Divisions of Labor in School and in the Workplace: Comparing Computer and Paper-Supported Activities Across Settings

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This study uses the concept of division of labor to investigate the comparative uses of media in 2 organizational settings (a middle school classroom and a professional architecture firm). In both settings, participants used both computer and paper-based media in architectural project work. This study found that, in both settings, collaborative labor was divided between designers who worked on paper and draftspersons who worked with computers. The analysis compares the origins of these divisions of labor and finds important similarities in the reasons for the divisions of labor and important differences in the implications of the divisions of labor for participants. The analysis links the similarities to the comparative affordances of different media for supporting collaboration and links the differences to how the 2 environments differently evaluated its participants as individuals and as members of a group.

Technology is never purely technological: it is also social. The social is never purely social: it is technological. This is something easy to say but difficult to work with. So much of our language and so many of our practices reflect a determined, culturally ingrained propensity to treat the two as if they were quite separate from one another. (Law & Bijker, 1992, pp. 305–306)

The aim of this study is to contribute to a better understanding of how computer use shapes and is shaped by the organization of work and learning in modern institu-
tional life. My approach is broadly comparative and grounded in two case studies from distinct institutional settings, one a classroom and the other a workplace. In both settings, people worked and learned, together and apart. It is the wax and wane of together and apart that this analysis addresses. In so doing, my analysis offers a few grounded concepts for thinking about the forms that collaboration takes, how media supports it, and how it takes on meanings for institutional participants in ways that vary with surrounding organizational conditions.

This study argues for the importance of developing relational concepts as a means to accelerate the progress of interdisciplinary research communities like those of the learning sciences and computer-supported collaborative learning (CSCL). Computer-supported collaborative learning is an emerging perspective that promises to go beyond good old fashioned instructional technology, beyond the interface, and beyond the isolated individual (Koschmann, 1996). The centerpiece of the relational approach that I sketch in this article is an extension of the division of labor concept as articulated by Strauss (1985, 1988). My extension explores a three-part relation: how people, tasks, and technologies are divided and coordinated in activity.

Although the division of labor concept will probably strike readers as natural for studying activity in workplaces, it may seem less so for classrooms. I argue here that this concept is equally relevant to understanding classroom life, especially in an era that involves consistent experimentation with new ways of organizing classrooms. Under the traditional social organization of classrooms, each individual student in a particular classroom is assigned the same work and is assessed as an individual; in this situation, there is no apparent division of labor to explore. In contrast, recent experiments in classroom social organization provide students with more discretion to organize their own activities, aside from whatever may be assigned. In addition, these new experiments typically involve having students work in groups. Under the assumption that these conditions—student discretion and group work—are now common in many classrooms, the division of labor concept should be just as important to understanding classrooms as it is to understanding workplaces.

As part of my exploration of the relations between people, tasks, and technologies, this study also addresses sociogenetic questions about how these three-part relations formed in each setting. Answering questions about why a particular technology is being used by someone for some task is one that I believe to be exceedingly complex in almost every case. As this analysis seeks to show, functional explanations are only part of the story. Other considerations include the possibilities that particular technologies are used out of habit, because of contingencies of local history, because they are at hand, or because the proximal authorities insist on them. Recent waves of techno-enthusiasm in education suggest that we take very seriously the question of whether students are using computers because they are “the right tool for the job” (Clarke & Fujimura, 1992) or because they have been given no other op-
tions. It is worth noting, in this regard, that it took a very long time for people to seriously question whether textbooks were the right tools for the job of supporting learning. At the other end of the spectrum from techno-enthusiasm, a deep skepticism about computers in classrooms swells (e.g., Cuban, 1986; Healy, 1998). The proposition that this analysis seeks to defend is between the poles: that empirically grounded research on technology in its situations of use can provide well-founded answers to when computers are the right tool for the job and when they are not.

As a study of naturally occurring activities, this comparison takes as its units of analysis teams of people doing design projects.1 In following these natural units across time and space in both settings, I realized early on that my study of computers would require an account of media besides computers and that to make sense of computers vis-à-vis other media, overarching patterns of collective and individual activity needed to be understood. What I also noticed early in my analyses and what spurred this analysis were two comparative facts evident across the settings: (a) Types of media use were asymmetrically distributed with respect to both tasks and people, and (b) the asymmetries were strikingly similar across the settings. Specifically, I found that both settings shared the emergent property that labor was divided between people who did design on paper and people who drafted on the computer (Figure 1). In the case studies that follow, I use these two empirical facts as an analytic starting point for thinking through issues of how specific media support specific collaborative activities or, in other words, what computers are right for and what they may be less right for. Of course, what they may be less right for is not necessarily a permanent condition for the design-abled learning sciences community. In my concluding remarks, I suggest some ways that this comparative analysis can inform further design work.

Turning to the cases, consider first the professional architecture firm, where I did ethnographic and videographic fieldwork for nearly a year. With regard to the distribution of media use, this firm resembled most contemporary firms; despite the promise and increasing ubiquity of computers in architectural firms, the phases of the overall design process that practitioners consider “real design” (architect’s phrase) still typically happen on paper. Designs on paper are then translated into digital form using CAD (computer-aided design) programs.2 During these early conceptual and schematic development design phases, designers work almost ex-

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1 This comparative case study comes from a larger sociocognitive comparison of the classroom and the workplace (Stevens, 1999a) that was part of a still larger comparative research project involving multiple classroom and workplace settings (see Hall, 1995, for a brief description). From the workplace setting, data collected includes approximately 100 hr of fieldnotes and video recordings as well as many documents produced by participants. A similar corpus was collected in the classroom, with fewer hours of videotape because the duration of the classroom project was shorter.

2 Beyond the firm where I did my fieldwork, I continued informal inquiries of other architects in the Bay Area region to confirm this attribution of typicality since I have not been able to find any statistical data addressing this issue.
FIGURE 1  Grid of still images summarizing the comparative findings reported in this study. Counterclockwise from the upper left: students drafting at the computer (upper left), architects drafting at the computer (lower left), students designing on paper (upper left), and architects designing on paper (lower right).

FIGURE 2  Detail of the package of tools and media used by architects during the design phase of an architectural project.
clusively by hand on paper, using a simple but flexible package (Figure 2) of base drawings, tracing paper, scale ruler, and corresponding embodied competencies (cf. Stevens and Hall, 1998; Stevens, 1999a).

This early phase of paper-based designing is high-status work; it is usually done by principal architects (i.e., owners of firms, analogous to partners in law firms) and by architects specially designated as designers. In larger firms, translating hand-inscribed designs into CAD form is usually the work of draftspersons, and the distinction between draftsperson and designer is a common one in the architectural community (Cuff, 1991; Robbins, 1994). In smaller firms, such as the one I studied, the lower status work of drafting paper documents into CAD and working out the necessary details was done by associate and beginning architects because the firm didn’t employ any designated draftspersons. (These more junior architects are typically younger and much earlier in their careers than principal architects and are paid a salary rather than participating as owners.) Regardless of the size of the firm, designing and computer drafting are currently regarded as two quite different kinds of activities in architectural practice.

