REVISITING THE PARADIGMS OF INSTRUCTIONAL TECHNOLOGY

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Abstract

In this paper I revisit a previously-published analysis of paradigm shifts within research on instructional technology (IT). Following Kuhn, I will use the term 'paradigm' to denote an actual scientific achievement. Used in this way, a particular experiment or research study must meet two criteria to qualify as a paradigm: it must be novel, that is it must be demonstratively different from those that came before and it must be sufficiently open-ended to provide a basis for further work. In the original analysis, I identified four paradigms operating in IT research (i.e., CAI, ITS, Logo-as-Latin, CSCL). I re-evaluate the evidence for each of these putative paradigms and attempt to sharpen the original analysis. In so doing, I focus in particular on the CSCL paradigm and assess its status as an emerging paradigm. Conducting a Kuhnian analysis of IT research is useful for at least two reasons. First, it provides a means of rationalizing and lending order to the vast range of activities that fall into this broad area of research. Second, such an analysis provides an opportunity for reflection—reflection on where the field has been and where the field might be going.

Keywords

paradigm shifts, research methodology, theories of learning, *learning technologies*

Introduction

Roughly five years ago I was faced with the task of writing an introductory chapter for an edited collection on CSCL (Koschmann, 1996). In this introduction, which I entitled "Paradigm Shifts and Instructional Technology," I attempted to historically situate the emerging field of CSCL within the broader context of research on instructional technology. I approached this task using key concepts borrowed from the writings of T.S. Kuhn, particularly his seminal notion of a 'scientific paradigm.'

In this paper I will review that analysis, commenting critically on certain aspects that no longer ring quite true for me. I will then turn my attention to an assessment of CSCL specifically and evaluate its status as an emerging paradigm. Along the way, I will touch on each of the conference themes of reflection, convergence, collaboration, and innovation.

Kuhn's Notion of a Scientific Paradigm

The notion of a scientific paradigm is undoubtedly the most widely known and appropriated aspect of Kuhn's writings on the history and philosophy of science. The term 'scientific paradigm,' however, has been used in a variety of distinctly different senses.[1] It is sometimes used, for example, to refer to a research agenda that carries with it a shared set of beliefs about goals and methods. Others use it to refer to the community of researchers who pursue such an agenda.

Following Kuhn (1972), I will use the term to denote a "scientific achievement," one that a "particular scientific community acknowledges for a time as supplying the foundations for its further practice" (p. 10). Used in this way, a particular experiment or research study must meet two conditions to qualify as a paradigm: First, it must be novel, that is it must be demonstratively different from those that came before. Kuhn wrote the paradigm must be "sufficiently unprecedented to attract an enduing group of adherents away from competing modes of scientific activity" (p. 10). Second, Kuhn specified that a paradigm must be "sufficiently open-ended to leave all sorts of problems for the redefined group of practitioners to resolve" (p. 10). These criteria of novelty and open-endedness will be useful to us when we examine actual "scientific achievements".

Why would we want to do a Kuhnian analysis of research in instructional technology? I can think of at least two reasons. First, it provides a means of rationalizing and lending order to the vast range of activities that fall under the title "instructional technology research". In the past, authors have attempted to categorize work in this area on the basis of functionality of the designed artifacts (e.g., Crook, 1994; O'Shea & Self, 1983; Taylor, 1980) or by the nature of the underlying theories of learning and instruction (e.g., Derry & LaJoie, 1993; Duffy & Jonassen, 1992). Categorizing work on the basis of actual research practices, as one does in a Kuhnian analysis, allows us to see connections that would not necessarily be seen if we studied the field in the more traditional ways. A second motivation for undertaking such an analysis, is that it provides an opportunity for reflection—reflection on where the field has been and where the field might be going. With that goal in mind let us now turn to the actual analysis published in 1996.

Reflection: Analyzing the Paradigms of IT

In the published chapter, I identified three existing paradigms in instructional technology (i.e., CAI, ITS, and Logo-as-Latin) still employed within instructional technology research and posited CSCL as a possible emergent paradigm. These are summarized in Table 1, which is reprinted from the original chapter. The table provides various attributes for each paradigm such as the event marking the emergence of the paradigm, its underlying theory of learning, its embedded model of instruction, the research issue or question to which the paradigm is addressed, and, finally, a list of references to paradigmatic studies. I will organize my comments around two particular issues. First, is the structure adopted in this analysis and reflected in the table the proper one for a Kuhnian analysis? And, second, is the content of the table, particularly the list of paradigms, accurate and complete?

