Probing Learning Scientists' Beliefs About Learning and Science

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Abstract: The learning sciences have experienced a proliferation of research paradigms over the last several decades, resulting in a complex theoretical and methodological landscape. Based on our readings of prior debates in the literature, we identified nine frameworks or dimensions that have been used to characterize differences among learning scientists. To better understand this complex landscape, we interviewed 22 learning scientists and analyzed their responses using qualitative coding methods. This paper presents a cross-section of that analysis, focusing on the limitations of existing frameworks in capturing important nuances in researchers' beliefs. The findings reveal a variety of ways learning scientists resist particular frameworks. Overall, these findings paint a picture of a field evolving towards a largely pragmatic view of learning research.

Introduction

In 1991, the Fifth Conference on Artificial Intelligence and Education was re-named the Fifth International Conference of the Learning Sciences (later re-branded as the First ICLS). Two years later, the Sixth World Conference on Artificial Intelligence in Education was held, and in 1996, the Second International Conference on the Learning Sciences. A community had fractured. Two new communities had formed. The reasons behind this fracturing lay, at least in part, in different notions of what it means to learn and to study learning.

As an interdisciplinary field, the learning sciences are rife with varied beliefs about the nature of learning and the nature of science. Many labels exist for different "groups" of researchers (cognitivists, constructivists, situativists, and so on). Even within each of these groups, many sub-groups exist, and the same labels do not always carry the same meaning. Underlying beliefs about learning and science are often left implicit, so researchers may need to read between the lines to determine the ontology and epistemology behind another researcher's work. Yet this can make it challenging for novice researchers to understand the nuanced and complex landscape of the learning sciences. Even experts can get lost when their worldview clashes with the unspoken worldviews of others. As Greeno (1997) remarked in a debate (around situativist vs. cognitivist theories) with Anderson, Reder, and Simon (1996),

> proponents of the two sides tend to talk and write past each other because they address different questions…[but by] identifying the presuppositions of the different questions, we can clarify substantive differences between the perspectives and thereby understand better what theoretical and educational issues are at stake in the debate" (Greeno, 1997, pg. 6).

However, Anderson, Reder, and Simon (1997) made it clear that they very much disagree with Greeno's interpretation of their unspoken questions. Reviewing these and other published discussions, a complex landscape of learning scientists' beliefs about learning and science began to reveal itself. To better understand the landscape as it exists today, **we chose to ask the learning scientists themselves**.

Based on our readings of the literature, we identified nine frameworks along which learning scientists have been said to differ. Using these frameworks, we ask: **How well do various frameworks help characterize disagreements among learning scientists with respect to beliefs about learning and approaches to research?** In doing so, we hope to provide clarity to new researchers entering the field, as well as to experts who may have blind spots, misrepresenting other researchers' positions.

The Learning Sciences: A dichotomized field

In 2018, ICLS was co-located with the International Conference on Artificial Intelligence in Education (AIED) for the first time since 1991, and also with the newer Learning @ Scale conference. The theme of the conference was "Rethinking learning in the digital age: Making the Learning Sciences count." Were the learning sciences reuniting with their AI and technological roots? In 2020, the ICLS theme is "Interdisciplinarity in the Learning Sciences," recognizing that ICLS as a field consists of many disciplines: "psychology, sociology, anthropology, linguistics, historiography, critical theories, and philosophy." No AI. No computer science. No technology.

Within the diversity of learning theories, historical trends from 1991 to 2020 seem to paint a picture of two broad "camps" of learning scientists. These camps tend to differentiate themselves along several dichotomies. At the risk of oversimplification, one camp tends to be described as being more reductionistic, quantitative, positivist/realist, and in favor of direct instruction, while the other as being more holistic, qualitative, interpretivist/constructivist, and in favor of discovery learning. We use Kolodner's (2002) terminology to refer to these two camps as "neat" and "scruffy," respectively. According to Kolodner (2002), prototypical "neats" include Herb Simon, Allen Newell, and John Anderson and prototypical "scruffies" include Seymour Papert, Marvin Minsky, and Roger Schank. These notions informed our methodology, guiding which researchers we initially chose to interview and what frameworks we used to characterize learning scientists.

