Divisions of Labor in Computer-Assisted Design: A Comparison of Cases from Work and School

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Abstract

This paper uses the concept of division of labor (Strauss, 1985) to explore two design settings (a middle-school classroom and a professional architecture firm) where people use both computer and paper-based practices for designing. I report that in both settings collaborative labor is divided between designers who work on paper and draftspersons who work with computers. Reasons for this division are explored, and implications are considered for educational initiatives aimed at supporting design collaboration and learning.

Keywords —computer-assisted design, distributed cognition, ethnographic case studies

Introduction

In this paper I compare two design settings (a middle-school classroom and an architecture firm) to explore a basic question for studies of collaboration, computers and learning. How do computers, in this case computer design tools, shape the division of labor among human collaborators thereby influencing what is learned and who is learning?

A perhaps little-known aspect of professional architectural design in this age of omni-present computers frames this analysis; the phases of the overall design process that are considered by practitioners as those when 'real design' occurs happens on paper. Designs on paper are then translated into digital form using CAD (computer-aided design) programs1. During these early conceptual and schematic development design phases, architects work almost exclusively by hand on paper, using a simple but flexible *package* of base drawings, trace paper, scale ruler, and corresponding embodied competencies. (Stevens, 1997)

The designing that occurs in these early phases of a professional architectural projects is high status work, usually done by principal architects (i.e. owners of firms, analogous to partners in law firms) and architects with special designation as 'designers'. In smaller firms like the one I studied, the lower status work of translating the paper documents into CAD and working out the necessary details is done by associate architects2. In larger firms, translating hand-inscribed designs into CAD usually falls to 'draftspersons', and the distinction between draftsperson and designer is a standard one in the architectural community (Cuff, 1991; Robbins, 1994). As such, designing and computer drafting are currently regarded as two quite different kinds of work activity.

While it is common, and probably unsurprising that newer computer-based design tools have not usurped more traditional media in professional practice yet — since the current generation of principal architects learned exclusively paper and physical model-based design — I present a finding here that is somewhat surprising. In a middle-school

1 This was definitely the situation at the firm described in this paper and, based on informal queries, at many other firms in the region. The continued centrality of paper-based practices in engineering is discussed in Henderson (1991) and Hall and Stevens (1995). In many design fields like architecture, this situation may be changing and some analysts predict that soon computers will become the primary medium for doing design. (e.g. Mitchell and McCullough, 1995)

2 Associate architects are typically younger and much earlier in their careers than principal architects and are paid a salary rather than participating as owners.

classroom, where students were provided a computer program for designing, the emergent division of labor between a group of kids doing an architectural design project reproduced the designers-using-paper/draftspersons-translating-paper-into-the-computer division found among professional architects. This paper explores this occurrence through a comparative case study of designing in a school and a professional setting and considers explanations and implications of this division of labor for computer-supported collaborative learning.

Theoretical Background

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 made work processes more efficient, but held very different views about the effects of these divisions on the well-being of society and the individual. At the end of the last century, Emile Durkheim took up 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 as it appeared in modern society. Durkheim argued that the division of labor produced a type of human solidarity, based on complementary differences between social units (e.g. professions) and individuals, that was stronger and better than the type found in societies in which solidarity was based on societally-enforced similarities between persons (what Durkheim called *the common consciousness*).3 One of Durkheim's central analytic concerns was "the connection between the individual personality and social solidarity" (Durkheim, 1997/1993: *xxx*), and he believed that as societies evolved away from a foundation in common consciousness and towards increasing divisions of labor and individual specialization, parallel development of increasingly complex and autonomous individual personalities would occur.

In this century, the issue of the division of labor between people and machines also has occupied analysts, with some like Braverman (1974), following Marx, who argued that in capitalist economies technology tend to function as a means for "deskilling" persons, making them less autonomous (at least in terms of economic self-determination) and, in general, producing deleterious social effects. More contemporary analysts have seen the possibilities of technology, specifically information technologies, alternatively positively and negatively, depending on how these technologies are used (Zuboff, 1984).

