: Past delves into the origins of the field, traversing vibrant locations of effort as well as philosophical differences that impelled participants in the early days to form, disperse, and re-form in the initiative to establish a new field to improve education. As these chapters show, the motivations and goals that established the field still reverberate to the present day. Part 2: Present covers a broad range of topics to define what LS is today in theory and practice. Contributing authors place a mirror before the LS community in a reflective exercise to articulate what learning scientists do, how they do it, and where. Part 3: Future points to possible (though by no means all) directions in which LS might be heading now that it has "grown up." These predictions, obviously, must be tentative given the continually shifting landscapes of the field. The concluding chapter draws on theories from the history of science, particularly those of Michel Foucault, to provide a theoretical framework to analyze the emergence of LS, and to anticipate how it might develop in the future. What follows are summaries of each of the chapters, organized by section.

Part 1: Past

Chapters 2 to 5 are written by senior scholars in the field, all of whom have been working on teaching, learning, and education since before the emergence of a distinct field known as "the learning sciences." They provide valuable historical perspectives on how, why, and where LS emerged; what intellectual questions and topics it focused on; why it was considered necessary to create a new field; and why it was adopted, increasingly broadly, and rapidly grew.

Chapter 2. Roger C. Schank: Why Learning Sciences?

Roger Schank is universally acknowledged to be a key founder of LS, first because he coined the term "learning sciences," and second because in 1991, at Northwestern University, he created the first research unit focused

on LS research, the Institute for the Learning Sciences. He played key roles in the creation of both the *Journal of the Learning Sciences* and the International Society for the Learning Sciences (both also formed in 1991). He left Northwestern by 2001 (although he still holds an honorary professorship there) and has largely been absent from the LS field since then. His is an important chapter because this is the first time that Schank has commented on LS in well over a decade.

Schank's chapter documents the origins of LS in 1970s and 1980s cognitive science, particularly its artificial intelligence (AI) wing. At that time, Schank was working on designing "intelligent computer programs that could simulate human behavior" (p. 20), and the majority of his research focused on memory, not directly on learning. His focus changed to learning in the early 1980s, and he was hired from Yale by Northwestern in 1989 to build an LS research institute. Schank's chapter notes that the original focus of the Institute was corporate training, in part because Andersen Consulting, a Chicago-based consulting firm close to Northwestern University, provided major funding. He states that he was receptive to this focus, "because I had realized that schools couldn't be easily changed" (p. 23).

Schank deliberately established this institute outside of the School of Education because he felt that Schools of Education had low status within universities. In this chapter, Schank is his famously cynical self in criticizing universities and K–12 schools. He calls for learning scientists to be more vocal in opposing ineffective pedagogies, and he uses provocative language such as insisting that they "confront this charade" and "state publicly that … online efforts are not grounded in learning sciences research" (p. 29) and that they oppose "big testing companies" that are "assessing nothing" (p. 30).

In sum, Schank argues that learning scientists should work harder to connect with policymakers and should communicate the findings of their research to educational software designers and to school and university leaders.

Chapter 3. Roy D. Pea: *The Prehistory of the Learning Sciences*

Roy Pea, like Schank, also provides an important history of LS before 1991. In particular, Pea provides valuable insight into why this new endeavor did not align itself with existing scholarly organizations with well-established conferences, such as AI in Education, Cognitive Science, or the American Educational Research Association (AERA).

Pea's chapter makes it clear that LS was not suddenly created at one university, Northwestern, in 1991. He describes the many other research units that predated this endeavor, including:

- Bolt Beranek and Newman's Educational Technology Department (ETD) and Intelligent CAI project (ICAI)
- Bank Street College's Center for Children and Technology (CCT), where Roy Pea himself got his start
- University of Pittsburgh's Learning Research and Development Center (LRDC)
- The Education Math, Science and Technology (EMST) program at the University of California Berkeley's Graduate School of Education
- Vanderbilt University's Learning Technology Center (LTC)
- Xerox Palo Alto Research Center (PARC) and the Institute for Research on Learning (IRL) in Palo Alto

Three of these research units continue today to be strong centers of LS research (LRDC, Berkeley, and Vanderbilt).

Pea, like Schank, notes that these efforts were very much in contrast to the focus on Computer Assisted Instruction (CAI) that was grounded in 1950s and 1960s behaviorism, and which dominated instructional technology programs.

Unique among the chapters in this volume, Pea's chapter situates LS in the broader field of educational technologies. (In contrast, the other chapters focus more exclusively on the realms of ideas, concepts, theories, and research.) His chapter paints a complex historical portrait of multiple efforts coming together, in the 1980s, into an interdisciplinary community focused on information technology in education: "The 1980s were ... a time ripe with optimism about technology access and the emerging cognitive sciences" (p. 38). Pea describes a seminal 1986 meeting co-hosted by UC Berkeley and Lawrence Hall of Science, where many significant learning scientists – now quite senior in the field – were in attendance, a meeting called "The Science of Science Education" (p. 38).