Methods

To capture the views on learning and learning research through the lens of several frameworks, we conducted semi-structured interviews, lasting between 30 to 60 minutes, depending on interviewees' availability. The interview scripts included three sections: first, asking researchers to briefly characterize the kinds of research they engage in; second, locating their research within nine different frameworks; and third, reflecting on the nine frameworks collectively rather than individually. For each framework, the interviewer asked if the interviewee was already familiar with the framework, if they wanted any terms defined, and then where they located their work within the framework. The interview script went through multiple iterations and rounds of piloting. We reached out to 35 researchers, 22 of whom accepted our request to interview, 2 of whom declined, and the rest of whom did not respond. Three overall sampling frames guided the outreach. First, we wanted to ensure we had epistemological/paradigmatic variety, based on views expressed consistently in researchers' publications. Our resulting sample contained several intellectual descendents of the prototypical neat and scruffy researchers mentioned above. Second, we wanted to include researchers who had played prominent and field-building roles in the learning sciences and related communities. Our interviewees included five individuals involved in the founding of a relevant research community/society (e.g., ISLS, Educational Data Mining Society, Society for Learning Analytics Research) and ten individuals who wrote chapters in one of the editions of the *Cambridge Handbook of the Learning Sciences*. However, we also included several junior researchers – including three who had earned their PhD at most five years before the interview and another four who had earned their PhD at most ten years before – in the interest of capturing views from a new wave of learning scientists. Finally, we aimed to have representation from multiple institutions, while also focusing our efforts to see how institutional training might manifest in researchers' beliefs about learning and science. To do so, we focused on recruiting interviewees affiliated with four American universities with well-established learning sciences programs; 18 of our interviewees were from these institutions, four of whom had been at multiple of these institutions at various points in their careers.

Interviews were transcribed by one of the authors or a contractor. For the current analysis, we identified quotes from the interviews where interviewees either explicitly *located their beliefs* within a particular framework or *rejected* a particular framework. We then created a profile for each interviewee that visually represented where they located their work within each framework, which we share as supplementary material (3). Given the nature of this research, we also disclose our own positionalities as learning scientists by sharing visual representations of our own responses to the frameworks in the supplementary material.

The nine frameworks we selected were chosen to characterize prominent debates within the learning sciences or different means of characterizing learning sciences research. We provide a brief description and rationale for inclusion of each framework in the next section, before presenting results for each. Figure 1 shows visual probes for each of the nine frameworks covered in the interviews. We neither claim that this set of frameworks is *exhaustive*, nor that it represents the *best* set to characterize differences in learning scientists' beliefs. On the contrary, we presented these frameworks precisely to understand the ways in which they succeeded or failed in characterizing learning scientists' beliefs. If interviewees felt that a given framework was *not* well-suited to describe their research, they were encouraged to elaborate on the reasons why they perceived a mismatch.

Results

The present paper presents one analysis from a larger project investigating these interview data. For this analysis, we focus on responses that challenged a framework's accuracy, usefulness, or validity in characterizing beliefs about learning research. We omit the results for one framework (research communities), due to a lack of surprising results in this vein. We refer to interviewees by "I," followed by an interview ID.