If it is unsurprising that newer computer-based design tools have yet to encroach upon more traditional media in professional designing—because the current generation of principal architects and most associate architects learned exclusively paper and physical model-based design—I present a finding here that is somewhat surprising. In a middle school classroom where a student team was provided with a computer program for designing as well as with paper that was designated for “getting started,” a division of labor emerged within the team that mirrored the designers-using-paper/draftspersons-translating-paper-into-the-computer division found among professional architects. What makes this occurrence somewhat surprising is that the computer was the intended design tool in the classroom and that as newcomers to architectural design, the students arguably did not yet have any firm investment in paper-based tools. This analysis treats this emergent division of a labor as a puzzle to think through some of the issues of CSCL. My goal is to address this puzzle through a close analysis of how this division emerged and to argue that similarities to the division of labor in the professional setting were more than accidental.

My central argument is that (a) the similarity in the observed divisions of labor across settings can be tied to affordances of different media for collaborative design and that (b) these divisions of labor were productive in both settings from a perspective on the social and material team achievements in each setting, but that (c) the division of labor among the students was less productive and more complicated than for the professional team because of differences in the way that individual and collective contributions were understood and assessed.

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3 I include the qualifier arguably because research in a naturalistic and constructivist mode might show that children have an abundance of prior experience designing on paper in out-of-school practices.
The remainder of this article is organized as follows. I begin by offering some background on the division of labor concept. This is followed by the two case studies in which I describe the local history of media use, collaboration, and divisions of labor in each setting. After these cases, I analyze a key similarity (how forms of media supported collaboration) and a key difference (how the respective systems of assessment supported collaboration) across the settings. These analyses set the stage for a discussion of the educational implications of this work, including methodological implications for future learning-sciences research. I withhold my analysis of implications until the end of the article to clearly separate the ethnographic and prescriptive parts of the work. As educational researchers, we routinely face the daunting challenge of speaking both empirically and prescriptively, but to the extent possible, I believe that these ways of speaking should be separated. This gives readers the opportunity to understand the data and analysis first and then, with the author, to take a stance on what these phenomena mean for educational practice and research.

THEORETICAL BACKGROUND

All of the many ways in which the work of human beings is studied lead back at some point to the obvious, yet infinitely subtle, fact of the division of labor … The division of labor, in its turn, implies interaction; for it consists not in the sheer difference of one man’s [sic] kind of work from that of another, but in the fact that the different tasks and accomplishments are parts of a whole whose product all, in some degree, contribute to. (Hughes, 1971, p. 304)

The division of labor is, of course, one the most venerable concepts in the social sciences. Economists like Adam Smith and Karl Marx both recognized that divisions of labor make work processes more efficient but held very different views about the effects of these divisions on the well-being of society and the individual. Emile Durkheim addressed the topic in The Division of Labor in Society (published in France in 1893) asking questions about the origins and functions of the division of labor in modern society. For Durkheim, there were two basic types of solidarity to be found across societies. In some societies, solidarity is based on societally enforced similarities between persons, which Durkheim called organic solidarity. In other, more highly evolved societies, mechanical solidarity is achieved not by enforced similarities but by complementary differences between people within and across various social units (e.g., professions). Unambiguously, Durkheim asserted the moral superiority of societies based in mechanical solidarity. In making these dis-

\footnote{Durkheim’s moral affirmation of the division of labor, while unambiguous, was qualified by his assertion that there were many anomic forms it could take which were undesirable and did not foster solidarity. At the time of writing (1893), Durkheim recognized that these anomic forms were the prevalent forms of the division of labor but argued that these were pathological cases produced in a transitional period of social-structural change.}
tinctions, one of Durkheim’s central concerns was “the connection between the individual personality and social solidarity” (Durkheim, 1984: xxx), and he believed that, as societies evolved from organic to mechanical solidarity, increasingly complex and autonomous individual personalities would develop in parallel.

In this century, the issue of the division of labor between people and technology also has absorbed analysts, with some like Braverman (1974), following Marx in claiming that in capitalist economies, technology “deskills” workers, making them less autonomous (at least in terms of economic self-determination) and, in general, producing deleterious social effects. Contemporary analysts have seen the possibilities of technology, specifically information technologies, more ambivalently suggesting that computers can both “informate” or “automate,” depending on how they are used in a broader organizational context (Zuboff, 1984).

In recent years, Ed Hutchins (1995) and Bruno Latour (1994, 1996) have characterized modern work processes as complex networks of people and technologies acting together and apart (see also Goodwin & Goodwin, 1996; Suchman, 1994, 1995). These analyses have reopened questions about the distribution and redistribution of competencies between people and technologies with new concepts that blur the analytic (and often ontological) line between human and nonhuman actors in sociotechnical networks of activity. Unlike previous theorists, neither Hutchins nor Latour has as yet substantively engaged familiar moral issues about the redistribution of competencies between people and technologies in contemporary work. This research draws upon the analyses of Hutchins and Latour in describing how competencies are distributed between people and technologies but takes a more people-centric perspective by focusing on specific divisions of labor between people because of and around technologies (e.g., computers).

Anselm Strauss, working in the same sociological tradition as his predecessor Everett Hughes, framed his treatment of the division of labor with the observation that little research about this topic actually analyzed concrete cases of working, and in a pair of connected articles (Strauss, 1985, 1988) Strauss provided grounded theoretical concepts for this purpose. Taking a project as the unit of analysis, Strauss considered the entire collection of persons and tasks that compose a project. “The totality of tasks arrayed both sequentially and simultaneously along the course of [a] … project” was what Strauss called an arc of work (Strauss, 1985, p. 4). Along this arc, the rights and responsibilities of particular persons with respect to particular tasks vary from loosely to tightly coupled. The characters of specific divisions of labor were regarded by Strauss, as they were by Hughes, as originating in interactional processes of dividing tasks.

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5Strauss meant tasks in an ecologically valid sense that differs significantly from what has been meant by laboratory psychologists. In Strauss’ ethnographic work and here, tasks are discovered in people’s naturally occurring activity rather than made to happen, either in the laboratory or in the field. See Cole et al. (1997) for a brief discussion of different senses of ecologically valid tasks.
among people and fitting them together across an arc of work. Strauss called this form of ongoing activity articulation work.

