Chapter 7
Creating Knowledge

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Introduction

The five chapters that comprise this section are quite diverse. The first three are fundamentally think pieces, exploring different models and theories related to the volume's unifying concept, knowledge creation in education. The latter two have a more methodological bent, but orient to methodology in somewhat different ways. The Tsai, Chai, and Hoe chapter (Chap. 5) focuses on designing tools to support knowledge creation in classrooms. Its orientation, therefore, is to advancing *pedagogical* method. The final chapter, by Chiu and Fujita (Chap. 6), demonstrates one way to study knowledge creation in instruction. Its orientation, then, is to *research* method. In this commentary, I will delve into the phenomenon of knowledge itself, focusing on the kinds of things (e.g., acquiring, creating, using) that we can do with it. I end with some thoughts about where research on knowledge creation might go in the future.

Addressed in various ways in all five of the chapters in this section is the topic of knowledge building (KB). KB, of course, refers to the educational philosophy developed and espoused over the past two-dozen years by Carl Bereiter and Marlene Scardamalia. It has its roots in child reading research and includes recommendations for technology design that have strongly shaped subsequent research and design in computer-supported collaborative learning (CSCL). In its earliest incarnations, KB entailed a special kind of interaction in which learners take control of their learning (Scardamalia and Bereiter 1991). They observed that this kind of interaction is descriptive of adult learners, but is rare in schools. They argued that schools ought to be restructured to foster more "knowledge-building discourse," that is, discourse in which "ideas are conceived, responded to, reframed and set in historical context" (Scardamalia and Bereiter 1994, p. 266). Over the intervening

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years, they have reiterated and systematically refined this position (Bereiter and Scardamalia 1993, 2003; Scardamalia and Bereiter 1991, 1994; Bereiter 2002, 2014).

Related in some ways to KB is Engeström's (1999) notion of learning by expansion. Two of the chapters, those by Tan and Tan (Chap. 2) and Paavola and Hakkarainen (Chap. 4), seek to develop these connections. Learning by expansion has its roots in Marxist socioeconomic theory. It involves transforming activity systems as a means of resolving recognized contradictions within them. Like KB, learning by expansion aspires to a model of learning that goes beyond mere reproduction of established knowledge. Just as a distinguished form of discourse is foundational to KB, Engeström also envisioned a form of dialogue at the heart of learning by expansion. He wrote:

> An activity system is by definition a multivoiced formation. An expansive cycle is a reorchestration of those voices, of the different viewpoints and approaches of the various participants. (Engeström 1999, p. 35)

Exploring how this "reorchestration" of voices occurs might be a good way of better understanding how knowledge creation is done. The idea of expansive learning cycles has mostly been applied in organizational contexts. Paavola and Hakkarainen present their "trialogical approach" as an attempt to apply this idea to instructional reform.

Bereiter (2002) makes the argument that education needs to be restructured to be more attuned to the needs of the "knowledge age." This resonates with Nonaka and Takeuchi's (1995) conception of the "knowledge-creating company." Here, the proposal is advanced that forward-looking organizations should recognize the importance of knowledge creation to their successful operation. An implication of these two suggestions is that schools must do more than impart factual knowledge; they must also foster the development of knowledge-creation skills. The problem, however, is that before we can undertake wide-scale reform of the educational system, we need to have a better grasp of just what these knowledge-creating practices might be. As it stands, knowledge creation (KC) is more of a prescriptive notion than an empirically developed principle. Nonetheless, it is an idea very much in the air these days and, so, in this volume it becomes the supervening concept, encompassing both KB and learning by expansion.

One workplace in which knowledge creation would presumably be de rigueur is the scientific laboratory. Scardamalia and Bereiter (1994) cited research communities, particularly their practices for evaluating and disseminating findings, as a primary source of inspiration for their notion of KB. As Tan and Tan suggest in their chapter, scientists are members of a community for which the creation of knowledge is the cardinal objective. For scientists, knowledge creation would seem to be closely tied to discovery, discovery being pretty much what makes science science. Indeed, scientific discovery would seem to represent the epitome of knowledge creation. But what do we actually know about the "knowledge-building discourses" through which discoveries are made?

Discovery: An Interactional Account

Though the scientific literature is replete with retrospective accounts of discovery, we have little firsthand knowledge of the attested interaction that leads up to and eventually results in a discovery. One exception was a discovery in astronomy made, quite by chance, while a tape recorder was running. Because of the availability of this recording, the detection of the first optical pulsar has drawn considerable interest from social scientists studying the practices of scientific discovery (e.g., Garfinkel, Lynch and Livingston 1981).