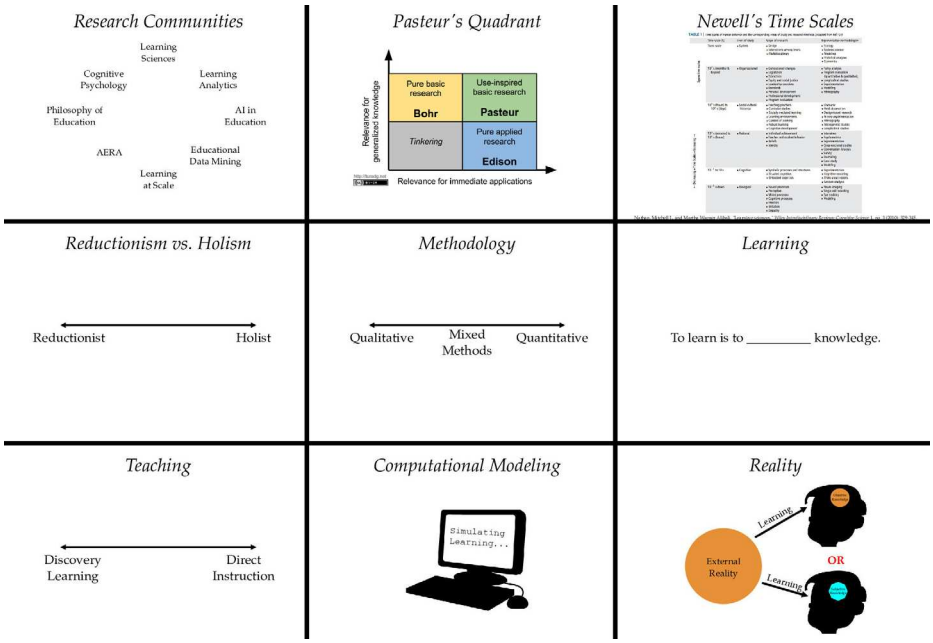

Figure 1. The visual probes for the nine frameworks in the interview.

Quantitative vs. qualitative methodology

Discussions around quantitative vs. qualitative methodology have been of utmost concern in education research in the twentieth century (Johnson & Onwuegbuzie, 2004; Smith & Heshusius, 1986). Some authors have advanced the view that these methodologies are incompatible due to epistemological differences that underlie them (Smith & Heshusius, 1986). According to this view, method is not simply meant to be a toolbox of techniques, but also "a logic of justification," which means it is inherently tied to an epistemology that determines what kind of evidence is valid. Others have argued that the two methods can be used in tandem with one another by rooting "mixed methods" research in *pragmatism* (Johnson & Onwuegbuzie, 2004).

Interestingly, the majority of our interviewees characterized their approach to methodology as either being mixed methods or spanning the entire spectrum from qualitative to quantitative. Indeed, many of our interviewees explicitly admitted a pragmatic stance when it came to methodology: *"I like both. I like the whole thing...Pick methods appropriate to the questions you're asking"* (**I4**) and *"Oh, I don't know. This is such a stupid distinction. I use math where it helps me and I use observation where it helps me."* (**I13**). Only four interviewees indicated that they do not identify with mixed methods, but even these participants saw value in such approaches. For example, **I2** said *"I'm very quantitative which doesn't mean that I'm hostile to qualitative...Science should be a mixture of quantitative and qualitative, but individual researchers often shouldn't."* Moreover, we noticed that researchers sometimes interpreted the terms "quantitative" and "qualitative" differently. For example, **I11** identified as being somewhat mixed methods, because to them, quantification of coded qualitative data would be considered quantitative. Another researcher clearly interpreted such work as being qualitative: *"All of my discourse studies end up having some numbers of codes or whatever something, but that's a quantification of the qualitative data. So, it remains qualitative the way we're talking about it"* (**I22**). This difference may have led to biases in researcher's perception of their research as being mixed methods.

Finally, two researchers (**I10**, **I21**) suggested that authentic mixed methods research should be more than just a mix of qualitative and quantitative techniques; rather, they should be combined in such a way that the whole is more than the sum of its parts, or according to **I10**, *"so that they are on the same epistemological foundation."* **I10** advocates for bringing methods back to the epistemological plane, suggesting that viewing methods as unidimensional is an oversimplification. All in all, researchers seem comfortable to identify as mixed methods, but this may mean different things to different researchers.

Reductionism vs. holism

One way in which learning sciences research has been characterized is by distinguishing between more reductionistic (or elemental) versus holistic (or systemic) approaches to research (Nathan & Sawyer, 2014). Reductionists decompose systems into their smallest constituent parts and build understanding from the top down, while holists study systems as a whole to achieve a bottom-up understanding.