For analyzing complex sociotechnical systems, one of the gaps in Strauss’ scheme is an absence of nonhuman mediators in the relation between persons and tasks. As surely as persons can be coupled to a task, so too can a person be coupled, by right or responsibility, to a specific mediator. Strauss’ scheme therefore needs to be expanded to a tripartite scheme (person, task, and mediator) in order to analyze divisions of labor in complex sociotechnical settings. By focusing on an analysis of naturally occurring events involving interaction between people and mediating artifacts, this expansion is consistent with many conceptions of activity theory (Cole & Engestrom, 1993) as well as those of Strauss’ intellectual successors (cf. Fujimura, 1987, 1992; Star, 1991; Star & Griesemer, 1989).

In the case study data presented below, I focus on early phases of arcs of work in the architecture firm and the middle school classroom. In each case, two types of tasks are described: designing and drafting. In both cases, particular persons were coupled to designing with hand-inscribed paper media, and other persons were coupled to drafting with computer-assisted design tools. The question I’ll address is how these couplings came to exist, and the answers I’ll provide are different for each setting. These differences reflect the very different sociohistorical trajectories of persons and practices in the classroom and the architecture firm; however, I’ll also argue that, despite these differences, the basic fact of a parallel division of labor is informative for thinking about how computers support collaboration and learning. In addition, I’ll argue that the implications of the similar division of labor are very different within the distinct organizational environments of a school and a workplace.

CASE 1: ARCHITECTURAL DESIGN AT JC

JC Architects is a midsized architectural firm in Berkeley, California. During the duration of my fieldwork, two principal architects, two associates, and an early-career architect worked at JC. At this firm, associates and principals both did “real design,” a practice that took place almost exclusively by hand on paper. Although the principal architects used computers frequently (e.g., for writing), they never used and were true novices with the CAD software; one of the principals joked with me that the extent of his capacity with CAD was zooming in and out. In fact, neither principal architect had experience with CAD, and each of them regarded this as a deficiency (that one called “scary”) that they wished to rectify. However, both also told me that the amount of other work they were responsible for prevented them from finding the time to learn the technology.

CAD work was done entirely by the three junior architects. Each spent a reasonable proportion of most days at CAD machines, with the youngest among them
spending almost all of his time working from red-lined\textsuperscript{6} paper documents and lists assembled by principals. Working from red-lines and lists, these juniors updated, revised, and completed drawing sets that were to be used by different groups throughout the design and building process. During early design phases, juniors were responsible for measuring building sites and making to-scale base plans that could then be used by principals, along with tracing paper, to propose and test design ideas through hand-inscription. Later, when the firm prepared to circulate CAD drawing sets to code reviewers or to contractors for building purposes, the juniors were responsible for producing complete drawings that were properly labeled and that followed the appropriate representational conventions for the audience (e.g., the public, the city, or a contractor) that would receive the drawings.

In the project I followed most closely, JC Architects collaborated with a team of consultants to complete a seismic and Americans with Disabilities Act upgrade on two historically preserved libraries in Oakland, California. In this project, many of the major design decisions were made at meetings in which principals and a diverse collection of consultants (e.g., structural and mechanical engineers, historical preservationists, and cost estimators) worked over the surface of work-relevant representations (e.g., plans, sections, elevations, photographs). These collaborative design meetings were temporally unfolding events in which the members of the design team used talk, gesture, and inscription in various coordinations (Goodwin & Goodwin, 1996; Hutchins, 1995; Stevens, 1999a; Stevens & Hall, 1998; cf. diSessa, 1991, for a related sense of coordination) to collaboratively make progress with their design problems. Although these resources are in some sense unremarkable, their importance for my argument is that so much of the collaboration seemed to hang on their coordinated use. It was the synchronous coarticulation of these resources, of saying and showing, by which participants made sense, made arguments, and made progress together. In turn, these practices are possible only in a media space that supports these sorts of interactions between people and media, properties lacking in any current version of a computer design environment.

In these meetings at JC, the associates were present but rarely contributed to the decision-making design conversations. Instead, they tracked closely the emerging, agreed-upon decisions made among the other participants and kept lists of tasks to be done or points raised. Following these meetings, the associates would frequently update CAD drawings. As more of the design decisions were made and the direction of the project stabilized, the associates moved into an intense phase of producing CAD drawing sets at 50\%, 95\%, and 100\% completion levels. The final

\textsuperscript{6}Red-lining is a graphic technique for proposing changes in drawings and communicating these to others. For example, a principal would take a current set of drawings, circle, add marginalia or redraw certain elements in red pencil and then return the drawings to a junior architect to make the required changes.
100% drawing sets are used by building contractors and are documents that the firm is legally responsible for in the building phase.

As the previous paragraphs indicate, doing CAD-related tasks is an essential part of a primary arc of work at JC and falls entirely to the junior architects. Furthermore, facility with CAD has become a precondition for earning an entry-level position in an architecture firm, as it was for the junior architects in this firm. Unfortunately for architects seeking a first job, many (if not most) university architecture programs have only recently begun to provide sufficient CAD instruction, which means that young architects have faced the challenge of either learning CAD themselves or finding other instruction. For example, one associate at JC took an intensive (and expensive) four-weekend course at a local state university to begin learning CAD and then continued to learn, through practical experience, at JC.

Young architects know that they need baseline facility with CAD to secure a position in a firm, and this precondition for employment means that the initial division of labor in architecture is substantively predetermined when junior architects are hired at firms like JC. Principal architects, because they are fully occupied with tasks they are uniquely accountable to (e.g., critical early design or client relations), hire junior architects to do CAD that they as principals have neither the time nor the training to do.7 This of course does not mean that divisions of labor cannot or do not change, especially in firms like JC that quite clearly had an organizational structure resembling what has been called legitimate peripheral participation (Lave & Wenger, 1991). Here, junior architects are progressively unleashed from their CAD machines as they move toward more principal-like activities and newcomers take on these tasks. However, despite this extended process of organizational change, the division of labor was relatively stable throughout my fieldwork at JC.

Summary: A Stable Division of Labor

As I remarked in the introduction, sociogenetic accounts of the three-part couplings of person, task, and technology are complex. Although the account that follows is tentative, I suggest that it is useful in laying out the heterogeneous, interacting elements that are involved in a sociogenetic story of technology use, and therefore, it represents an alternative to a purely functional account. First, the high status of early-design work and the learning histories of current principals seem like critical considerations. Because current principals learned to design on paper and have done so through their decades-long professional careers, these practices are relatively durable dispositions for

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7In more static firms, CAD labor—like essential technical work in other fields (cf. Traweek, 1988; Shapin, 1989)—remains the responsibility of some permanent, if interchangeable, draftsperson.
practical action. Another critical consideration is functional and relates to how paper practices support collaboration in ways that currently available computer-based systems do not. As I described above, designing involves important collaborative components in which multiple practitioners come together around a table where drawings are lain out. With these representations, participants continuously and fluidly draw, point, and gesture. Consider now how difficult these embodied collaborative practices would be with current versions of computer-based design tools that have relatively small vertical screens and where direct contributions are limited to the person who controls the single mouse or stylus. In other words, whatever benefits computers might have as design tools (see, for example, Mitchell & McCullough, 1995), current software and hardware cannot support one of the fundamental ways that architects currently collaborate with representational media.

