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Cognitive and Sociocultural Perspective on Learning: Tensions and Synergy in the Learning Sciences

Joshua A. Danish (jdanish@indiana.edu)
Melissa Gresalfi

Introduction

Since its inception as a field, the interdisciplinary nature of the Learning Sciences has led researchers to leverage, develop, and refine a wide variety of theories to better understand how to predict and support learning across diverse contexts. At the heart of this process has been a debate—sometimes implicit, and often quite explicit—between those who subscribe to so-called cognitive versus sociocultural theories of learning. Broadly speaking, cognitive theories focus on the *mental processes* of the individual learner, while sociocultural theories focus on the *participation* of learners in the social practices within a particular context. A number of well-known articles and chapters (Anderson, Reder, & Simon, 1996; Greeno, 1997; Greeno & Engeström, 2014; Sfard, 1998) have addressed the differences between these two approaches, often highlighting the perceived strengths or weaknesses of one approach over the other. Our goal is not to reproduce those debates. Rather, we believe that a defining characteristic of the Learning Sciences as a field lies in how scholars have used these tensions to advance theories of learning, and to demonstrate their utility in understanding and designing for learning. Through this process, scholars have not only advanced the respective fields of cognitive and sociocultural theory, but have also demonstrated the overlaps and synergies that exist between the perspectives. Our goal in this chapter is to briefly summarize the unique contributions of each theoretical perspective and how they have shaped our perception as a field, and then to describe what we view as promising synergies that have arisen. In doing so, we are influenced by work that has highlighted that experience within a discipline involves refining one's perception, necessarily shifting what one notices or disregards in the world (Goodwin, 1994; Sherin & van Es, 2009; Stevens & Hall, 1998). We want to similarly explore how adopting cognitive, sociocultural, or mixed theoretical frameworks may lead scholars to look at or ignore key aspects of learning in context. We begin with a brief summary of the core theoretical differences before focusing on how we see these theoretical assumptions have been taken up in research and design.

Core Theoretical Assumptions

Below we present some generalizations regarding the core assumptions of each theory and its application to practice. We recognize that a great deal of work in the Learning Sciences moves beyond these generalizations in productive ways, and also blurs these lines. Nevertheless, we see the noted patterns as driving a great deal of debate over the last few decades, and thus present them here. For each theory we present its approach to knowing and learning, transfer, and motivation (Greeno, Collins, & Resnick, 1996).

Cognitive Theories

We use the term cognitive to refer to theories that aim to model mental processes—the perception, encoding, storage, transformation, and retrieval of information—within individual minds. Scholarship in this space has been referred to generally as Cognitive Science and includes Schema Theory, Information Processing, and Constructivism,[1] as well as more recent work within Cognitive Neurosciences. These approaches share a focus on developing empirically testable models, often reminiscent of computer architecture, which can explain and predict cognitive processes. As a result, the focus is commonly on how an individual mind works. In fact, many early studies within this space focused on the individual to the exclusion of all else, typically treating the environment solely as a "variable" to be controlled. However, work over the last few decades has increasingly addressed how cognition occurs within rich environments, recognizing that knowledge impacts our perception as well as our actions, thus shaping our engagement with the environment, which is also continually changing and thus triggering new responses. Furthermore, scholarship within the field of embodied cognition has been particularly focused on exploring the role of the body as a source of knowledge within the environment (Alibali & Nathan, this volume).

Knowing. Broadly speaking, cognitive approaches view knowledge as the representation of information within an individual mind. Cognition, from this perspective, is the manipulation, transformation, and retrieval of these representations. The distinctions between specific cognitive theories lie in how knowledge is represented and transformed. Models of cognition also predict how the processes of representing and transforming knowledge are visible within experimental conditions. One of the strengths of the cognitive approach lies in the fact that these different models of cognition allow researchers to make explicit and fine-grained predictions about how humans will perform in particular problem-solving or learning situations. In fact, the ability to measure knowledge and cognitive performances is central to the cognitive tradition. However, rather than being measured directly, knowledge is inferred from observable behaviors connected by models of the mind.