Interestingly, for this spectrum, our interviewees rarely provided straightforward answers regarding where they situate their work. Instead of positioning themselves at a single point along this spectrum, two interviewees (**I4**, **I21**) positioned themselves at *both extremes* simultaneously. For example, **I21** said, *"I position myself at points close to both ends, some very reductionist stuff and some very holistic stuff. And I try to also bring them together."* Other interviewees challenged the idea that this spectrum could best be understood as linear (**I10**: *"What I'm trying to do in my work is not view that as a line but...as a circle. That is, to connect the two ends...You can't understand the bits and pieces without understanding the whole..."*). Yet others challenged the notion that their position along the spectrum could be meaningfully understood as static. **I18** said, *"I think we have to oscillate between the two,"* noting that switching from *analyzing* systems to *building* systems can often require a temporary switch from a more holistic to a more reductionistic perspective.

Several interviewees emphasized that the choice of approach should depend on the research questions being asked. **I12** emphasized that *"it really depends on the question that you're asking, whether you're interested in...more of the elemental aspects of learning, or more of the holistic aspects of learning."* Similarly, **I6** shared that, rather than sitting at a single point along this spectrum, they try to select a level of reduction appropriate for a given question: *"I break things into parts, but I break things into parts that are at the level of abstraction that's most useful."* Some interviewees suggested that the choice of question may sometimes depend on the ease with which that question can be approached. **I3** noted that while both holistic and reductionist approaches to research could be useful, *"it seems like [holism is] too hard."* Echoing this sentiment, **I8** said, *"I think part of the reason why people are skeptical is because they think that once you do this holistic stuff...you can't do very good quality work."*

I4 and **I19** noted that this spectrum is open to many interpretations. **I4** pointed out that reductionism/holism may be inherently relative: *"I'm not as reductionistic as the neuroscientist, but...I'm definitely more reductionistic than some of the education research approaches,"* and **I19** flagged this as a dimension that *"when you're asking people to self-report, everybody's doing it differently on different basis."* **I4** also noted that this dimension may not be best understood as unidimensional, giving the example of how connectionist models of learning *"[are] more holistic, in terms of how [they model] knowledge. But then neuroscience is very reductionistic in what it's trying to explain*." This highlights a distinction between reductionism/holism in the *target* of an explanation (i.e., the phenomenon under study) versus the *form* this explanation takes.

Finally, two interviewees (**I13**, **I20**) rejected the lens of "reductionism" and "holism" altogether. Instead, **I13** preferred to characterize differences among learning scientists based on whether their research investigates *necessary* or *sufficient* conditions for learning:

> *"I think a lot of science is about what is necessary. [For example] if your cognitive load is exceeded, you will necessarily decay in performance. [But] most of education is about sufficiency. So, I could really reduce your cognitive load, but you get bored, so it's not sufficient...My view is more there are necessary components and the challenge is how do you make a sufficient system out of it."*

Pasteur's Quadrant

Pasteur's Quadrant is a framework in two dimensions, representing the extent to which research aims at *immediate applicability* on one axis and *fundamental understanding of the world* on the other (Stokes, 1997). Research that aims at the former but not the latter is referred to as "Applied research" or Edison's quadrant. Research that aims primarily at fundamental understanding is referred to as "Pure basic research" or Bohr's quadrant. Finally, research that aims at *both* immediate applicability and fundamental understanding fall under "Use-inspired basic research" or Pasteur's quadrant (4). This notion of "use-inspired basic research" has often been described as an ideal for research in the learning sciences (Nathan & Sawyer, 2014).

Perhaps unsurprisingly, most of our interviewees either located their research primarily in Pasteur's Quadrant or expressed that they aspired to spend most of their time in this quadrant (even if this did not reflect their current reality). However, two of our interviewees (**I10**, **I21**) rejected this framework altogether. **I21** suggested that, in their mind, the learning sciences as a field *"kind of cuts orthogonally to these [quadrants]."* This orthogonality is consistent with the idea that while Pasteur's Quadrant may be useful in distinguishing the learning sciences from other fields, it may not have high utility in distinguishing research approaches *within* the learning sciences.