Pea also recounts how he co-chaired two influential conferences with Allan Collins, in 1988 and 1989, both of which had many of what we now call "learning scientists" in attendance. The 1988 meeting was called "Cognition and Education," but in 1989 the name had changed to "Learning and Education," owing to the increasing recognition of the importance of the social and collaborative dimensions of learning (p. 50). Pea later called this the "cognition, technology, and education nexus"

(p. 51), and this remains a generally accurate description of what LS continues to be today.

Chapter 4. James G. Greeno and Timothy J. Nokes-Malach: Some Early Contributions to the Situative Perspective on Learning and Cognition

James Greeno and Timothy Nokes-Malach provide an important historical account of the influence on LS of the "sociocultural turn" – a shift in focus away from cognitive structures and processes in isolated individual minds. This sociocultural turn was an important influence even during the founding of LS, and it has become increasingly central to the field since then.

In their account, during the 1970s and 1980s the cognitive sciences were focused exclusively on studying mental structures and processes. Greeno and Nokes-Malach refer to this as "the cognitive theory of information processing" (p. 59). Their chapter begins by briefly documenting this approach, as a way of providing historical context to the emergence of the sociocultural, or situated, approach in the 1980s. This new approach shifted the focus from the isolated individual as the cognitive unit toward the social and material contexts of people as they engaged in intelligent behavior. As their chapter describes it, this shift was in large part due to the influence of anthropologists who published compelling ethnographies of intelligent behavior in a variety of authentic settings, including Jean Lave's study of how grocery shoppers determine which products represent the best value, Lucy Suchman's studies of human–machine interaction, and Ed Hutchins' study of Polynesian navigation. Studies such as these demonstrated that humans do not process information in isolation; rather, their plans, goals, and mental processes and structures emerge, evolve, and change through moment-to-moment interactions with other agents and with the environment. These findings were difficult to reconcile with a foundational cognitivist approach; that approach seemed to require that mental structures (such as plans and goals) are relatively stable, and generally precede action. In contrast, these studies demonstrated that mental structures and processes do not precede action, but emerge in response to action, and that they change often and suddenly in response to the dynamic processes of that action.

The chapter provides valuable historical information about how the sociocultural perspective emerged, and identifies it with a specific time and place: the mid-1980s, at Xerox PARC and also at the IRL, both in the Santa Clara Valley south of San Francisco and both

involving faculty from UC Berkeley and Stanford University. Greeno and Nokes-Malach argue that the perspective emerged there, rather than elsewhere, because of the unique interdisciplinary teams that were formed to study learning and cognition – teams that included anthropologists, something that was not common at other universities with cognitive sciences programs.

At that time, many of the strongest programs in cognitive sciences were heavily focused on developing computational models of cognition that could be simulated in a computer program. Computer science models, at least at that time, were more readily aligned with individualist conceptions of intelligent behavior, because of the analogy between a computer (with its central processing unit and memory) and a single human mind. Of course, this would change in the 1990s, as individual computers became less expensive and as they became increasingly networked, particularly via the World Wide Web. "Massively parallel computers" and "distributed computation" are now well-established fields of computer science research, and notions of "collective intelligence" (Surowiecki, 2005) and the "hive mind" (e.g., Libert, Specter, & Tapscott, 2007) have become the conventional wisdom. As a result, the notion of distributed cognition is mainstream for today's computer scientists and cognitive scientists. But in the 1980s this was not the case, and the conceptual work done at Xerox PARC and the IRL was far ahead of its time.

The chapter concludes by noting that cognitivist and sociocultural approaches are now mainstream and are widely recognized to be important components of the scientific exploration of learning. Echoing Nathan and Sawyer (2014), Greeno and Nokes-Malach note that these approaches roughly fall into an *elemental* approach, focused on individuals, and a *systemic* approach, focused on distributed social and material systems.

Chapter 5. Gerry Stahl: *The Group as Paradigmatic Unit of Analysis: The Contested Relationship of Computer-Supported Collaborative Learning to the Learning Sciences*

Gerry Stahl's chapter provides a valuable historical account of how Computer Supported Collaborative Learning (CSCL) emerged, in parallel with and independently of LS. In the early years CSCL was much more international than LS, reflecting a dissatisfaction with what was perceived to be a US-centric agenda. This chapter documents the origins of CSCL and the work by early researchers to establish the foundations of the field and then describes how after several rounds of discussion CSCL and LS

gradually became more compatible. As a result, the two research communities joined together formally into a single society (the International Society of the Learning Sciences), and now jointly host their annual conferences, which are held on a rotating basis.

CSCL emerged in the 1990s, with the first annual conference held in 1995 and the first seminal edited volume published in 1996 (Koschmann, 1996). Unlike LS, whose origin story is largely one that takes place in the United States, the field of CSCL was broadly international from the beginning, with participants from Europe and Asia playing key roles. As Stahl notes, "The central participants in the CSCL community were largely European members of the AI-in-education community" (p. 77). They were angry with Roger Schank for hijacking the 1991 AI in Education conference, hosted at Northwestern, to "proclaim himself the leader of a new field" called the learning sciences (p. 77).