As to why drafting, which was a paper-based practice not so long ago, has become predominantly a computer-based one, a number of considerations seem relevant. First, as described to me by a number of architects, engineers initiated the use of CAD, and architects adapted to this to be able to share drawings with them in a uniform medium. Second, drafting, unlike designing, has traditionally been regarded as a mechanical production skill rather than a creative or artistic one (Robbins, 1994). This difference suggests that architects do not vest their professional identities in drafting and therefore would not likely resist shifting drafting tasks into a computer environment. Design, being the defining professional activity for architects, remains vested in the tools most closely associated with craft and artistry: paper-based drawing.

This is not to say that there were not tensions about the tools most appropriate for design. This tension was vividly represented for me in an a heated discussion between one of the associate architects (age 28, 5 years out of school) and the newest member of the firm (age 23, 6 months out of school). Whereas the slightly older, more experienced architect argued at length that people “simply cannot do good design” on the computer (a position also conveyed to me by one of the principals), the younger architect argued that not only could people design this way but that he did.9 In the mere 5 years between the schooling of these two architects, computers had come to be thought of and used differently. As such, the tension between these alternative media for design in architecture demonstrates that pure

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8 See Bourdieu (1977) for the concept of habitus and my related concept of disciplined perception (Stevens, 1999a; Stevens & Hall, 1998).

9 The rate of technological change in architecture, as in many professions, is producing many strata of generational dividing lines, with parallel debates about the appropriate forms of practice. The youngest architect told me a story about an event in architecture school that was informative about this issue. During his last year in school, a fellow student prepared a presentation for a studio course entirely in digital media, and the student’s reviewers (i.e., professors and practitioners) were unwilling to even evaluate the work because of the media of presentation. For remarks about similar generational tensions around technology in civil engineering, see Hall and Stevens (1995).
functionality is a limited explanatory resource; the tension makes clear that at issue also is how generations of practitioners identify their craft and how communities displace old-timers with newcomers (Lave and Wenger, 1991).

CASE 2: ARCHITECTURAL DESIGN AT PINE MIDDLE SCHOOL

The second case I consider involves a team of four students in a seventh-grade mathematics class at a middle school in Alameda, California. In this class, the teacher, Ms. Leoni, oversaw eight teams of students doing architectural design projects using MMAP (Middle School Math Through Applications) curricular material (MMAP, 1995) under the sponsorship of the University of California, Berkeley, Math@Work project.\(^\text{10}\) The main pedagogical premise underlying the development and enactment of the MMAP curriculum, like other prominent educational experiments (cf. Van Haneghan et al., 1992, and Petraglia, 1998, for a review of related projects), was the establishment of activity structures within which students could learn to use mathematical ideas and tools purposefully and collaboratively.

From the outset, this case presents two analytic challenges distinct from the workplace case. One challenge involves the relative instability of the division of labor in the classroom as compared with that in the architecture firm. As I described in the architectural case, the division of labor in the firm was quite stable over the duration of a year’s fieldwork. In the classroom, the individuals who formed the team had no prior experience working together and thus, changes in their division of labor were frequent initially, though divisions nonetheless stabilized. A second challenge involves the fact that the division of labor that emerged among the students competed and coexisted with a different division of labor assigned by the teacher (cf. R. Stevens, in press). The assigned division of labor used in the classroom was developed by Cohen (1994), and it involved having students take on rotating “complex instruction” roles of facilitator, recorder, reporter, and materials manager. Both of these challenges suggest that the classroom case necessitates a more time-compressed, sequential narrative that permits me to focus on how divisions of labor formed initially, how they interacted with the assigned roles, and how they ultimately stabilized.

\(^{10}\)As a participant in this research project, I collected data and, in collaboration with colleague Tony Torralba, helped the teacher Ms. Leoni prepare for and reflect on daily classroom happenings. Rogers Hall and Susan John performed similar activities at a different middle school with a different teacher. The entire Math@Work team (2 teachers and 4 researchers) also met regularly at University of California, Berkeley, to adapt and supplement the MMAP curricula, a facet of which included using the materials I collected at JC Architects to inform our collaborative redesign efforts.
In the 8- to 10-week curriculum units, collaborative teams of students were asked to play the part of architects designing hypothetical research stations for scientists “wintering over” in Antarctica. Teams of three or four students worked together from initial conception to final presentation. Compared with activities in more traditional classrooms, tasks and media varied greatly, including paper and computer-based design, analysis of mathematical properties of models, explanatory writing, reflective writing, semitraditional worksheets, and poster design. In addition, managing tasks across the arc of project work was challenging for the team because they faced two distinct types of tasks: those that emerged within their team out of their project activity and those that were assigned by the teacher from the curriculum package, usually to focus on a specific mathematical concept. In general, tensions between assigned and emergent modes, both with respect to specific tasks and the divisions of team labor, were ubiquitous (Stevens, 1999a).

The intended sequence of project activity entailed the following: (a) doing research about the conditions in Antarctica and the needs of research station inhabitants, (b) designing an initial structure that satisfied these conditions and needs, (c) analyzing the structure mathematically using specially designed software, (d) revising designs in light of mathematical analysis and other considerations, and (e) presenting work in a final form. The primary intended tool for designing these research stations and for doing subsequent mathematical analysis on costs, efficient uses of space, and insulation was a CAD-like program called ArchiTech©. In this Macintosh-based program, students rendered research stations in plan view (i.e., from above) using a tool palette and a mouse. In a separate mode, they used the software to do automatic computations (such as building cost, area, and perimeter) and set parameters of the model (such as insulation and temperature). The automatic computations, and the use of the model more generally, served as foundations for many of the mathematical analyses carried out by the teams.

The first question to address in this case involves the origins of the division of labor among the student team that mirrored the division of labor found in the architecture firm. Understanding the local origins of the division of computer and paper in the architecture firm was relatively unproblematic because newcomers were hired to do computer-aided drafting and old-timers did not have this competency. In the classroom case, the members of the team were all newcomers to both the project and to architectural design and, as such, the question of origins is open. This does not imply that individual differences in relevant competencies may not have predated this project and contributed to the emergent division of labor but rather that these differences needed to be discovered, negotiated, and enacted by the team members. What then set in motion these interactional processes such that within a week of class periods, two students had become the designers, drawing and debating plans for the research station on paper, and the other two students had become the draftspersons, translating the designers’ hand-drawn and verbalized ideas into the computer?
The origin of the division of labor can be located initially in a particular class period in which the teacher assigned specific students to specific tasks. The class period in question took place a little more than a week after the class officially began the project. During this class period, the teams were divided up into pairs to work on parallel tasks for the first time.11 Ms. Leoni announced that two team members would begin to design (on paper) and that two members would move to the computer to prepare a formatted list of features that the team had decided would be part of the station’s design.