The discovery occurred at the Steward Observatory on Kitt Peak in the Arizona desert on the night of January 16, 1969. Present on the telescope platform that night were John Cocke and Michael Disney, astrophysicists, and Robert McCallister, the "night assistant." Over the course of the night, they did a series of "runs," that is, they collected a series of samples of emitted light from different sectors of the sky. These samples were displayed on an oscilloscope screen (Cocke et al. 1969). Garfinkel et al. (1981) report that "the pulsar was in hand between the 21st and 23rd runs" (p. 136). During Run #18, however, the following exchange takes place:

(Excerpt 2 from Koschmann and Zemel 2009)[1]

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13  Disney:   We've got a bleeding ↑pulse here.
14            (2.0)
15  Cocke:    ↑He::y.
16            (4.5)
17  Cocke:    Wo::w!
18            (1.2)
19  Cocke: →  You don't suppose that's really it do you?
20            (1.8)
21  Cocke:    It ca:n't be.
22  Disney:   (Sure) it's right bang in the middle of the
23            period. (Look), I mean right bang in the middle
24            of the sca::le. It really looks something to me
25            at the moment.
26            (0.8)
27  Cocke:    Hmmm.
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Within this excerpt, we can see that a certain kind of noticing has already taken place. Cocke's "You don't suppose that's really it do you?" (l. 19) is the earliest moment at which the possibility of a pending discovery is first entertained.

The question that needs to be considered here is how do you talk about something before you know what it is that you are talking about? The answer is that you talk about it in "evidently-vague" (Garfinkel et al. 1981, p. 135) ways. I draw your attention to the use of *it* in line 19. Cocke's use of the indefinite pronoun has a retrospective/prospective character—its sense drawing on a shared understanding of what they are doing together (i.e., looking for pulsars) yet pulling back from

[1] The transcription conventions are described in Appendix A of Koschmann and Zemel (2009).

indexing it as a named thing. The status of the "bleeding pulse," then, is provisional pending further evaluation. What we see here is knowledge in the very process of being born.

By Run #22, Disney proposes, "We'll have to figure out what this means now." This proposal reflects a shift in their orientation to the thing at hand, previously an "object of sorts" with "neither demonstrable sense nor reference" (Garfinkel et al. 1981, p. 135), to something that now holds consequences for subsequent action. This subtle shift in how the principals discuss the object in question illuminates a discovery in progress. Indeed, we might say that it *is* the discovery or, at the very least, the "discovering work" (Koschmann and Zemel 2011). It is a work of "reorchestrating the participants' viewpoints," to recall Engeström's felicitous phrase, of recalibrating the local referential resources. These referential resources (and the practices that incorporate them) are built up in the moment, they are "radically local" (Engeström 1999, p. 36). They also provide us a means of studying discovery, not as an epiphenomenon or occult event, but rather as a form of observable action.

But how does this apply to discovery in the classroom?

"Cold" Discovery

Atkinson and Delamont (1977) made a distinction between "hot discovery," the outcome of inquiry into questions for which no answer is currently available, and "cold discovery," the result of inquiry into settled matters reenacted for pedagogical purposes. Can we study "cold" discovery by analyzing the participants' "referential practices" in the same way that we did in the case of the "hot" discovery described earlier? Like the optical pulsar episode, we happen to have a recorded example of a discovery being made under pedagogically arranged circumstances.

Roschelle (1992) reports a study in which two high school students, "Dana" and "Carol," worked together at a computer running simulations in Newtonian mechanics. He videotaped them as they worked, as well as in periodic interviews in which they were asked to explain what they were doing. The software they were using was designed to simulate aspects of displacement, velocity, and acceleration, but in a graphic representation consisting of balls, dotted trails, and arrows (Koschmann and Zemel 2009). By directly manipulating these elements and conducting various experiments, the students came to notice some regularities in the behavior of the objects on the screen. To call their work a rediscovery is a bit of a misnomer—it is a new discovery for them and it is a "radically local" one. Our task as analysts is to discover within Roschelle's collected materials just what their discovery might be.