Jeremy Roschelle has been said to have published the first representative CSCL paper, in 1992; Roschelle had been an intern at the IRL in Palo Alto, so the influence of the sociocultural turn on CSCL (at least, in the United States) is evident. Stephanie Teasley, another intern at the IRL, presented analyses conducted by the two at the conference on Computer-Supported Cooperative Work (CSCW) in 1988 and also at the first CSCL event, a workshop in Italy in 1989 (Roschelle & Teasley, 1995).

What Greeno and Nokes-Malach call "situativity" Stahl calls "the post-cognitive paradigm": studying meaning making as a joint group activity. His Figure 5.1 suggests that recognizable intellectual influences on CSCL are Vygotsky and the phenomenology of Schutz and Garfinkel, filtered through ethnomethodologists and conversation analysts including Sacks and Schegloff. All of these scholars emphasized interaction, dyads, and groups as units of analysis, in contrast to the individual. Nevertheless, CSCL scholars (as well as learning scientists) struggle with the implications of espousing and implementing in their research activities a "post-cognitive" paradigm. These are matters that continue to inspire and divide the LS community.

In summary, Stahl's chapter highlights an early contestation of paradigms and research agendas between LS and CSCL. Nevertheless, as detailed in this chapter and others in this volume, the tolerance for multiple perspectives and the willingness to strive for areas of collaboration, whether across philosophical positions or geographical settings, could be viewed as positive attributes of both CSCL and LS. Stahl's chapter serves well as a transition to the next section of this book, as this examines the present conditions in the field.

Part 2: Present

The three chapters in Part 2 use distinct analytical frameworks to document the current state of LS, though sometimes relying on historical or archived data. They help to define the scope of the field, and they provide a snapshot of what LS is today to a significant degree, how it has evolved since its founding in the early 1990s, and the intellectual forces that continue to drive that evolution.

Chapter 6. Victor R. Lee, Min Yuan, Lei Ye, and Mimi Recker: Reconstructing the Influences on and Focus of the Learning Sciences from the Field's Published Conference Proceedings

Victor Lee, Min Yuan, Lei Ye, and Mimi Recker provide an innovative and illuminating corpus analysis of the published proceedings of three LS conferences, those held in 1991, 2010, and 2014. With this analysis, their chapter helps provide answers to the questions "What is the learning sciences?" and also, "How has the learning sciences evolved and changed since its founding?" This is an impressive effort; many of the papers had to be manually scanned and processed using optical character recognition software; some of them had to be "obtained from conference organizers" (p. 209).

Lee and colleagues document how the focus on practice, context, and situation has increased in prominence. They also show how design experiments and design-based research have increased and become more central. As they put it, "In all, the trend appears to have been from more cognitive and domain general approaches in 1991 to more situated and domain specific practices, with an emphasis toward the domain of science, and design-oriented research in 2014" (p. 116). They conclude that LS is "interventionist" in nature, focusing on the "design and study of new learning environments" (p. 121) as was noted at the start to this chapter.

This is a fascinating chapter and an important contribution to understanding the current state of the field, and how it has changed since its founding in 1991.

Chapter 7. Martin J. Packer and Cody Maddox: Mapping the Territory of the Learning Sciences

Martin Packer and Cody Maddox offer a series of conceptual maps of the territory of LS, to define what LS *is* by exploring its boundaries.

They explore three tensions in the field: laboratory versus real-world research, formal versus informal settings, and authentic versus inauthentic instruction.

Their chapter begins by identifying LS graduate programs and discussing the language these programs use to describe themselves. They then analyze various aspects of the content of the first edition of the *Cambridge Handbook of the Learning Sciences*, and of the *Journal of the Learning Sciences* in its first twenty years.

These analyses provide a helpful "map" of the space of topics, individuals, and institutions that constitute LS research. For example, Packer and Maddox are able to show that in addition to the obvious attention to learning, LS research also treats *teaching* as central. That is to say, it tends to equate learning with classroom instruction. They are also able to show that despite the sociocultural turn, individual cognition continues to be viewed as central to learning, even though there is little agreement about the character of the mental representations that define individual cognition.

The second half of their chapter explores three distinctions that are commonly used to conceptualize the sites in which LS research is conducted. LS has long drawn a distinction between the laboratory and what it describes as the "real world." It has also drawn a distinction between "formal" and "informal" settings (and between formal and informal learning). In addition, a distinction is often drawn between authentic (LS grounded) and inauthentic (traditional classrooms) learning environments. Packer and Maddox explore how these oppositions overlap, come in tension, and reinforce each other, and then discuss some recommendations for how the field might rethink these distinctions to move forward.

Chapter 8. Susan McKenney: Researcher–Practitioner Collaboration in Educational Design Research: Processes, Roles, Values, and Expectations

Susan McKenney's chapter discusses what is perhaps the defining methodology of LS: design-based research. In design-based research, learning scientists work closely with practitioners in authentic learning environments. This is sometimes called a "design experiment" because the learning scientist and the practitioner collaborate to implement a change in the design of the learning environment, one that is grounded in LS theory and past research. Then, the impacts of that change are examined immediately (rather than using a post-test evaluation study), and the design is