The way that the teacher initially assigned particular students to designing and others to the text-formatting task involved an unintended though clever use of the complex instruction roles. Because the conventions of these roles had already been established and they were textually represented on the wall for each team, Ms. Leoni used them to randomly assign a pair from each team to designing at the table and another pair to a text-formatting task at the computer.12 The teacher made it clear that she would rotate students through tasks with the use of these role assignments, as she would also use them to assign the actual complex roles. In this particular instance, the reporter and materials manager (Henry and Cathy) were assigned to the computer, and the recorder and facilitator (Ted and Marsha) were assigned to begin designing on a single piece of graph paper.

I recount the details of this mundane classroom event because in the end, it was Ted and Marsha who became the paper-based designers and Cathy and Henry who became the computer-based draftspersons. This outcome, along with the ethnographic details I have thus far provided, might lead to the inference that the division of labor that formed was simply an accident of the initial random assignment of pairs to particular media and particular tasks, an implication that is neither intellectually interesting nor likely to provide any general insights. However, although I have considered this possibility, the subsequent days’ events undermine this simple interpretation. Whereas I argued in the first case that a purely functional explanation of technology use was too simple, here I argue that an explanation based purely on authoritative directive and compliance is likewise too simple. In this case, what emerges is a picture of how divisions of labor emerge from a complex interplay of contingent initial events, personal inclinations, the

11 During the prior week, group activity had taken only two forms; they either completed either a single task as a group of four (e.g., discussing what features the station could have prior to designing), or they completed individual versions of the same task in parallel (e.g., each individual writing about their expectations about working in a team).

12 This may seem like a confusing use of these roles, but from my perspective, it was entirely sensible. I liken it to how preexisting symbolic structures are sometimes used as devices for sorting groups into subgroups, as when people count off numbers 1 through 4 in a large group and then all the “ones” collect themselves. Without this device, the teacher would have either had to individualize the task assignments for 8 teams of 4 students or would not have been able to organize parallel tasks at all.
affordances of particular media, and evolving shared histories between particular students, artifacts, and tasks.

Factors Supporting a Sociogenetic Account

Although the initial pairings probably were relevant to the stable division of labor that emerged, they were not its sole cause. Other important factors that support a more complex sociogenetic account include the following.

Personal inclinations. Marsha and Ted demonstrated inclinations toward designing that Henry and Cathy did not during discussions that occurred the week before actual work began on the design-on-paper. Ted in particular was very enthusiastic about designing, and when the random assignment of roles chose him to begin with the paper in hand, he was demonstratively pleased. Henry and Cathy also displayed inclinations of their own toward the computer. Cathy in particular sought out the computer-based tasks, whether they involved drafting or mathematical analyses.

Evolving couplings. Further evidence that compliance with assigned pairings was not the sole cause of the emergent division in labor can be found in efforts made by team members to reorganize themselves to continue with the types of work they already had underway. By the phrase evolving couplings, I am referring to the notion that couplings between each pair in the tripartite relationship of persons, tasks, and tools can develop a history that enhances the likelihood of its continuance. The quick evolution of couplings became evident to me when, just a day after the initial pairings had been enjoined, the students resisted Ms. Leoni’s attempt to rotate them via another complex role assignment. The resistance took a quiet form, one invisible to the teacher. Because of the bustling environment of the classroom, Ms. Leoni was too busy to monitor whether every assignment she made was followed, and in this case, the students negotiated an alternative among themselves. This sort of negotiation probably takes place very often in classrooms, especially when students want to work with their friends. What was striking about this instance is that students negotiated to continue parts of the project they already felt some commitment to and competence with rather than negotiating to work with the person in the group with whom they were closer friends.

There is more, however, to the character of evolving couplings than students’ using discretion to reorganize their assigned tasks and couplings. In my view, there were certain inevitable sociocognitive properties of the evolving couplings that contributed to their stabilization. For example, in the design interactions between
Ted and Marsha, the design’s history was not entirely represented and available as drawn features on paper. Instead, the design existed in a reflexive relationship between a schematic drawing and an intersubjectively maintained account of the design (Livingston, 1993; Stevens, 1999a). What this meant was that becoming part of the design interaction became difficult for the other two group members after just a short time. For instance, while working together, Ted and Marsha drew office spaces where they agreed to put computers for the resident scientists. When Cathy returned to the group table, she showed an interest in the design by attempting to make a design proposal. She suggested that maybe they “should have a computer room,” to which Marsha explained that they (she and Ted) already had determined that computers would go in the offices, pointing to what visually for Cathy was just a set of drawn rectangles (i.e., they were not labeled nor bore any identifying icons). When Cathy again proposed a computer room, Marsha asked, “for what?” to which Cathy responded with a tentative “I don’t know, a special computer?” and then quickly dropped out of the scene.

A similar point can be made about the evolving coupling between Cathy and the computer-based tools, though for somewhat different reasons. For example, as in all computer-based work, certain iconic and haptic conventions need to be learned to draft structures in the software program Architech (e.g., how to use a bulldozer function to eliminate a wall); once Cathy learned these conventions, she was called upon to do this work while other team members did other tasks to which they had become more closely coupled and accountable. In addition, there were not only sociocognitive properties of these couplings that contributed to the stabilization of the division of labor but also a sort of relational stabilization at work. As members saw others becoming coupled to tasks or persons, they tended to find and seek their own couplings and to hold others accountable to theirs.

Affordances of media. To this point, I have described how personal inclinations and evolving couplings help explain how particular pairs of persons became coupled to particular tasks. Still to explain is how these person-task couplings came to be coupled to particular media, in this case either computers or paper. Here, an appeal to the properties of the media for particular tasks or, in other words, their affordances (Gaver, 1996; Gibson, 1979) is useful. Recall first that students were asked to “get started” with paper. Once started, however, the designers quickly incorporated some of paper’s affordances into their design interactions.

By focusing on the interaction between the designers, I am emphasizing the affordances of paper for collaboration. Despite this focus, it would be an oversight to neglect how paper also afforded the individual designers’ expression of ideas during the early, creative problem-solving phase of the overall design process. Students could get their ideas down in a durable form, with resources they appeared to bring to the class: the capacity to draw or trace lines that represented built
space from above (i.e., in plan view). In short, paper was a flexible representational resource for designing in a way that the software could not be, and this appeared to be a factor in why, once started, the student designers continued to use paper.