Transfer. Transfer is the use of knowledge in a new situation, different than where it was originally acquired. Traditionally, cognitive approaches to transfer contend that knowledge has to be represented in a suitably abstract manner to be applied in multiple situations (Day & Goldstone, 2012). The similarity between these situations involves mapping features of the original situation to the new context (Reed, 2012). More recently approaches within the cognitive tradition have noted that these mappings do not involve only static concepts, but also processes and approaches which may be used to solve problems (Day & Goldstone, 2012). Broadly speaking, however, cognitive approaches to transfer focus on how information has been represented within the individual mind, and whether this representation affords the use of this information in new contexts.

Motivation. Within cognitive traditions, motivation involves the internal states and drives that predict whether one approaches or avoids a situation. The theories of motivation that have developed from this perspective are wide ranging and diverse, but generally share a focus on how an individual feels (about herself, her abilities, about the situation), what the individual

desires (her goals, values), how those fit together, and how they respond to environmental characteristics (Wigfield & Eccles, 2000). For example, when students attempt to solve a science problem and succeed, they gain knowledge regarding their ability with respect to that class of problems. Motivation is thus informed by their awareness of how challenging this kind of problem is for them, as well as the likelihood of overcoming that challenge. A key assumption that underlies these theories is that motivation is an individual trait that is tied to existing individual interests, that has some stability, and can be investigated independently from contexts. For example, motivation is commonly measured by surveys or questionnaires that ask respondents to rank their relative agreement with a set of statements. These questionnaires often mention particular contexts (for example, "mathematics," in general, or "math class,") but do not examine motivation in relation to those contexts.

Sociocultural Theories

The class of theories that we term "sociocultural" include perspectives that, at their core, consider human activity to be inseparable from the contexts, practices, and histories in which activity takes place. From this perspective, studies of learning must focus beyond the individual to include the context in which the individual is interacting. There are myriad theories that fall into this category, the most well-known of which is called "Sociocultural" theory, but also within this category are Situated Cognition, Cultural-Historical Activity Theory, Social Constructivism, and some versions of Distributed Cognition. Although there are distinctions among these theories, both in their histories and in their specific foci, they share more commonalities than differences, particularly when contrasted with cognitive theories.

Knowing. Sociocultural perspectives generally take a Sociohistorical stance to knowing (Cole, 1996; Engeström, 1999), assuming that the origins of knowledge and the processes of engaging knowledge stem from the cultural and historical practices in which the individual is immersed. This means that *how* one comes to know something is inseparable from *what* one ultimately comes to know. Across sociocultural perspectives, few doubt that language, tools, social categories, or histories influence the ways we see and experience the world. Indeed, this assumption is central not only to sociocultural theories, but also to many cognitive theories, seen, for example, in the claim that the structure of schema influence perception of new information. However, the implications of the focus on *inseparability* of person and context is unique to sociocultural theories, leading, for example, to skepticism regarding the generalizability of research that takes place primarily in rarified laboratory environments. Sociocultural theorists argue that each context (including experiments) is unique in its own right, and experiences or findings may not apply to other contexts (Lave, 1980). Contexts are richly theorized and complex places that include histories and cultures that frame what one is expected or entitled to do, the meaning that is made of those actions, and how those actions are mediated by artifacts, people, and motives (Engeström, 1999). The core assumption is that cognition and knowing are a *joint accomplishment* between the individual and the rich context in which she is participating. Furthermore, due to the centrality of activity contexts in explaining knowing and learning, sociocultural theorists believe it is valuable to explore how they came to be, and how they may transform over time.