Newell's time scales

Newell's time scale of human action was originally proposed by Allen Newell (1990) to describe different time bands in which human behavior operates: biological (milliseconds), cognitive (seconds), rational (minutes to hours), and social (days to months). To better suit learning sciences research, Nathan and Alibali (2010) extended this framework (which they called "time scales of human behavior") to include an organizational band along with a systems level that operates across multiple bands. They contended that different researchers use different approaches depending on the time scale of the learning phenomena they are studying. We used Nathan and Alibali's (2010) figure depicting the time scales as our visual probe.

Many interviewees spanned a range of time bands, with a majority centering their range around Newell's rational band. Three of our interviewees rejected this framework, questioning its validity (**I16:** *"I don't make stark delineation/demarcations between these as levels"*) and its practical utility (**I5:** *"Why? How is this relevant to anybody? How about just build some good stuff?"*). **I10** found it difficult to situate their tool/methods-oriented research within Newell's time scales, noting for a particular research project that both researchers and teachers could use a tool they built, but along different time scales.

Learning

To gauge researchers' views on the nature of knowledge and how it relates to learning, we asked them to fill in the following sentence: *"To learn is to ____ knowledge."* In doing this, we were open to researchers rejecting the framework entirely, as we realize that not all learning scientists speak of learning in terms of knowledge. However, we wanted to avoid asking them about their learning theories, because theories are value-laden and can be interpreted differently. Instead we want to elicit researchers, intuitive conceptions of learning. This follows Sfard's (1998) use of metaphors to discuss learning:

> Indeed, metaphors are the most primitive, most elusive, and yet amazingly informative objects of analysis. Their special power stems from the fact that they often cross the borders between the spontaneous and the scientific, between the intuitive and the formal…Thus, by concentrating on the basic metaphors rather than on particular theories of learning, I hope to get into a position to elicit some of the fundamental assumptions underlying both our theorizing on learning and our practice as students and as teachers.

Six interviewees (**I1**, **I10**, **I13**, **I14**, **I17**, **I19**) strongly rejected this framework. While these interviewees generally recognized the role of knowledge in the learning process, they did not see it as the ultimate aim of learning. For instance, one interviewee rephrased the sentence as, *"to learn is to deepen understanding…to become more capable"* (**I19**). **I17** similarly noted that *"knowledge is only interesting in so far as it manifests itself in the actions that we take."* Another interviewee explained that *"knowledge is a direct object here [in the sentence], and knowledge is dynamic, it's not a thing…To learn is to adapt to circumstances, hopefully in a good way"* (**I13**). Similarly, **I10** identified learning as "a process of enculturation." Finally, one researcher stated that there is not one static definition of learning, rather it is a *"choice a researcher takes that I think needs to be justified"* (**I1**). That the definition of learning is a choice resulting from a research paradigm is something alluded to by another one of the five interviewees:

> *"Well, here's the thing, as much as I talk about all this other stuff, I was brought up as a cognitive scientist. So it's where I come from, and I'm trying hard to get better than that. But...I think in terms of, you know, of knowledge and skills. I don't really want to, but I don't know any other way to do it"* (**I19**).

The quote above expresses how sticky conceptions of learning are, and that other conceptions might be inaccessible or inapplicable, especially if one is already deeply ingrained/established.

Teaching

To gauge researchers beliefs about teaching, we asked them to locate their work on a spectrum with discovery learning at one end and direct instruction at the other, which was based on the popular debate around the two approaches in the learning sciences (Kirschner, Sweller, & Clark, 2006, Tobias & Duffy, 2009). Four interviewees rejected the framework and five interviewees located their work along the entire spectrum. Of the rejections, two (**I17**, **I20**) specifically pointed to rejecting the framework because it requires caricatures of the two kinds of teaching: *"in order to make it a debate, one side always has to caricature the other side as taking some extreme position which they don't really take"* (**I17**). The third rejection pointed out that the opposite of direct instruction is not discovery learning (**I5**). The fourth rejects the dimensionality of the visual representation:

> *"I'm not a huge fan of dichotomies…I don't like gray...[if] you're in the middle between the black end and the white end, you're at gray. But what I like is purple and blue and green and yellow. Like, the world is multidimensional."* (**I4**)

The full-spectrum responses stressed that various forms of teaching are important; what matters is their application, stressing the need for flexibility (**I1**), responsiveness to learners (**I2**, **I6**), and sequencing/ordering of the teaching methods (**I12**, **I13**).