Over the course of several experiments conducted with the simulator, both students make observations. Carol says at one point, "OU:H, you know what I think it is? It's like the li::ne, (0.3) that arrow it's the li::ne, of where it pu:lls that down like see how that makes this dotted line, that was the black arrow (.) it pu::lls it." She uses several 'evidently-vague' *its* here, the first apparently referencing the

thing they are seeking—an explanation for the behavior of the objects on the screen. (Note the similarity to Cocke's use of "it" discussed earlier.) A bit later, Dana reports an epiphany of her own, "OH: I got it!" and, then, "When you add on this arrow (.) it's the length of the total (.) that it it assumes." Both had articulated partial understandings of what they had seen, but it was not clear that they were attending to the same features of the display. When doing a later experiment, however, they were able to integrate their proposals and make a prediction that proved to be correct and the following exchange occurs:

(Clip #8 from Koschmann and Zemel 2009)

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95  Carol: Ri⌈ght it does.
96  Dana:    ⌊That's per⌈fect!
97  Carol:              ⌊It travels right along that edg:e.
98         (0.5) So we want it to travel along that edg:e
99         until (0.4) there. (0.6) Cuzz that will make it
100        come (.) down straight.  See it will travel along
101        that edge =
102 Dana:  = yeah =
103 Carol: = Until it's straight there =
104 Dana:  = So, but what we didn't realize before.
105 Carol: Might have to make it a little shorter though.
106 Dana:  Can't believe we didn't like think of this at
107        all yesterday.
105 Carol: I know. Makes me feel quite stupid.
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Dana's "Can't believe we didn't think of this at all yesterday" references a newly developed understanding and related set of practices for manipulating the objects on the screen. So what one sees here, and this is a much abbreviated account of their unfolding deliberations, is a gradual progression from evidently vague reference to something that indexes their newly acquired understanding as a thing in hand. By analyzing how they recalibrate their referential practices, we can unpack the processes by which their discovery occurred.

This is all well and good provided we have a recording (preferably video) and a transcript, but what if we lack such resources? Indeed, what if there is no face-to-face interaction to record at all, as is common in many modern learning environments? That is, what if the interaction is entirely computer mediated? Finally, what if the learning does not involve a classical scientific experiment?

I have one additional instance of a kind of knowledge creation that matches these characteristics. When interaction occurs through networked computers, there is no embodied conduct to analyze, but the interactants' referential practices can still be studied, though the pragmatics of the interaction may be somewhat different. Zemel and Koschmann (2013), for example, reported on two student teams doing mathematics problem solving within the Virtual Math Teams Project. Members of the teams were geographically distributed and their sole means of communicating was through a screen-based interface. The interface affords two ways of interacting: participants can communicate through a chat window or they can create objects on a

shared, electronic white board (Stahl 2009). A log is created of their interaction over time and, by running this log through a "player," it is possible to sequentially reconstruct the students' interaction from moment to moment.

One of the two teams, Team B, consisted of three students who had chosen the tags, Bwang8, Aznx, and Quicksilver. They had been assigned a sticks-and-squares combinatorics problem. It involved generating a progression of patterns in a series and, for each iteration, predicting how many sticks would be required and how many squares would be produced. Bwang8 started off the session by typing, "you can divide the thing into two parts." His proposal is a cryptic one. Moving to the whiteboard he then drew 9 vertical lines, followed by 9 horizontal (see Zemel and Koschmann 2013). Just as he was completing his figure, Quicksilver, who had just returned to the group, inquired, "What are the lines for?" and Aznx directed him to the problem statement. Bwang8 then returned to the chat exchange and typed, "so you can see we only need to figure one out to get the total stick." His closing statement, prefaced with "so you can see," was produced as if his presentation on the whiteboard self-evidently represented a completed solution.

Unlike a traditional mathematician at the board, Bwang8 is not able to talk/type while drawing, so he must undertake these activities in sequence. His original proposal creates a context for understanding his representations on the whiteboard and the specific way in which he constructs this representation reveals the logic of the solution he is presenting. His two sets of sticks can be seen as a decomposition of one of the stick patterns that had been supplied in the problem statement. What he is able to show, in effect, is that the problem can be broken in half and that if they can develop a formula for the number of sticks in each half, they will have solved that part of the problem. Despite initially posing some problems of intelligibility for his audience, the team was eventually able to build on Bwang8's solution. His demonstration was built up in stages, and just like the two discoveries mentioned earlier, it can be analyzed in terms of the referential resources utilized. It represents yet another example of how the creation of knowledge can be studied in practical terms and speaks to the generalizability of the method.

Creating Knowledge

Bereiter and Scardamalia posit in Chap. 3 that when "dialogue succeeds in advancing from one shared knowledge state to a more advanced knowledge state, knowledge has been created" (see Chap. 3). By substituting "recalibration of referential resources" for "advancing knowledge state," however, we are able to translate their criterion into observable conduct. The knowledge created becomes translated into new ways of referencing a world held in common. As mentioned earlier, this kind of knowledge is "radically local," that is, it is lodged within the situation at hand for the purposes of the situation at hand. Seen in this way, the situatedness of

knowledge is not something that needs to be overcome (pace Bereiter 1997), but rather an inescapable aspect of knowledge itself.