Transfer. Sociocultural theories of transfer often explicitly recognize the fact that transfer, as defined by cognitive traditions, is really hard to find. However, they note that human activity is full of examples of transfer, as we routinely move from situation to situation with little effort or challenge. Thus, the question becomes one of accounting for this cross-situational fluidity. To answer this question, sociocultural theories of transfer broaden the unit of analysis beyond the individual to include the contexts in which information is engaged. Although specifics differ, theorists who have written about transfer from a sociocultural perspective focus on: 1) the practices that are present in the learning situation; 2) the participation of individuals with those practices; 3) the potential overlap between the transfer context and the learning context (Lobato, 2012). The paired focus on individual participation in relation to context and the overlapping practices in the transfer context, are consistent with the different assumptions about learning that are made by sociocultural theories, specifically, that whether or what the individual does is only part of the ultimate activity.

Motivation. When exploring motivation, sociocultural theories tend to move away from considering individuals' goals, desires, and confidence independently, and instead consider the ways that activities and practices frame participation and human agency such that people act in more or less motivated ways (Gresalfi, 2009; Nolen, Horn, & Ward, 2015). From this perspective, motivation is seen as both an individual and collective endeavor: the behavior of pursuing or avoiding an activity is co-constructed between the opportunities in the environment and the individual's participation with those practices. Central to these kinds of analyses is the claim that people are not motivated or unmotivated, but rather, act in motivated or unmotivated ways in relation to the practices of the context. This shift in the unit of analysis requires examining not whether or how to make *people* more motivated, but rather, to consider how to reform practices and contexts to invite engaged and motivated participation. Furthermore, motivation shifts to being a mediator that may shape how people participate instead of simply informing whether they will (Engeström, 1999).

Tensions and Synergy in Theoretical Assumptions

Cognitive and sociocultural theoretical perspectives make different assumptions about the world and human activity. Cognitive perspectives are critiqued for their focus on individual characteristics within experimental contexts, thus missing or ignoring details that reflect the real-world links between individuals and their context. Sociocultural perspectives are critiqued for their focus on context, making it difficult produce any systematic, actionable and generalizable results; they often lose the individual due to the focus on the collective. For many, these differences are irreconcilable. However, there are also scholars who view these different theories as an important starting point to build upon the models that are central to cognitive science while also accounting for the importance of context and social-historical issues which are central to sociocultural theorists.

In line with the tension noted above, traditional cognitive approaches typically aim to refine models of how individual students understand and learn core disciplinary concepts. In contrast, sociocultural approaches focus on the social environment which supports and inhibits students' engagement with the discipline. However, the two perspectives can come together in the same work. For example, a project by Enyedy and colleagues (Enyedy, Danish, & Fields, 2011)

explored teaching the mathematics of central tendency to traditionally under-represented middle school students in the Los Angeles, CA area. The authors began with extant models of student cognition related to mean, median, and mode as a starting point (c.f.,Bakker & Gravemeijer, 2003; Konold & Higgins, 2002; Makar, Bakker, & Ben-Zvi, 2011). Enyedy et al. also used Culturally Relevant Pedagogy (Ladson-Billings, 1995) as a framework for adapting their instructional design to focus on students' use of mathematics to support argumentation using data that were relevant to their lives (such as the presence of graffiti in their neighborhood, or violence in local parks). Enyedy et al.'s focus was thus on how students might learn normative mathematical concepts *while* engaging in difficult but locally meaningful questions and arguments. The results are thus tied more closely to the kinds of generalizable mathematical conceptions favored in prior cognitive work, while also attending to important issues of context that are valued by sociocultural theorists.

Data Collection and Methods

The data collection and analytic methods that are leveraged by theorists must be tightly coupled with the questions that are posed, and thus it is often the case that cognitive and sociocultural theorists use different analytical methods. The distinction between the perspectives generally falls along the lines of debates between quantitative and qualitative methodologies, a conversation not revisited here. However, with respect to developing and contributing to theories of learning, the distinctions between the questions posed, the methods used, and ultimately, the claims that are made, matter, both in terms of what the field learns, and ultimately, what kinds of questions get play.