Computational modeling

We elicited researchers' attitudes towards computational modeling to meaningfully differentiate between "neat" and "scruffy" views. Somewhat to our surprise, all interviewees either believed it is possible to simulate learning (to some extent) or did not know enough to voice a clear stance (three interviewees: **I8**, **I9**, **I22**).

However, one key difference in responses did emerge among interviewees who believed it is possible to computationally model learning: several unequivocally expressed their belief in and support for the enterprise of computational modeling (e.g., **I4**, **I5**, **I6**), while others caveated their belief in the ability to model learning and/or questioned its value in some cases. Interestingly, there does not seem to be a clear pattern to discern which researchers unequivocally support the enterprise and which have reservations. Some of the researchers involved in computational modeling and who belong to the AIED and EDM communities, which engage heavily in computational modeling, were among the first to bring up its limitations:

> *"I think you can model restricted phenomena of learning exceptionally well. Developing a general simulation of a general learner, despite what some people say, is really hard"* (**I2**).

> *"I think most of the attempts to do so have missed a lot of the factors that influence learning experiences in the real world...Are you modeling whether kids have eaten breakfast, and what that does to their processing? Have you modeled social influences?...Until you take all of those into account, we're never going to have a fully simulated learner"* (**I15**).

In retrospect, it is perhaps not entirely surprising that researchers who identify with more socio-cultural and constructivist traditions were optimistic about computational modeling, as we found that researchers from these traditions have also, at times, advocated for computational modeling in the literature (Abrahamson & Wilensky, 2005; Greeno & Moore, 1993; Hutchins & Hazelhurst, 1991). However, these researchers advocate for different forms of computational modeling (compared to information-processing models), such as using agent-based models to give insights on complex phenomena rather than offering precise mechanistic explanations for how students learn. Thus, while we have found that computational modeling does not appear to be a useful framework for distinguishing different learning scientists, this could be due, in part, to different interpretations of what a computational model is and what we might hope to learn from it. This may stem from epistemological differences.

External reality

The final framework presented to researchers had two parts, one focusing on ontology (the existence of an external reality) and another focusing on epistemology (whether our understanding of reality can be subjective or objective). We hypothesized that the former would not be controversial and hence would not be a salient dimension to discriminate researchers. However, we included it because researchers often categorize radical constructivists as rejecting external reality (see e.g., Nathan & Sawyer, 2014, p. 56). But radical constructivists are quick to point out that they do not deny the existence of an external reality, but only that we each construct a subjective reality which does not necessarily match any external reality. Therefore, if there is a difference between constructivist learning scientists and more traditional cognitivists, we posited it would be in terms of epistemology, namely whether we can know reality as it is, or if our knowledge of it must be subjective.

Indeed, almost all interviewees unequivocally believe in an external reality. Two researchers labeled themselves as adopting a pragmatic philosophical position, focusing on and understanding the reality at hand without needing to know whether or to what extent that reality represents ultimate Reality. As **I1** summarized: *"this is as real as it gets, so you might as well get on with it."* More interestingly, almost all interviewees *also* believe that our knowledge of reality is necessarily subjective. Only two believe our knowledge of reality is objective (**I7**, **I11**), two suggest the possibility of approaching objective knowledge (**I3**, **I4**), and in addition to the two pragmatists mentioned earlier, another researcher *pragmatically* treats knowledge as being objective: *"So,*

the idea that it's all relative and that social reality is fully constructed, it may be true, but I find it a very difficult space to operate in, because it's hard to write papers about that" (**I13**).

Neats vs. scruffies: Correlations between frameworks

Finally, we mentioned earlier that many of our frameworks aimed to characterize differences between two groups of learning scientists as portrayed in the literature: neats and scruffies. We wanted to see whether our findings are consistent with the existence of such "camps." We found that nine interviewees self-identified one way or another on the reductionism vs. holism spectrum, and the overall profile of these researchers tend to match prototypical neat and scruffy researchers, as shown in Table 1. In particular, Table 1 shows the percentage of researchers who self-identified as reductionists or holists that located themselves in various ways on different frameworks. Thus, it appears that almost half of our researchers could be loosely clustered into these two groups. However, as we discuss below, this could be a misleading characterization.