Finally, during the last decade Ed Hutchins (e.g. 1995) and Bruno Latour (e.g. 1996) have characterized modern work processes as complex networks of people and machines acting together. They have reopened questions about the distribution and redistribution of competencies between people and technologies, with new concepts that blur the analytic (and perhaps ontological) line between human and non-human actors in complex socio-technical networks. Unlike previous theorists, neither Hutchins nor Latour has substantively engaged familiar moral issues about the redistribution of competencies between people and machines in contemporary work.

The questions raised in this paper relate to those pursued by Hutchins and Latour, but differ because this analysis focuses less on the re/distribution of competencies *from* people to computers (or vice versa) and more on specific divisions of labor (Strauss, 1985) *between* people because of and around computers. Following Hutchins and Latour, there is much to recommend treating both human and technological agents symmetrically within a socio-cognitive activity system, but if the primary concern is, as it is here, what *people* learn and do, the practical analytic value of foregrounding people *vis-a-vis* machines endures.4

Anselm Strauss framed his discussion of the division of labor (1985) with the observation that little research about this topic actually analyzed

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3Durkheim called the former *mechanical solidarity* and the latter *organic solidarity*. 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.

4 It is of course possible to use symmetric conceptual terms to describe contributions of competence by people and technologies, while still valuing and understanding these contributions differently. Under plausible readings of both Hutchins and Latour, restoring the "missing masses" of technology to studies of activity enables us to better appraise what people need to and do contribute.

concrete cases of working, and his collected studies provide many useful theoretically-grounded concepts for this purpose. In this short paper, I will employ only a few of these.5 Strauss directs attention to the entire collection of persons and tasks that compose a *project* from inception to completion. “The totality of tasks arrayed both sequentially and simultaneously along the course of [a]…project ” is called the *arc of work* (Strauss, 1985: 4). Along this arc, the rights and responsibilities of particular persons with respect to particular tasks vary from loosely to tightly coupled. While Strauss does not highlight *tools* as analytic units that are coupled to both persons and tasks, adding this element to the scheme is certainly compatible with his analyses and is essential for this one.

In the ethnographic descriptions 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 analyzed, 'designing' and 'drafting'. In both cases described, particular persons were coupled to designing with hand-inscribed paper media and other persons were coupled to drafting with computer-assisted design tools. I also focus on how sequential and simultaneous *phases* of work relate to specific configurations of persons, tools, and tasks. I now turn to these short ethnographic descriptions to investigate in more specific detail divisions of labor around computers and their import for what and how people learn.6

5 Strauss' concept of *articulation work* (Strauss 1985,1988) is perhaps his most important, since it focuses analytic attention on work that is too often invisible or taken-for-granted: achieving and maintaining the "fitting together" of people and tasks across a project. While the ethnographic descriptions below give some indication of the articulation work done at both sites, this type of work is not highlighted. Subsequent analyses of these materials (Stevens, forthcoming) will explore articulation work directly.

6 From the architecture firm, data collected includes approximately 100 hours 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 much shorter. For a concise description of the wider research project in which I participate, see Hall (1995).

Case 1: Architectural Design at JC

JC Architects is a mid-sized architectural firm in Berkeley, CA. During the duration of my field work, two principal architects and three associates worked at JC. At this firm associates and principals both did 'real design', though this happened almost exclusively by hand on paper. CAD work, on the other hand, was done entirely by the associates. The principals architects used computers frequently, but 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 knowing how to zoom in and out.7 Each of the three associates however spent a large percentage of their time at CAD machines, with the most junior among them spending almost all of his time working from red-lined8 paper documents and lists assembled by principals and more experienced associates.

Working from red-lines and lists, associates updated, revised, and completed drawing sets that were to be used by different groups throughout the design and building process. During early design phases, associates were responsible for measuring building sites and making to-scale base plans that could then be used by principals, along with trace 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 associates were responsible for producing complete, accurately rendered drawings that are properly labeled and follow the appropriate representational conventions for the audience (e.g. the public, the city, the contractor) that would receive the drawings.