With regard to the first question, I now suspect some of the attributes displayed for the named paradigms are at least confusing and, at worst, may be at odds with the strict form of Kuhnian analysis that I had in mind when I undertook the project. For example, the attribute 'theory of learning' is a bit confusing since, as we will see in a moment, a candidate study may have an *expressed* theory of learning which may be inconsistent with the theory of learning implicit to its method. The 'model of instruction' is similarly confusing since research representative of the type labeled here as "CAI" can be applied to the task of evaluating virtually any sort of method of instruction, so the method of instruction need not be an attribute of the paradigm. In sum, these matters might be germane to a paradigmatic analysis if we were treating a paradigm as a shared research agenda or a community of researchers. If we take a paradigm to be an actual "scientific achievement," however, they may be less relevant.

We might also raise questions about the choices of paradigms represented here. Are they formulated accurately and is the list complete? In the description for the CAI paradigm provided in the chapter, the impression is created that the paradigm was invented concurrent with the introduction of computers into classrooms. I now think that this is erroneous. CAI paradigm might be better understood as an the appropriation of a much older paradigm that serves as a foundation of practice in educational psychology and whose roots stretch back at least to the days of E.L. Thorndike and possibly earlier.[2] It is, therefore, simply an extension of a more general framework of study designed to evaluate any form of instructional innovation. It is this established tradition of

use that partially accounts for the dominance of this paradigm in IT research. It is not difficult to find examples of CAI research (it is finding examples of IT research that is not based on a CAI paradigm that is sometimes difficult!).

	Event marking emergence of paradigm	Theory of Learning	Model of Instruction	Research Issue	Paradigmatic Studies
CAI	Introduction of Coursewriter 1 (1960)	behaviorist	programmed instruction/ instructional design	instructional efficacy	Coulsen et al. 1962; Gilman, 1967; Merrill et al., 1980; More & Ralph, 1992; Riding & Chambers, 1992
ITS	Carbonell's dissertation (1970)	Information Processing Theory	one-on-one tutorial, interactive	Instructional competence	VanLehn 1982; Clancey, 1983; Woolf & McDonald, 1984; Koedinger & Anderson, 1990
Logo-as-Latin	Publication of *Mindstorms* (1980)	cognitive constructivist	discovery-based learning	instructional transfer	Clements & Gullo, 1984; Lehrer & Littlefield, 1993; DeCorte et al., 1992; Verzoni & Swan, 1995
CSCL	NATO Workshop (1989)	socicocultural theories of learning	collaborative learning	instruction as enacted practice	Roschelle chapter; Glenn et al., 1995; Roth (in press)

Table 1: Some paradigms of research in instructional technology (reprinted from Koschmann (1996) with permission from Lawrence Erlbaum Associates)

The CAI paradigm has an implicit theory of learning that derives from the psychological tradition from which it arose. A study, therefore, might espouse a particular theory of learning (e.g., Vygotskian, situated, distributed cognition) and employ it in designing an instructional intervention. If it uses Thorndikean outcome measures to evaluate the intervention, however, it displays an allegiance to an entirely different theory of learning. There may be a conflict, as a result, between the *espoused* and the *applied* theory of learning.

I believe the ITS paradigm was accurately described in the original chapter. ITS research is concerned with machine emulation of skilled instruction. It involves the development of algorithms to represent pedagogical and domain knowledge and student understanding. The examples of ITS research cited clearly employ a methodological framework that is different from the CAI paradigm and that derives from work in Artificial Intelligence (AI).[3] The problems identified in these early papers (e.g., student modeling, instructional discourse management) are difficult ones that are still being investigated by AI researchers. ITS research, therefore, would seem to satisfy both of Kuhn's criteria for a paradigm shift.

I am less confident with regard to the Logo-as-Latin paradigm. Though Papert (1987) did argue for an alternative form of research in IT,[4] the research examples cited are not necessarily examples of the type of research that Papert was proposing. They are studies that focus on the question of whether or not learning to program in Logo and other languages leads to benefits in other domains (e.g., logical reasoning). Such forms of research, like the CAI paradigm, arise from an old tradition in educational psychology. It is so closely related to CAI research, in fact, that it might better be treated as a variant on the CAI paradigm rather than a distinctive paradigm in its own right.

When I completed the chapter, I indicated that I was not sure whether or not the list of paradigms was complete and I continue to have reservations in that regard. One possibility for a new inclusion, for example, would be the frequently cited methodology of "design experiments" (Brown, 1992). Whether or not research based on this notion satisfies Kuhn's criteria of novelty and open-endedness, however, is not a question I am prepared to answer at the moment. The fourth paradigm listed in the table, the CSCL paradigm, was really a proto-paradigm at the time that the chapter was written and we will take up its current status in the next section.

Convergence: Antecedents of a Paradigm Shift

In the early and mid-1980s, there were a number of developments that set the stage for the emergence of the field of study we now know as CSCL.[5] All of these developments were oriented toward examining the affordances of technology in collaborative settings and all focused, at least initially, on instruction at the post-secondary level.