Among paper’s affordances for collaboration, portability and availability were two that students exploited in this case. Ted made use of these affordances when he returned to school on the 2nd day of designing with a new sketch of the floor plan. Once he and Marsha began their design discussion, he used his homemade plan to make proposals to Marsha. This new sketch differed in some key ways from what he and Marsha had done together on the 1st day, but it also took many of those features as settled. Because there were now two different versions of the design available in the shared visual space of the group table, the alternative design proposals could be discussed and directly visually compared. Because the computer and software were available only during classtime, Ted would not have been able to produce this alternative proposal had they been designing with the computer. In addition, because the computer-based design interface provided very little screen real estate (13 in.), the designers would not have been able to place two versions in their shared visual field simultaneously.

As the design process between Marsha and Ted progressed, the pair incorporated other affordances of paper into their collaborative design practice. For example, on the basis of demonstrations from their teacher and a visiting architect, Ted and Marsha incorporated “trace” (tracing paper) into their collaborative design interactions in ways that closely mirrored the uses of the professionals. Trace allows for the layering of different alternatives over an existing base drawing. Trace also allows quick tracing of parts of existing structures and redrawing of others, a practice supported by the trace’s transparency. In the discussion between Marsha and Ted, trace was used in this way to heatedly debate and draw alternatives to a narrow hallway.

Summary: A Stable Division of Labor

The phenomena that this case study has sought to explicate is how an emergent division of labor, parallel to one found among professional designers, stabilized amidst a field of contingent forces and in opposition to a succession of assigned

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13 Current technologies such as Wacom tablets, penlike electronic styluses and software allow closer approximations to the experience of paper based drawing. These tools were not used in the classroom design projects nor are they routinely used in professional architectural practice. For a discussion of how technologies can support practices closer to those associated with paper, see A. H. Stevens (in press).

14 Some students had computers at home, but most used a different operating system than the one running in the classroom, and no students had copies of the software at home.
divisions of labor. Once divisions of labor had stabilized, the designers (Ted and Marsha) used paper to debate and draw possible design features while the draftspersons (Cathy and Henry) translated the design from paper into the computer and undertook other computer-based tasks. This design on paper moved back and forth between the computer draftspersons and the designers, each needing it to pursue their respective tasks of design and drafting. The interaction across the division of labor was efficient; in the end, the team had a complete design in the computer environment, ready for subsequent analyses, which had been forged in a productive paper-based collaborative design process. Finally, and significantly, this emergent division of labor produced an exceptionally successful conclusion to the project for this team. At both times when all eight teams’ projects were evaluated by professional architects, this team’s project was judged as the most complete and accomplished in the class.

In summary, it is important to highlight the differences in the character of the discussions and activities between the designers and the draftspersons in their respective workspaces. At the table, the designers considered alternatives for the geometry and use of spaces, frequently warranting their proposals with references to normative living practices (e.g., Marsha challenging a proposal by Ted to place a bathroom between a kitchen and living room: “Nobody does that”) and arguing in quantitative terms about design issues such as fit, scale, and size (e.g., Ted challenging a proposal of Marsha’s: “That hallway’s way too big”). In contrast, at the computer, the draftspersons discussed how to use the program to input the designers’ work, learning how to manipulate the mouse and tool palette to efficiently place windows, rotate furniture icons, and the like.

Within the team, these differences in types of knowledge across the division were known to the team members, were resources for the organization of their own collective activity, and were treated as ordinary given the many tasks they faced across the arc of the design project. However, because this division of labor emerged in a classroom, the corresponding differences in knowledge were not unproblematic, an issue I turn to in the comparative analysis of the two settings.

15 As an interesting aside, it is worth noting that the couplings that stabilized overrode, all else being equal, more likely self-selected couplings, such as those based on gender (Thorne, 1993) and friendship networks. Had either of these preferences prevailed, it would have been the pairs of Ted and Henry on one hand and Marsha and Cathy on the other who organized themselves to work together, and in fact, pairwise socializing sorted out this way. In addition, the coupling of Ted and Marsha as designers also overcome some evident interpersonal repulsion; throughout the unit Marsha displayed evident distaste for Ted, but nevertheless she continued to work with him and respect his design contributions: a reaffirmation of the maxim that collaboration is not equivalent to cooperation.

16 I also observed, less systematically, similar divisions of labor among some of the other teams in which pairs of four student teams favored work at the table and others favored work at the computer.
COMPARATIVE ANALYSIS

In this section, I offer an example of a strategy for doing comparative analysis that differs from the traditional experimental strategy of staging similarities (e.g., of specific tasks) to achieve comparability. This alternative involves finding first-order similarities in naturally occurring data across cases (i.e., the similar divisions of labor in the two settings) and using these similarities as the basis for subsequent second-order comparisons of similarities and differences. This strategy represents one way to do comparative work while also observing the criteria of ecological validity (Cole, Hood, & McDermott, 1979; Newman, Griffin, & Cole, 1989).

In this section, I exemplify this across-setting comparative strategy by exploring one similarity and one difference relevant to studies of collaboration, media, and learning. The similarity involves relations between forms of media and the types of collaborative activity they support. The difference involves the ways in which the classroom and the architecture firm were very different environments for the assessment of individuals and collectives.

A Similarity: How Forms of Media Supported Collaboration

In both cases, collaborative design occurred, final designs reflected contributions by multiple participants, and collaborative design interactions happened mostly on and over paper surfaces rather than at computers. Explanations for why paper-based practices claimed priority during critical design phases in the two settings differ significantly, reflecting different site specificities and developmental histories of persons and practices. Nevertheless, in both settings, what appears similar is that, given the specific forms of collaboration observed in each case, the paper-centered practices more easily supported these types of collaboration than could have screen and mouse-based practices.17

At JC Architects, design conversations often involved as many as ten stakeholders seated around a table. In these situations, each participant had spatial access to the table surface where drawings lay, and all had the simple tools (fingers and pencils) for making design proposals visible to themselves and others. Similarly, paper forms could be rearranged on the table so that participants could simultaneously see and compare representations, and these rearrangements could happen quickly, keeping pace with evolving discussions. A ubiquitous roll of trace was always nearby for a participant to unfurl, layer over existing drawings, and quickly sketch a design proposal. Sketches on trace were as easily discarded as saved and, more important, they were saved by different participants for different purposes to develop further.