Cognitive approaches. Due to the focus on empirically testable models of cognition and learning, studies within the cognitive tradition frequently contain measures that allow for comparisons between people and across time points such as surveys or standardized assessments. These measures can then be easily quantified so that parametric statistical methods can be employed. In this strand of research, scholars are often interested in making claims about causality, to link specific activities or events to models of cognition and learning. As a result, experimental designs that contrast intervention and control groups are quite common, and indeed considered by some to be the gold standard of "scientific" research (Feuer, Towne, & Shavelson, 2002).

Sociocultural critiques of these approaches have noted that they are often conducted in settings that lack ecologically validity (e.g., laboratory experiments and interviews), and that can over-simplify important interactional and cultural dimensions. The very same assumptions that allow for these kinds of statistical inferences are theoretically problematic in that they do not allow for the messy interactions between individuals and their environment; quantifying results can inadvertently gloss the role of interaction and the research setting in producing those results.

Sociocultural approaches. In contrast, many sociocultural studies rely heavily upon qualitative methodologies including discourse and interaction analysis, interviewing, and ethnographies. The goal in employing these approaches is to understand learning as continually mediated by the local activity system, which is in turn continually in transition. Key concepts that are treated as "variables" are considered to be dynamic and locally produced within the

sociocultural tradition. For example, sociocultural theorists note that culture is not static, and should not be treated as such (Gutiérrez & Rogoff, 2003). Rather, culture is continually created and transformed in the moment, as individuals contribute to and are impacted by their cultural milieu. Likewise, key mediators of activity, including tools, classroom practices, language, and students' relations are analyzed along with student participation.

These theoretical assumptions therefore frequently lead sociocultural theorists to focus on qualitative analyses which allow for a deeper look at how a specific set of participants engages within their local context. The highly localized nature of these analyses is often what draws critique from those in the cognitive tradition who are skeptical that findings will generalize. Cognitive theorists also frequently note that core theoretical concepts are not effectively operationalized in this tradition, remaining vague and underspecified as a result of looking for them as produced in interaction rather than identifying them a-priori.

A synergy in methods. In short, cognitive approaches frequently aim to collect systematic, generalizable, and quantifiable data from controlled environments whereas sociocultural theorists place a higher premium upon ecological validity and rely more heavily upon qualitative data to support exploration of emergent and interactional results. Is it possible to reconcile these tensions and support both experimental, a-priori contrasts and analyses of emergent, interactional accomplishments? We believe it is, and that the learning sciences have developed increasingly robust hybrid approaches that reflect the strengths of both traditions (see Strijbos & Dingiloudi, this volume). One example is work by Russ, Lee, and Sherin (2012), who explored the impact of social framing on student answers provided during interviews about science concepts. The authors built on the notion of social frames from interaction analysis to note that while there were patterns in student cognition within their interviews, those patterns were also heavily influenced by the perceived social frame that the students engaged in with the interviewer. The authors were thus able to incorporate social cues into their model of how individual students presented their knowledge in interaction, accounting for the concepts that students understood as well as how their view of the context shaped their presentation of that understanding.

Designing for Learning

The assumptions we make about how people learn fundamentally drive the ways we design to support that learning. Designing for Learning is very broad and can focus on different areas, such as classroom norms and instructional practices, particular disciplinary tools, or broader immersive learning environments. In the sections that follow, we offer overviews of the ways the two perspectives have typically thought about design, and then offer examples of designs that represent the extreme of each perspective. We then follow with two examples of synergistic designs, drawing from our own research, and highlight the contribution of that work.

Designing from a cognitive perspective. At the core of the majority of cognitive designs is an explicit awareness of and inclusion of a specific model of cognition. For example, much of the prolific work in the domain of cognitive tutors often builds on Act* model of cognition (see Graesser, this volume). Furthermore, cognitive designs usually build on a refined model that is specific to the kinds of cognition that have been observed in experts within the specific content

area, such as a model of how students learn new science concepts (White & Frederiksen, 2000) or how they process historical information (Wineburg, 1991). Cognitive models which drive design also frequently include an acknowledgement of previous, common misconceptions that the target population holds. Once these models have been specified, designs in the cognitive tradition are intended to help students to develop the target normative model or schema, addressing common misconceptions on the way.