Some early preliminary work was devoted to the development of technologies to support learning at a distance. Notable among these efforts was the development of the so-called "Virtual Classroom" (Hiltz, 1988) by Roxanne Hiltz and Murray Turoff at the New Jersey Institute of Technology (NJIT) and the development of the CoSy program (Kaye, 1995) at the Open University in the U.K. These projects were, of course, precursors to what we now know as the "virtual university". Another early influence was the proliferation of computer-based programs to support teaching in composition, what Gruber, Bruce, and Peyton (1995) referred to as the "CSCWriting programs". These programs reflected a view of learning as joining an established community or discourse (Bruffee, 1993). One of the early workers in this area was Trent Batson in the ENFI project (Bruce, Peyton & Batson, 1993) at Gallaudet University. Focusing on student epistemologies and the development of skills for knowledge sharing, the CSILE program (Bereiter, 1997; Scardamalia & Bereiter, 1996) developed at the Ontario Institute for Studies in Education (OISE) at the University of Toronto by Carl Bereiter, Marlene Scardamalia, and their colleagues, became one of the most widely used and studied CSCL applications. Its influence stemmed in part from the fact that it was designed upon a very well-articulated theory of instruction (Bereiter, 2002). A fourth early influence was the 5th Dimension Project (Blanton & Cole, 1997; Kaptelinin & Cole, in press) developed by Mike Cole and other researchers at the Laboratory for Comparative Human Cognition (LCHC) at the University of California in San Diego. The 5th Dimension is an international multi-site network of after-school teaching programs initially developed as clinical training sites for pre-service teachers. The 5th Dimension Project was less technologically-oriented than the other early projects, but it made considerable contributions toward the development of a theoretical framework for studying learning from a sociocultural perspective (Newman, Griffin & Cole, 1989).

These influences began to converge in a series of meetings that took place around 1990.[6] A NATO-sponsored workshop on computer-supported collaborative learning was held in Maratea, Italy in 1989. A workshop with a similar theme was held at Southern Illinois University in the U.S. in 1991 (Koschmann, 1992) with sponsorship by Xerox PARC.[7] The first full-fledged CSCL conference was organized at Indiana University in the fall of 1995. Subsequent international meetings have taken place on a biennial basis, with conferences at the University of Toronto in 1997, Stanford University in 1999, and the University of Colorado in 2002. The first European conference on CSCL was held at the University of Maastricht in the Netherlands in 2001. In the period since the Maratea workshop, a number of edited collections specifically focusing on CSCL research have been published (Bonk & King, 1998; Dillenbourg, 1999; Koschmann, 1996; Koschmann, Hall & Miyake, 2002; Littleton & Light, 1999; O'Malley, 1995).

In the introductory chapter, I wrote "[CSCL] is built upon the research traditions of those disciplines—anthropology, sociology, linguistics, communication science—that are devoted to understanding language, culture, and other aspects of the social setting" (p. 11). As a result, it relies upon what I termed "socially oriented theories of learning" (p. 16) and I provided three examples, namely social constructivism, cultural-historical Activity Theory (CHAT), and situated learning (also known as social practice theory). This was not meant to be an exhaustive list, however, and I might now include neo-Piagetian conflict theory (Doise & Mugny, 1984), Bandura's theory of observational learning (Bandura, 1986), Bakhtinian dialogic theory (Koschmann, 1999b; Wertsch, 1998), and Distributed Cognition (Hutchins, 1994). As discussed earlier, however, the espousal of a new learning theory does not necessarily constitute a paradigm shift. To determine whether or not a shift in paradigm has occurred, one must examine actual instances of research.

Collaboration: Examining a Paradigm Case

One approach to studying paradigms would be to identify distinctive forms of research and then trace back through the research literature to find the original "paradigm" upon which the research was based. A diachronic analysis of this sort, however, is often difficult to do in practice. As we have seen with regard to the CAI paradigm and the ITS paradigm, the paradigm is not a new invention but is based instead on methods and tools appropriated from other contexts. What one tends to find then are chains of borrowed practices rather than the abrupt introduction of novel paradigms. It is still possible, however, to conduct paradigmatic analyses synchronically. By this approach, a search is made for examples of scientific achievement that can satisfy the Kuhnian criteria of novelty and open-endedness. If examples of such paradigm cases can be found, they serve as evidence of the existence of a new paradigm even though the actual paradigm cannot be identified.