In the project I followed most closely, JC Architects worked with a team of consultants to complete a seismic and ADA (Americans with Disabilities Act) upgrade on two historically preserved libraries in Oakland, CA. In this

7During my fieldwork, both principals told me that this was a deficiency they wished to rectify, but that the amount of other work they were responsible for prevented them from finding the time to learn the technology. One of the principals described this deficiency as “scary.”

8 Red-lining is a graphic technique for identifying errors and vagaries in drawings and communicating these to others. For example, a principal will take a current set of drawings, circle, notate and re-draw certain elements in red-pencil, and then return the set to an associate to make the required changes.

project, many of the major design decisions were made at meetings in which principals and consulting engineers worked (inscribing, pointing, etc.) over the surface of paper documents. In these meetings at JC, the associates were present but rarely contributed to these decision-making design conversations, instead tracking closely the emerging, agreed-upon decisions made among the other participants and keeping lists. 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 100% drawing sets will be 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 is an essential part of a primary arc of work at JC and falls entirely to the associate architects. Furthermore, facility with CAD has become a pre-condition for earning an entry level position in an architecture firm. Unfortunately for beginning architects, many (if not most) undergraduate architecture programs do not provide sufficient CAD instruction, which means that young architects face 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.

Because CAD is so important to primary arcs of work in architecture and because young architects know that they need baseline facility with it to secure a position in a firm, the division of computer labor is, at least during the early phases of an associate's employment, pre-determined in professional architecture settings like JC. Principal architects, because they are fully occupied with tasks they are uniquely accountable to, hire associates to do CAD that they as principals have neither the time nor the training to do.[9]

9 In dynamic organizations (such as I understand JC to be), associates can move along trajectories that progressively unleash them from their CAD machines to take up more principal-like activities (Lave and Wenger, 1991), but I suspect that in other, more static firms, CAD work — like essential technical work in other fields (cf. Traweek, 1988; Shapin, 1989)— remains the responsibility of some permanent, if interchangeable, draftsperson.

Case 2: Architectural Design at Pine Middle School

In the Fall of 1996, 7th grade classes at Pine Middle School undertook architectural design projects based on MMAP (Middle School Math Through Applications) curriculum under the sponsorship of the Math@Work project led by Rogers Hall. As a participant in this research project, I recorded the work of the group described in this case 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 UC 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.

This case study documents one focus group of four students in Ms. Leoni's mathematics class. In these 8-10 week curriculum units, groups of students were asked to play the part of architects designing research stations for scientists 'wintering over' in Antarctica. The intended sequence of group activities in these units entailed the following: doing research about the conditions in Antarctica and the needs of research station inhabitants, designing a structure that satisfied these conditions and needs, analyzing the structure mathematically using specially-designed software, revising designs in light of mathematical findings and other considerations, and presenting work in a final form. The primary intended tool for designing these research stations and for doing subsequent mathematical analysis on costs and efficient uses of space and insulation was a CAD-like program called ArchiTech©. In this Macintosh-based program, students drew research stations in plan view (i.e. from above) using a tool palette and a mouse. In a separate mode, they did important computations (such as building cost, area, and perimeter) and set parameters of the model (such as insulation and temperature).

Learning in these classroom projects is designed to be collaborative, with teams of 3 or 4 students working together to bring a project from initial conception to final presentation. From the time when students receive initial documents that describe the project scenario (of them as a team of architects designing a research station) to the time when they present their completed designs, the arc of work included a heterogeneous collection of tasks in a complex sequential and simultaneous temporal ordering. These conditions are much more similar to the professional setting than to a traditional classroom and undoubtedly contributed to the emergent division of labor. In these projects, unlike traditional classrooms, tasks and media vary greatly (paper and computer-based design, analysis of mathematical properties of models, explanatory writing, semi-traditional worksheets, poster design, etc.) and managing tasks in time is challenging not only because of the complex temporal ordering of tasks but also because the tempo of work activities is largely iterative and culminant rather than repetitive.