A long-running program of research which exemplifies this approach is the development of cognitive tutors (Koedinger, Anderson, Hadley, & Mark, 1997). At the core of this approach to computer assisted instruction is a model of student cognition. In one of the most famous examples, the Algebra Tutor, there are models of how to solve algebra problems as well as common mistakes made by students. Students can attempt to solve problems, and the continually updated model of their performance allows the cognitive tutor software to offer guidance as needed. Thus, the cognitive model is not only an inspiration for this research, but an actual core component of the software system. One of the goals of the cognitive tutor research was to bring cognitive science into the classroom, and it has been quite successful in doing so. As a result, researchers have paid quite a bit of attention to how the tutor might be adapted into local classroom contexts.

Designing from a sociocultural perspective. Sociocultural perspectives on design aim to accomplish two things. First, they look beyond the individual to understand the multiple mediators within the local context. As a result, sociocultural designs typically focus on entire activity systems rather than single tools (e.g., the 5th Dimension projects). This also means that sociocultural theorists are often interested in supporting "authentic" environments that mirror the practices of the discipline and not just the concepts to be learned. Second, as a result, sociocultural perspectives on design tend to question what it means for practices to be authentic, and for whom. These approaches often challenge the status quo, noting how schools, and the disciplines they aim to prepare students for, are frequently not as valuable or well-aligned with the goals, experiences, and histories of all students. Inequities within the multiple levels of our societal systems are thus a common focus of these design approaches.

As an example of this work, we highlight a well-known project that is now over 20 years old. Lee (1995) developed a high school curriculum for literary interpretation, drawing on and leveraging practices from the African American community, particularly, *signifying*, and incorporating them into classroom activity. Signifying is a form of verbal play in the African American community that involves sophisticated language use, including "irony, double entendre, satire, and metaphorical language" (Lee, 1995, p. 612). A key assumption of this work was that African American students' performance on school-based assessments of literary interpretation did not accurately represent their' actual understanding of literary interpretation. Instead, Lee hypothesized that the practices of interpretation of the spoken word, such as signifying, in which students were already central participants, were treated as unrelated to the practices of school English classrooms. As a consequence, students failed to transfer the practices of signifying to the classroom, because although the underlying skills were equivalent, the contexts of use were notably different. Thus, the intervention, involved bringing into alignment the tacit, everyday practice of signifying and the formal, academic practice of interpretation. Lee's work demonstrated that students who participated in the instructional

intervention involving connecting everyday signifying to school practices learned twice as much as the control group.

Synergy in design. The examples above highlight the differences in the ways that theoretical frameworks direct our perception of problems and, relatedly, the solutions that we pose. Taking extreme cases from Cognitive Science and Sociocultural Theory, we see work that has demonstrated effectiveness by carefully considering the way individual processing unfolds, and work that has demonstrated effectiveness by theorizing about the nature of the context that shapes individual participating. However, there is nothing inherently incommensurate between these two foci: one can draw on our understanding of the structure of human mental representation while simultaneously acknowledging that this structure is only part of understanding and predicting learning and activity. To highlight the potential to design across theoretical perspectives in design work, we present two examples of our own work, where we explicitly attempted to build on both traditions.

In the BeeSign project, Danish (2014) designed a series of activities intended to help early elementary students engage with complex systems concepts in the context of honeybees collecting nectar. Danish began his design work by exploring more individually-focused work which describes the challenges and misconceptions that students face in exploring complex systems concepts. At the same time, Danish aimed to support this individual learning by focusing on designing collective, mediated activities where multiple participants were necessary to help students explore these concepts, and where key new practices were developed or supported. For example, inquiry with the BeeSign software relied upon the teachers' ability to help guide the students through cycles of inquiry, and also built on students' ability to help their peers' attend to useful patterns in how bees collect nectar, and to challenge each other's assumptions by running simulated experiments. Student learning was demonstrated in both the changes in students' ongoing collective activity, as well as in individual interviews that took place afterwards. In particular, Danish demonstrated how ideas that were first made visible in collective activity were also seen within the individual interviews, though sometimes in different forms. This is an example, therefore, of how cognitive analyses of individual learning can be synthesized with a focus on collective activity to better understand how the design of collective activity can lead to new forms of interaction as well as individual outcomes.