The chapter written by Jeremy Roschelle (1996) and cited in Table 1, can serve as an example of a paradigm case for the latter type of analysis. In this chapter, Roschelle postulates that conceptual convergence "is achieved incrementally, interactively, and socially through collaborative participation in joint activity" (p. 211). He suggests, however, that this poses a puzzle. When one examines the interaction of learners engaged in such activities it is often unclear what is being accomplished through their discourse. Roschelle asks how is convergent change possible using "only figurative, ambiguous, and imprecise language and physical interactions" (p. 212)? He proceeds to demonstrate that this is not only possible, but does occur. He describes a longitudinal case study of two high school students (Carol and Dana) and their use of a graphical program that simulates the acceleration and velocity of Newtonian particles.

Roschelle conducted an analysis of interaction between the students over two one-hour sessions using the program. He reports in great detail on five particular exchanges within this period. For each exchange, he describes the "conversational action" capturing not only the lexical components, but also timing and prosodic features. For some of the episodes, he also describes gestural exchanges and the available representations produced by the simulation program. For each of the episodes he attempts to summarize the "conceptual change" evidenced in the exchange and the displayed "shared knowledge".

Instead of attending to *what* was learned using some sort of performance measurement, Roschelle's study focuses on *how* learners achieve new conceptual understandings in the presence of computational artifacts. Research of this type that attempts to document "thinking practices" (Goldman & Greeno, 1998) is decisively different from that that employs the CAI paradigm. Though some of Roschelle's terminology (e.g., shared knowledge, conceptual change) arises from cognitive science, his methods and research questions are distinctively different from those pursued in research employing the ITS paradigm. As a result, his project satisfies Kuhn's criterion of novelty. Also, I think there can be no doubt that Roschelle's study left behind an adequate supply of "problems for the redefined group of practitioners [i.e., CSCL researchers] to resolve" (Kuhn, 1972, p. 10). In the next section, I will take up some of these problems.

Innovation: The Need for Better Theories and Methods

Traditional theories of learning treat learning as a concealed and inferred process, something that "takes place inside the learner and only inside the learner" (Simon, 2001, p. 210). CSCL research has the advantage of studying learning in settings in which learning is observably and accountably embedded in collaborative activity. Our concern, therefore, is with the unfolding process of meaning-making within these settings, not so-called "learning outcomes". It is in this way that CSCL research represents a distinctive paradigm within IT. By this standard, a study that attempted to explicate how learners jointly accomplished some form of new learning would be a case of CSCL research, even if they were working in a setting that did not involve technological augmentation. On the other hand, a study that measured the effects of introducing some sort of CSCL application on learning (defined in traditional ways) would not.

In the two decades that have passed since the initial efforts to introduce technological artifacts into settings of learning and collaboration, however, we have yet to develop a consensus within the CSCL community with regard to what it means to learn and how to study the process. Many methodological questions also remain. What constitutes adequate documentation of learning? When describing practices of thinking and learning how much of the context must be included in order to make the practices meaningful? How is an analyst's account shaped by prior experience and how can this be reflexively displayed within an analysis? What are the limits of what can be viewed and described "in the moment"? How does one aggregate findings from purely descriptive studies? Answers to questions such as these must be found before research applying the CSCL paradigm will enter into a phase of "normal science".

I have found this exercise of revisiting my prior paradigmatic analysis of research in instructional technology to be a useful one. As a first attempt at doing such an analysis, the original chapter raised some interesting questions and stimulated much thinking about the actual practices of educational research. In looking at this analysis with fresh eyes, I can see many ways in which it could have been improved, but my commitment to the original project is undeterred. The original task is far from complete, even to the degree that such a task can ever be completed in such a large and ever-expanding body of work. Further examinations of research practice are needed as is an illumination of the theories that guide our work.

Endnotes

1. Kuhn was as guilty in this regard as anyone. Masterman (1970) listed 21 distinctive ways in which the term was used in *The Structure of Scientific Revolutions* and suggested that her listing was not exhaustive.
2. See Koschmann (2000) and Koschmann (2001) on the theoretical foundations of research methods in education.
3. This does not preclude testing ITS systems using the CAI paradigm and many examples of such research can be found.
4. He argued strenuously against what he termed the "treatment method of research" (p. 26) which is roughly the same as what is being described here as the CAI paradigm. The gist of his argument was that the effects of using computers in schools were multiple and that they could neither be studied in isolation nor be studied exhaustively.
5. The traditional expansion of CSCL is "Computer-Supported Collaborative Learning," but see Koschmann (1999a) for a discussion of other possible interpretations.
6. Well prior to this there had been a Workshop on Joint Problem Solving and Microcomputers (Cole, Miyake & Newman, 1983) at LCHC in 1983 that brought together researchers from the 5th Generation Project and educational researchers from Japan.
7. Attendees at the U.S. workshop came primarily from research centers in the U.S., but had connections to work going on elsewhere. Jeremy Roschelle and Denis Newman had both participated in the earlier European workshop and Newman had been one of the organizers for the 1983 workshop at LCHC.

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