In the group I describe here, I observed a division of labor among its members that mirrors that found in the architecture firm. Two students became the 'designers', drawing plans for the research station on paper, and the other two students became the 'draftspersons', translating the designers' paper drawings and undrawn ideas into the computer. At the outset, I should state that this division of labor was less complete than in JC architects, but the similarities in design practices between the settings were nonetheless striking.

The first day of designing was initiated as the teacher instructed groups to begin sketches on paper. Quite quickly, two students asserted their interests in the features of the design, Marsha who was drawing and Ted who proposed ideas for the station while she drew. During this first day, there was contention about who was "doing it", the day ending with Marsha retaining control of the paper. The next day, Ted arrived at class with a sketch of his own. Ms. Leoni told all the groups to begin putting their sketches into the computer and she also organized them to work in pairs based on a pedagogically-motivated division of labor.10 For reasons involving personal preferences within the group, the assigned pair of Cathy and Ted didn't go to the group's nearby computer as stipulated by the teacher. Instead, Henry joined Cathy, as per a suggestion by Marsha, and they began inputting the design into the computer.

During this class period and the following one, the structure of group activity and the division of labor stabilized. Ted and Marsha, at the group table with paper in front of them, debated possible design features and drew them on separate pieces of paper. The station, by group agreement, was to have two floors, and Cathy and Henry waited for Marsha to finish the first floor and turn the paper over to them to input it into the computer. This paper moved back and forth between the computer draftspersons and Marsha the designer, each needing it to pursue their respective tasks of design and computer drafting. Ted continued to work on his own paper, while engaging Marsha in an ongoing design discussion.

The character of the discussions between the two pairs were markedly different. The designers considered alternatives for the geometry and use of spaces while the draftspersons discussed how to use the program to input the designers' work, discovering how to manipulate the mouse, how to place windows, how to rotate objects, and the like. Between the divided pairs, questions were far more frequent from the draftspersons to the designers, questions about location of design elements and about minor errors, like a missing entrance to a bathroom. By the end of this day, collaboration across this division of labor had produced a complete, first floor plan in the computer.

Subsequent days saw some blurring of the boundaries in the division of labor, since Marsha did spend some time with Cathy at the computer working out details and adding furnishings, but when it came time again to make major revisions (following a design review by professional architects) the previous division of labor returned. Ted and Marsha worked again at their table considering alternatives for changes suggested by the architects, this time working with an enhanced set of paper tools (floor plans layered by trace paper for making selective changes) that they had been demonstrated by the architects and their teacher, while the draftspersons worked to input their changes.

Comparative Analysis and Discussion

In comparing these cases, I consider one similarity and one difference relevant to studies of computer-supported collaborative learning. The similarity concerns relations between forms of media and the types of collaboration they support. The difference concerns the ways these

10 Students were assigned roles as facilitator, recorder, reporter, and materials manager. This was a rotating set of roles, used by the teacher in the early part of the curricular unit, to have students work in different capacities. While beyond the scope of this paper, it is interesting to consider how these sorts of assigned roles integrate or conflict with emergent, practical divisions of labor such as designer and draftsperson.

two settings are socially organized for learning and displaying competence.

How Different Forms of Media Support 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.[11]

At JC, design conversations often involved as many as ten stakeholders seated around a table. All participants had nearly equal 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 re-arranged on the table so that participants could simultaneously see and compare representations, and these re-arrangements could happen quickly, keeping pace with evolving discussions. The ubiquitous roll of trace paper 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 importantly, were saved by different participants to develop further.

While the computer might support such embodied collaborative design processes, it did not at JC, and certain features of JC's CAD system (the industry standard) make this situation unlikely to develop very soon. With limited screen real estate and 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. While their CAD system had complex layering tools — seemingly digital analogs of trace paper — creating layers in the machine is not nearly as quick, savable or discardable as working with trace. This analysis of course overlooks all of the potential advantages of computer-assisted practices over paper-based practices (Mitchell & McCullough, 1995), but nevertheless, paper-based practices appear at this moment more finely tuned to tempo and structure of professional design *collaboration*.[12]

Paper-based practices also prevailed among the student designers, Marsha and Ted. The CAD-like system the students used was even more limited than the architects' system as a design tool (having less screen real estate and no layering tools). But I will argue that the larger issue for the CSCL community is not the absence of this or that specific software or hardware feature, but a more general deficiency of computers to support certain kinds of *collaborative* design practices. For Marsha and Ted, it was central to their collaboration that each develop a version of their floor plan and, at various moments, that they have their respective versions in development *simultaneously*.