Similarly, Gresalfi and Barnes (2015) describe a series of design studies that focused on supporting the development of a particular kind of mathematical problem solving practice, which they call critical engagement. Beginning with research about the development of students' multiplicative and proportional thinking (Lesh, Post, & Behr, 1988; Misailidou & Williams, 2003), they designed an interactive immersive game and focused on the ways the narrative and feedback of the game supported students to consider different possible solutions, and the effectiveness of those solutions. This design framework built on ecological psychology, specifically focusing on the kinds of affordances that are included in designed environments, and how those affordances interact with students' incoming effectivities (prior knowledge, history with mathematics, etc.). Integrating theories of student knowing about ratio with an ecological framework allowed for the development of a set of conjectures about individual student reasoning as it related to and played out in relation to the interactive tools that were a part of the game.

Conclusions

There are many fundamental differences between cognitive and sociocultural theories of learning. As a result, the field has discussed, debated, and taught our students about these differences. One of the most important results of this ongoing work, and a hallmark of the Learning Sciences, has been that both traditions have continually refined their approach, and many scholars have worked to synthesize findings, theories, and designs from both traditions. We do not mean to suggest that we are moving, as a field, to one grand unified theory—while that might be possible, many productive debates and differences still exist. Rather, we believe that the last few decades' worth of push-back, argument, and discussion have led researchers across the Learning Sciences to focus on issues of interest to all of us. Regardless of the theoretical orientations that are taken up, we see more work that is explicitly addressing issues of individual performance and cognition while also focusing on social context and its role in constructing and being constructed by individual cognition. Perhaps even more importantly, we see scholars across the Learning Sciences explicitly recognizing that in order to unpack the role of context in learning, we have to recognize and begin to address fundamental issues of equity and access which we know are so intertwined with the learning opportunities and experience of students across the world.

Further Reading

1. Greeno, J. G., Collins, A., & Resnick, L. (1996). Cognition and learning. I DC Berliner & RC Calfee (red): Handbook of educational psychology: New York: Prentice Hall.

   This classic piece provides a clear breakdown of the core principles within each theoretical framework. While more recent work has moved towards greater synergy, this remains a clear, high-level summary of core differences.

2. Sfard, A. (1998). On two metaphors for learning and the dangers of choosing just one. *Educational Researcher, 27*(2), 4-13.

   On two metaphors for learning and the dangers of choosing just one. Educational Researcher, 27(2), 4-13. This canonical piece helps to not only contrast the two core theoretical approaches, but to highlight the impact of their underlying differences. Sfard also argues compellingly for the danger of focusing too closely on only one.

3. diSessa, A., Sherin, B., & Levin, M. (2015). Knowledge Analysis: An Introduction. In A. diSessa, M. Levin, & N. Brown (Eds.), *Knowledge and interaction: A synthetic agenda for the learning sciences.* New York, NY: Routledge.

   In this edited volume, efforts to analyze knowledge and interaction are compared, contrasted, and synthesized. The efforts to do so parallel our own in noting how not all of the differences in theoretical camps are irreconcilable, and contributions provide promising next-steps for synergy.

4. Svihla, V., & Reeve, R. (Eds.). (2016). *Design as scholarship: Case studies from the learning sciences*: Routledge.

   This volume provides a rare look into the actual design process within the Learning Sciences, providing the kinds of depth and exploring challenges that

rarely fit into a traditional article format. In doing so, it also helps make visible the role of the different theories in informing the design process.

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[i] We are referring here to the theory proposed by Piaget as opposed to the philosophical approach, though many cognitive theories agree with the philosophical approach