In choosing a title for this commentary, I opted to invert *knowledge* and *creation* to emphasize the active and processual nature of the phenomenon we are exploring. *Creating knowledge* still does not quite get it either, however. When knowledge becomes the direct object of the verb, we are misled by our grammar into thinking of it as a commodity, as something that has a reality separate from the situations in which it is made relevant and brought to bear on practical concerns. It would be good if we had a better way of talking about such things.[2] More to the point, however, is that we need to find a new way of *thinking* about knowledge that treats it not as a thing, but rather as a form of action or, even better, as a property of *all* action. We have methods by which we create knowledge and these methods are foundational to how we build a world in common. In the three examples presented here, I attempted to show how these methods could be studied by examining the referential resources actors utilize in accomplishing practical tasks.

In closing, I wish to thank the editors of this volume for their invitation to weigh in on the topics being considered here. As should be apparent from my remarks, these are matters that have been occupying my thoughts for some time now. It is my hope that the space opened up for discussion here will foster new inquiry into in the myriad ways in which knowledge and knowing are manifested in our everyday lives.

References

Atkinson, P., & Delamont, S. (1977). Mock-ups and cock-ups: The stage-management of guided discovery instruction. In P. Woods & M. Hammersley (Eds.), *School experience: Explorations in the sociology of education* (pp. 87–108). London: Croon Helm.

Bereiter, C. (1997). Situated cognition and how to overcome it. In D. Kirshner & J. A. Whitson (Eds.), *Situated cognition: Social, semiotic, and psychological perspectives* (pp. 281–300). Mahwah: Lawrence Erlbaum.

Bereiter, C. (2002). *Education and mind in the knowledge age*. Mahwah: Lawrence Erlbaum.

Bereiter, C. (2014). Principled practical knowledge: Not a bridge but a ladder. *Journal of the Learning Sciences, 23*, 4–17.

Bereiter, C., & Scardamalia, M. (1993). *Surpassing ourselves: An inquiry into the nature and implications of expertise*. Lasalle, IL: Open Court.

Bereiter, C., & Scardamalia, M. (2003). Learning to work creatively with knowledge. In E. De Corte, L. Verschaffel, N. J. Entwistle, & J. van Merriënboer (Eds.), *Powerful learning environments: Unraveling basic components and dimensions* (pp. 55–68). Oxford.: Elsevier.

Cocke, W. J., Disney, M. J., & Taylor, D. J. (1969). Discovery of optical signals from Pulsar NP 0532. *Nature, 221*, 525–527.

[2] Dewey and Bentley (1991/1949) proposed replacing the word *knowledge* with the duplex, "knowing and known." For some reason this never really caught on.

Dewey, J., & Bentley, A. (1991/1949). Knowing and known. In J. A. Boydston (Ed.), *John Dewey: The later works, 1949–1952* (Vol. 16, pp. 1–294). Carbondale: Southern Illinois University Press.

Engeström, Y. (1999). Activity theory and transformation. In Y. Engeström, R. Miettinen, & R.-L. Punamäki (Eds.), *Perspectives on activity theory* (pp. 19–38). New York: Cambridge University Press.

Garfinkel, H., Lynch, M., & Livingston, E. (1981). The work of discovering science construed with materials from the optically discovered pulsar. *Philosophy of Social Science, 11*, 131–158.

Koschmann, T., & Zemel, A. (2009). Optical pulsars and black arrows: Discoveries as occasioned productions. *Journal of the Learning Sciences, 18*, 200–246.

Koschmann, T., & Zemel, A. (2011). "So that's the ureter": The informal logic of discovering work. *Ethnographic Studies, 12*, 31–46.

Nonaka, I., & Takeuchi, H. (1995). *The knowledge-creating company: How Japanese companies create the dynamics of innovation*. New York: Oxford University Press.

Roschelle, J. (1992). Learning by collaboration: Convergent conceptual change. *Journal of the Learning Sciences, 2*, 235–276.

Scardamalia, M., & Bereiter, C. (1991). Higher levels of agency for children in knowledge building: A challenge for the design of new knowledge media. *Journal of the Learning Sciences, 1*, 37–68.

Scardamalia, M., & Bereiter, C. (1994). Computer support for knowledge-communities. *Journal of the Learning Sciences, 3*, 265–283.

Stahl, G. (2009). Interactional methods and social practices in VMT. In G. Stahl (Ed.), *Studying virtual math teams* (pp. 41–55). New York: Springer.

Zemel, A., & Koschmann, T. (2013). Recalibrating reference within a dual-space interaction environment. *Computer-Supported Collaborative Learning, 8*, 65–87.