This type of simultaneity[13] is one feature of collaboration better supported by paper than by computers. While 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 to make them visible for comparison with the other designer's work. In one instance simultaneous comparison led to a compromise on the width of a hallway entrance and on another led to an acknowledgment by Ted that the direction that Marsha was taking the plan was "better" than his.

While Ted and Marsha made productive use of simultaneity, they also made use of its opposite — call it temporal independence — in

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11 By arguing that paper *more easily* supported *these* collaborative practices, the point I am making is comparative and made relative to the technological resources available to members in practice, rather than a statement of autonomous determinativeness of a particular technological package.

12 Part of the reason for this is undoubtedly the *entrenched* (Goodman & Elgin, 1988) character of the architects' existing practices; design competence, collaborative or otherwise, is centered in paper-based practices (as is much of their design identity).

13 I am referring, of course, to a simultaneity understood with respect to to interactional time, not precise clock time.

their collaborative design process. After the first day of designing when Marsha retained control of the developing paper 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. The relevant features of paper here are, of course, that it is both accessible in and portable to and from almost all homes, unlike specialized software and expensive hardware.

With these arguments I am not proposing a Return to Paper Movement. At the architecture firm, CAD's advantages in other parts of the overall arc of work are manifold. These include (just to mention a few) the capacity to re-scale drawings with ease, to borrow and transform design elements from other work, and to ship drawings electronically in a few seconds. The same point can be made about the system the students used; it was, for example, uniquely suited to helping them perform mathematical analyses of the relationship between geometrical properties of the structure and its projected costs.

What these arguments do support then is the concept of selective use as an empirical reality and as a guiding principle for pedagogical and research sensitivity. As Engestrom has argued, a technology always has the potential to be introduced to a setting not as a *tool*, but as a *rule* — i.e. "as an administrative demand from above" (Engestrom, 1990:179). Computers could easily become little more than the new rule if its users are not given opportunity to use alternative media tools when they are better suited to the organization of specific tasks.

In schools, providing this opportunity may be especially crucial, because schools are well known as places where rules can predominate. However, if students have the opportunity to learn to make judgments about what representational media are good for what tasks (Becker, 1986) and to sometimes workaround certain features of technologies, rather than simply bending themselves and their tasks to these technologies, they may particularly well served. In the case of the classroom designers, where it was important for participants to have multiple representations of a design in process and visible at one time, the designers' use of paper-based practices in the early phases should therefore be considered a discovery and achievement of selective use. And this achievement contributed to the collaborative production of the most highly regarded design in their class, as judged by both classmates and professional architects.

Social Organizations for Learning and Competence

In both the professional and middle-school settings, the division of designing and computer labor led to successful progress through critical phases of projects. Furthermore, 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 their distinct social organizations.

In the architecture firm, associates are the experts with CAD, and their capacities in this realm represent critical ones within larger, collaboratively-achieved arcs of work. The associates' expertise in the CAD realm allow the principal architects to use and develop their own expertise in such realms as design, management, and the solicitation of other projects. As principals bring more architectural jobs to the firm, new opportunities are opened up for associates to develop their "real design" competencies, thereby moving them along an architectural career trajectory. In short, the division of labor at JC is productive and integral to the ongoing success of the firm and to expanding forms of participation for its newcomers (Lave and Wenger, 1991).

Public schools are, of course, dramatically different kinds of organizational settings and here the division of labor that emerged here between the designers and the draftspersons may be more problematic, indexing a important general issue and creative challenge for educators. This is the issue of homogeneity/heterogeneity of competencies across individual students.