Table 1: Differences between self-identified reductionist-leaning and holist-leaning researchers.

	Reductionists (I2, I3, I7, I12)	**Holists (I1, I14, I16, I19, I22)**
Quantitative / Qualitative	100% / 0%	20% / 80%
Direct Instruction / Discovery Learning	50% / 0%	0% / 60%
Part of AIED Community	100%	40%
Rejected "Learning" Framework	0%	40%

Discussion and conclusion

The learning sciences have experienced a period of paradigmatic proliferation, yielding a sense of balkanization and caricaturization of specific communities (Donmoyer, 1996), and a lack of a core identity (Salomon, 1995). Yet, these interviews demonstrate that even though many of the frameworks and debates have inspired division, learning scientists are able to cohere while retaining individual identity in important ways. Our interviewees revealed a willingness to engage with the frameworks, reflect on their own views and beliefs, and also to *push back* against the frameworks as needed. Overall, we notice two major patterns emerging from our analysis.

First, we noted earlier that almost half of our interviewees could be loosely characterized as neat or scruffy researchers; however, this grouping may hide the more salient trend that that many of our interviewees actually took a *pragmatic* approach rather than a *paradigmatic* approach. For example, **I1** and **I2** could be classified as reductionist or holist, but both are philosophical pragmatists who are appreciative of researchers who take other approaches (*"I'm very much a reductionist but I seem to get along very well with holistic people"* (**I2**)). Thus, perhaps pragmatism is replacing paradigms in the learning sciences, even if not immediately obvious at first. This is clear in a number of the quotes we illustrated when discussing frameworks, such as reductionism vs. holism, methodology, and external reality. Many researchers consistently gave pragmatic answers on several frameworks. This pragmatism consists of choosing theories and methodologies based on the research question/problem rather than a singular paradigm that consistently manifests across all frameworks. The pragmatism observed in our interviewees perhaps demonstrates a rebellion against traditional epistemological positions (although not typically couched in philosophical formalism). Yet, we note that other practical and philosophical possibilities exist. For instance, multivocal analysis brings together researchers from diverse epistemological traditions to study a single phenomenon (Suthers, Lund, Rosé, & Teplovs, 2013). The frequent recognition of the validity of multiple approaches and viewpoints in our interviews may open the door for some variation of this approach. Overall, these findings seem to recast philosophy's role in our evolving field.

Second, our findings indicate that these frameworks are not as useful for characterizing differences among learning scientists as prior discussions may suggest. For some frameworks, most researchers locate similarly (e.g., in a single quadrant or squarely in the middle of a spectrum). In many cases, researchers reject a framework entirely. Indeed, many researchers argued that some of these frameworks pose a false dichotomy (e.g., *"I'm not a huge fan of dichotomies"* (**I4**)). While we agree, it was precisely by presenting these "false dichotomies" that we were able to elicit such rich beliefs about learning and science in these interviews. As such, we see these dichotomies not as a way to characterize learning scientists in and of themselves, but rather as a starting point to reflect on the diversity of beliefs and approaches in the learning sciences. Dichotomies allow for

dialectical syntheses that can advance the field, as long as we recognize and discuss their limitations. Such syntheses and discussions may in turn help suggest *new frameworks* that can better situate and stimulate the learning sciences today, especially for new researchers entering into a field that continues to evolve.

Endnotes

(1) These co-first authors contributed equally.
(2) Doroudi performed some of the research while at Carnegie Mellon University and Stanford University
(3) For a visualization of interviewees' response profiles and our own response profiles, see: https://tinyurl.com/ICLS2020
(4) Research in the bottom left quadrant is research that focuses on particular phenomena that does not lead to generalizable insights or useful applications, such as describing different species of birds (Stokes, 1997). However, in the visual probe we used, which was a version of Pasteur's quadrant created by Turadg Aleahmad, this quadrant was labeled with "Tinkering," which some interviewees identified with as being part of the research process they partake in.

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