17By arguing that paper more easily supported these collaborative practices, I am making a relational point about the media resources available to members in practice, rather than an absolute statement about these particular technological packages.
Although some future version of computer-supported tools may support such embodied collaborative design processes, current versions (like JC’s CAD system, the industry standard) do not. With limited screen real estate and with drawing actions being mouse and keyboard controlled, the capacity to simultaneously see multiple representations at an acceptable scale or to make an inscribed contribution from locations beyond close proximity to (the front of) a small screen is limited. Although their CAD system had layering tools—seemingly digital analogs of tracing paper—creating layers in the machine is not nearly as quick, savable or discardable as working with trace. In my observations, the layering facility in the CAD environment, unlike trace, was more of a technical distinction than a design-relevant phenomenological resource.

Paper-based practices also prevailed among the student designers, Marsha and Ted, for whom the CAD-like system available was even more limited than the architects’ system as a design tool (having even less screen real estate and no layering tools). For example, it was central to the collaboration of the student designers that each member develop a distinct version of the floor plan, and at various moments, each had their respective versions in development simultaneously. This type of simultaneity was one feature of collaboration better supported by available paper resources than by computer-based ones. Although there was plenty of available paper, there was only one computer per group accessible during any one moment. If Marsha and Ted had worked together at the computer, they would have undoubtedly been working on a single version, but for Marsha and Ted, maintaining materially realized, different versions was important. It was important not only because this allowed them to try out design possibilities but also made them visible for comparison with the other designer’s work. In one instance, simultaneous comparison led to a compromise on the dimensions of a room, and in another, it led to an acknowledgment by Ted that the direction that Marsha was pursuing was “better” than his. Although Ted and Marsha made productive use of simultaneity, they also made use of its opposite—call it temporal independence—in their collaborative design process. Recall that, after the first day of designing, when Marsha retained control of the developing paper version of the floor plan, Ted returned on the second day with a plan of his own. Neither Ted nor Marsha’s versions became the plan, which instead reflected contributions from both versions. To summarize, in both cases, paper-based practices were more finely tuned to the tempo and structure of synchronous collaborative design than computer-based ones could have been.

A Difference: How the Respective Systems of Assessment Supported Collaboration

In both the professional and middle school settings, the division of designing and computer labor led to successful progress through critical phases of projects. Also
in both cases, the different experiences of laborers on opposing sides of this divide meant that different, complementary competencies developed. However, the emergence of different competencies has differing implications in the two settings because of the differences in the way the two settings were organized to assess individual and collective units of performance.

In the architecture firm, though it was true that individual members were continuously assessed informally, the relevant assessable social unit in more consequential irreversible assessments (i.e., formal ones) was the team (Stevens, 1999a). What this meant was that the different competencies that developed from the division of labor were affirmed by the informal assessment system. Principal architects valued the associate architects for being able to do the CAD work that they could not do but that was critical to longer arcs of work relevant to the success of the firm. Furthermore, because the associates did this CAD work, the principal architects were able to use and further develop their own characteristic competencies in such realms as design, management, and the solicitation of other projects. In turn, as principals brought more architectural jobs to the firm, new people could be hired to do CAD work, and new opportunities were opened up for the associates to participate in and develop these more principal-like activities, thereby moving them along an architectural career trajectory. In short, the division of labor at JC and the commensurate distinct competencies that developed from it was productive and integral to the ongoing success of the firm and to expanding forms of participation for its newcomers (Lave & Wenger, 1991).

In contrast, the division of labor that emerged in the classroom between the designers and the draftspersons was more problematic because the practices of individual and collective assessment were less compatible. From a perspective that treats the team of students as the unit of assessment, the division of labor was productive in nearly every way. The team, by dividing labor among its individuals, was able to simultaneously satisfy assignments from their teacher, make progress on a design, and input the design into the software for subsequent mathematical analyses. It also led to a final design and a set of mathematical analyses that were the most highly praised in this class. Finally, it provided these students an opportunity to engage in a collaborative process of inquiry and production that resembled the activities of professional designers. Alternatively, from a perspective that treats the individual team member as the unit of assessment, the division of labor was more problematic. The reason for this was that the division of labor meant that individuals on different sides of the divide (e.g., Ted the designer vs. Cathy the draftsperson) developed quite different competencies and understandings18 that the more formal uniform classroom assessment practices registered differentially.

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18This also was true with regard to other competencies (e.g., mathematical analysis) that resulted from other divisions of labor in this team (see Stevens, 1999a; Stevens, in press).
The assessment practices enacted in Ms. Leoni’s classroom mixed formal with informal and new with old, but ultimately, the overarching accountabilities faced by the teacher meant that more traditional practices of assessing individuals predominated; in other words, grading of worksheets and tests of mathematical competencies. This meant that the many competencies that emerged in the project did not count. For example, Ted exhibited a significant commitment to the completeness and functional rationale of the design, a commitment that drew his energies away from the activities that were graded. As such, Ted’s performance on tests and worksheets involving particular types of mathematics were relatively poor. The irony of this situation was that Ted did display significant mathematical competencies but did so during design interactions, and so these competencies became invisible during the formal and individual assessment events (Stevens, 1999a; R. Stevens, in press).

Classrooms using project-based curricula are somewhat paradoxical ones with regard to the development of diverse student competencies. On the one hand, collaboration in complex, temporally extended projects implies emergent divisions of labor. Because these divisions of labor in turn imply distributions of individual knowledge, the production of consequential individual differences of the types represented in the classroom case study is arguably built into educational initiatives organized around project-based activities. On the other hand, the infrastructure for formal assessment in schools, generally and in this school in particular, is organized for uniformity of educational experiences and of assessment events. Overcoming this infrastructure and putting in its place one that did greater justice to the diversity of competencies that emerge in project-based work would have been a major challenge, one that was surely beyond Ms. Leoni and our research team at the time. As a result, it was unsurprising that Ms. Leoni fell back on traditional assessment practices. In summary, the paradox is that, in hybrid educational settings like Ms. Leoni’s classroom, there are competing organizational forces, some that affirm the development of diverse forms of knowledge and others that penalize this development.

**IMPLICATIONS FOR EDUCATIONAL PRACTICE**

An overarching goal of this study has been to show that both settings considered here were complex sociotechnical environments, the classroom no less than the architecture firm. In light of this complexity, no magic wrenches are offered for the repair of education as a result of this comparative analysis; however, some implications for research and practice can be drawn.

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19It is worth noting that this uniformity has also been considered a safeguard for many students in a system that often reproduces broader societal prejudices. In other words, uniformity has stood in for equity.
My analyses of the multiple technologies in use in the classroom have highlighted the unique affordances of paper for the collaboration of student designers and contrasted these to the relative inadequacies of the computer tools. In so suggesting, I hope not to be mistaken as an advocate for a misguided Return to Paper movement; computers in the classroom serve unique and valuable functions. What I do advocate is a genuinely experimental attitude toward the introduction of new technologies into the classroom. By this I mean that researchers and educators should continue to explore how new technologies can support learning in innovative ways but also prepare themselves to acknowledge as many failures or nonevents as they do successes through careful scrutiny of cases. This type of healthy skepticism has been one of the ideals of science for a long time, and it seems particularly appropriate to a cultural moment in which many are swept up in waves of techno-enthusiasm and the prospects of financial gain. To stand on the side of students and learning may be to stand on the side of humble, unplugged, widely available technologies (cf. Stevens & Hall, 1997).