Treating *the group* as the analytic unit, the division of labor was productive in many ways. The group, by dividing labor among its individuals, was able to simultaneously satisfy assignments from their teacher, to make progress on a design, and to 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 design. However, the division of labor that arose from the practical exigencies of the arc of work also meant that *individual students* developed quite different competencies and understandings through participation in the unit.[14] While the development of such complementary competencies is valued in many institutional settings like JC[15], it does somewhat collide with a dominant and pervasive assumption that schools, at least at the middle school level, should provide all students with equal opportunities for learning valued competencies and fairly position them *vis-a-vis* each other in situations of formal assessment of these competencies. Traditional classroom practices avoid this collision by prescribing uniformity of learning and assessment experiences, but uniform assessment practices in places like Ms. Leoni's project-based, collaborative learning classroom would likely create even more perilous collisions. Where then does this leave the designer of educational experiences?

Conclusion

With collaboration in complex, temporally-distributed projects comes spontaneous divisions of labor. And with these divisions of labor come the possibility of distinct forms of individual competence. In schools, this presents creative challenges to educators, two of which I sketch briefly here.[16] First, educators are challenged to design and implement new activity structures for classrooms (e.g. reciprocal teaching, jigsaw) that take advantage of emergent, practical divisions of labor and learning so that students can participate with each other in ways that distribute what they've learned to others.[17] Second, educators are also challenged to implement new assessment practices that recognize and register productive diversities of competence and, more generally, become appropriate instruments for the assessment of learning in classrooms that are increasingly less amenable to traditional uniform testing procedures. (Hall, Knudsen, & Greeno, 1995/96) In summary, an implication for CSCL designers is that for every technical design endeavor, putting systems into use will involve a accompanying set of design problems that lie "beyond the interface" (Bannon & Bødker, 1990).

A century ago Durkheim forcefully argued that spontaneous, relatively durable divisions of labor would create a cohesive, diverse and unrepressive society composed of well-developed individuals. Current interest in distributed cognition and in collaborative, project-based educational initiatives invite a re-inspection of this hypothesis, if not at Durkheim's macro-societal level but (pace Strauss) within and between concrete institutional settings. Based on this comparative case analysis, a tentative response to Durkheim's hypothesis is that divisions of labor are in themselves neither favorable or unfavorable for people who are working and learning in institutional settings. The value of divisions of labor *for learners* depends on how people divided come together, how different types of work divided among people are made visible and accounted for, and on how divisions of labor enable or constrain changing forms of participation and the development of new competencies.

Extending this line of work

I conclude with two directions for extending this analysis that should widen its scope and deepen the account of how divisions of labor appear, stabilize, and change.

Widening the analytic focus to include the entire arc of project work in both settings. This widening will bring other types of work that are divided among persons under analytic scrutiny, including mathematical practices, writing, document management, and graphic design. Computers support many of these types of work as well and widening the scope will provide a more complete view of how these technologies enable and constrain project development and how they shape different kinds of learning.

Exploring the interactional, negotiated organization of divisions of labor. While this paper has found similarities in divisions of labor in two settings, it has not analyzed the "articulation work" involved in dividing the labor among persons or fitting it together once divided. Much of this fitting together work will be understood through analyses of talk-in-interaction. (e.g. Drew & Heritage, 1993;

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14 This also was true with regard to other key competencies, such as mathematical analysis, explanatory writing and poster design.

15 All institutions must of course strike some balance between shared competencies and differentially-distributed ones.

16 Strategies for meeting these challenges currently are being explored in the two educational research enterprises associated with this study (MMAP and M@W).

17 The Fostering Communities of Learners project (see, Brown & Campione, 1994) is reported by James Greeno to employ a variety of these activity structures such that, despite divisions of labor (which are scripted), their assessment materials register no significant differences between individuals as a result of these divisions. (Greeno, 1997).

Goodwin & Heritage, 1990)) However, in design projects, fitting together also has a decidedly material character and further analyses will look closely at how persons transform representations from one media state to another (e.g. from paper to digital form or from a collection of disparate papers to a single poster) and at what people learn in the process of making these transformations (Hutchins, 1995). Documenting both these types of articulation work should move my analysis from claims *that* particular divisions of labor happened to accounts of *how* they happened.

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