Another implication of this study is that the issue should not be conceived of in “either–or” terms (i.e., either computers or traditional learning technologies). As research in computer-supported cooperative work has shown so vividly over the last decade (cf. Bowker, Star, Turner, & Gasser, 1997), settings are nearly always inhabited by a combination of old and new, digital and analog, standardized and ad hoc. From these combinations, hybrid practices emerge such as those in both of these case studies, in which movement across the digital-and-paper divide became fluid and functional. For educational settings, the implied principle therefore is the maintenance of media diversity. Yrjo Engestrom has argued that a technology (be it a computer or a textbook) always has the potential to be introduced into a setting not as a tool, but as a rule—in other words, “as an administrative demand from above” (Engestrom, 1990, p. 179). The computer could easily become little more than a new rule if users are not given opportunities to use alternative media when they are better suited to the organization of specific tasks. In schools, providing these opportunities is especially crucial for two reasons. First, schools are well known as places where rules predominate. Second, following a constructivist logic, students will perhaps learn most productively if, in an environment of media diversity, they are given opportunities to make choices about what tools are right for what jobs and to learn to “workaround” (Gasser, 1986) the inevitable limitations of specific technologies, rather than simply bending themselves and their tasks to these technologies. In the classroom case study described here, this diversity allowed the student team to rediscover a distributed arrangement for doing collaborative design that is an established and productive practice for professionals.

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20 For example, students were able to perform mathematical analyses of relationships between the geometry of floor plans and projected building costs.

21 Compare the analysis of diSessa, Hammer, Sherin, and Kolpakowski (1991) of how a group of middle school students reinvented Cartesian graphing in a middle school classroom.
A second implication arises from my analysis of the relationship between emergent practices and traditional assessments in the classroom. By this analysis, the placement of technology in a classroom is only a small part of an educational design endeavor. We also are challenged to implement new assessment practices that recognize and register productive diversities of competence that emerge, because new classrooms are increasingly less amenable to traditional uniform assessment procedures (Hall, Knudsen, & Greeno, 1995/1996). Unless assessment and student activity are better coordinated, the sort of conflict I described here between emergent student learning and uniform assessment practices may be resolved in favor of a return to traditional uniform pedagogical practices. In addition, our energies will be well spent thinking about how emergent student learning can become a resource rather than a problem through the design of pedagogical activity structures (e.g., reciprocal teaching and jigsaw) that respect and legitimize what emerges (which, in my analyses, the complex instruction roles did not) while providing opportunities for students to learn from each other (cf. Herrenkohl & Guerra, 1999).22

A final educational implication of this comparative study is that professional settings like the architecture firm may provide some valuable guidance for educational design. The notion of design experiments (Brown, 1992; Collins, 1992; cf. Cole, 1996) is now well established in the learning sciences community, but what remains vague are the particular conceptual resources that can serve as the food for our design thoughts. The point is not to make the students into little architects or the classroom into a replica of the firm but to explore how the practices and technologies observed in evolved and evolving adult settings can be selectively borrowed and adapted for use in classrooms (Stevens, 1999b).

ISSUES FOR FURTHER RESEARCH

Understanding the Affordances of Technology in Context

In finding a strong similarity across cases in the way that particular forms of media were coupled to particular types of tasks, I have described some of the affordances that can be found in practice. Important to highlight is the fact that many of the affordances I found are quite different from those that might be found in user studies conducted with individuals under laboratory conditions. For example, some of the affordances of the paper observed in both cases were portability, layerability,

22James Greeno reported (1997) that in the Fostering Communities of Learners project (see Brown & Campione, 1994), scripted divisions of labor did not produce significant differences in performance between individuals.
and availability. Another was shared joint graphical access to paper from different sides of a table for collaborative design. Surely many important affordances can be discovered in laboratory studies, but if these case studies are any measure, there is also a great deal to be learned “in the wild,” especially about affordances for collaboration in practice.

Getting a better analytic handle on the affordances of particular technologies for learning in classrooms may help resolve the undergrounded argument between computer advocates and critics. On one hand, critics of computers in classrooms skeptically question the value that computers add to the educational experience as judged in terms of existing educational goals. On the other hand, advocates of computers in classrooms argue that new tools create new and desirable practices or do old jobs better. Under the analysis presented here, the critic and the advocate both articulate a partial truth, but neither perspective is of much heuristic value because a sufficiently grounded corpus from which to make inferences about particular cases does not yet exist.

Understanding Emergent Practices as Features of Educational Settings

A concern with emergence—with what happens alongside and often despite an institution’s official story—has animated various lines of interactionist research for some time. Perhaps the perspective has been infrequently extended to educational phenomena because most schools are commonly understood as authoritative disciplinary institutions that leave little room for practices to emerge among students, at least not in classrooms. However, as educators experiment with new participation frameworks in schools that de-center the teacher and provide students with greater discretion about the organization of their activities, this issue deserves further theoretical attention. Schools are particularly complex settings for exploring the issue of emergence because schools, without exception, seek to enact intended pedagogical practices. On the basis of the larger study from which this analysis is drawn (Stevens, 1999a), the coexistence and frequent collision of the intended and the emergent is routine in project-based classrooms (cf. R. Stevens, in press). Further case studies of these types of classrooms should be helpful in creating a theoretical language for describing the varieties of ways these two modes coexist, collide, and ultimately hybridize.

CONCLUSION

A century ago, Durkheim forcefully argued that emergent, relatively durable divisions of labor would create a cohesive, diverse, and unrepressive society composed
of well-developed individuals. This comparative case study, along with the current interest in distributed cognition and in collaborative, project-based educational initiatives, has provided an occasion for a reinspection of this claim, not at Durkheim’s macrosocietal level but rather within and between concrete institutional settings. Perhaps in contrast to Durkheim’s overarching theoretical arguments favoring social environments that allow emergent divisions of labor to develop, this comparative case study has made the grounded theoretical argument that such divisions of labor are in themselves neither inherently favorable nor unfavorable for people working and learning across all institutional settings.

My conclusion is a more institution-specific, relational one. The impact of divisions of labor on learners in school depends on the relations between how students, whose labor is divided, come together, how their divided labor is made visible and assessed, and how these divisions enable or constrain changing forms of participation and the development of new competencies. It is from a concern for these relations first that we should consider the role of technologies, however sophisticated or mundane. In this way, we may begin to provide better answers to questions of how particular technologies and learning intersect—or don’t—in context.

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