The Constitution of Intellectual Work By Programming Teams

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Abstract

This paper is drawn from a large study of intellectual collaboration. In a component of the research we focused on computer scientists and the ways in which they work together to produce complex programs. Relying upon the methods of participant-observation and analytic-induction we followed four teams of programmers from the inception of a project to its completion. Here we present our analyses of the groups' intellectual work as situated in cultural systems, social relations, and institutional matrices. In particular we describe the teams' changing perspectives on the purpose of their work. These perspectives which we call "activity frames" affected the type of work that the teams did and the manner in which it was carried out. Our findings have implications for the building of computer tools, and for the theorizing and researching of collaborative work.

The Constitution of Intellectual Work by Programming Teams

In a recent article entitled "Time Matters in Groups," McGrath argues that the tasks performed by intellectual teams as well as the teams themselves change over the course of a project. These time-dependent, historical processes and the ways in which intellectual work is situated in such processes are not well understood. Intellectual teamwork is typically studied only as it is carried out in one or two specifiable, repetitive tasks assigned to the team by management or by an experimenter. The longer-range historical processes affecting a team's work are virtually ignored (McGrath 1990:27). In this paper we describe groups of computer programmers and their work practices from the inception of a project to its completion. We found, in corroboration of McGrath, that time makes a difference. We found that the teams construed their work in varying ways during the project and that these differences made a difference for the type of work that got done and for the manner in which it was carried out.

In our project student programmers composed the intellectual teams. Anticipating that their students will one day be employed to produce large-scale computer programs that demand collaborative work, the computer science department in which we conducted our research requires that their graduate and undergraduate students take a course in software engineering. Students are given explicit instruction about collaboration and are required to carry out a project that no one individual could do alone. We both sat in on the classes and observed the work of student teams.[1] After briefly describing the set up of the teams and the study we will discuss the actual work practices of the student teams and compare them to the practices taught in the class.

Team Organization

Course procedures, common over the many years that the class had been taught, dictated a number of aspects of the group project. The workload is significant and, for many of the students, anxiety provoking. The class establishes a situation of dependency; in order to be successful, the students have to work together.

The student groups are given responsibilities to two external persons: the Boss and the Client. The course instructor acts as the Boss (and actually uses this title) for all of the software engineering teams. The teams are required to meet with the Boss at least once per week. Each project has a Client from the University community who has submitted a project that the instructor deemed appropriate for the class. During the second meeting of the course, students indicate their preferences from the menu of possible projects. At the third class meeting students learn of their team assignments and begin their projects.

All groups are required to choose a Producer and a Technical Director from their members. The selection is left to the group. The responsibilities of the Producer are administrative activities such as reserving rooms for meetings, making schedules, making sure deadlines are met, securing resources such as hard-disk space and machine time, representing the group, locating

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[1] This study is part of a larger study funded by the National Science Foundation (Grant # IRI-9015443; PI: John B. Smith; Co-PI: F. Donelson Smith). We would like to thank the members of the teams that we studied as well as the instructor of the class for their assistance in this research. In addition we would like to thank John Smith, Marcy Lansman, Dana K. Smith, James Coggins, Don Smith, and a number of other members of the larger project who have contributed comments and ideas to our work.

gurus[2], etc. The Technical Director is ultimately responsible for design, coding, documentation, and testing--in short everything associated with the technical versus administrative aspects of software engineering. Both the Producer and Technical Director have the authority to delegate tasks and responsibilities to other group members as they see fit. The positions of Producer and Technical Director are clearly leadership roles, but it is left to the group to decide which, if either, is dominant.

The team's first formal requirement is a project definition. After selecting the project, the team is required to meet with the Client and produce a Project Definition Document. This document is a contract between the team and the Client detailing exactly what the team has agreed to produce and what the Client has agreed to do to help them.

The Study

Each of us followed one software development team from its formation until the end of the course. An additional team was followed by periodic interviews of the Producer. Our observations of the teams included group meetings, meetings with the Boss and meetings with the Client. We also observed working events (such as group debugging sessions) and followed e-mail exchanges. Most meetings were audio-taped and subsequently transcribed, and roughly a third were videotaped. Both formal and informal artifacts produced by the groups were collected by the researchers. Team members were interviewed about their experiences with the class at the end of the semester. We also sat in on class lectures, during which we made field notes and collected handouts. Videotapes of the lectures were made accessible to us as well. At the end of the semester, the instructor provided us with his assessment of the projects (see table of Research Materials).

As the study progressed, field notes and artifacts were catalogued. Preliminary categories were developed and coded for each entry into the files, including artifacts or copies of artifacts collected from the groups. The Notabene database program was used to organize and locate the coded notes, artifacts and transcripts. After the observations were completed, each of us used our field notes to produce a week by week summary of the work of the group we followed. We noted significant developments in each week's events and the materials produced by the groups in their work.

Class Instruction Versus Team Practices

As we analyzed our data and wrote the week by week summaries, the discrepancy between the perspective and practices encouraged by the class and those of the teams became apparent. The class lectures conveyed techniques for the production of individual and collective intellectual labor. Drawing upon familiar notions of intellectual work as rationally ordered, the lectures encouraged a flow of activities and intermediate products that contributed in a logical, efficient manner to the final product. Early in the project goals are set, design work comes next, then implementation. The students were told that extra time spent "up front" in designing, planning, and learning needed skills will pay for itself by the end of the project. Intermediate products such as drafts of users' manuals were explained as important to the guidance of future work. Student teams were urged to quickly solve problems that came up in the design and

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[2] "Guru" is a colloquial term used in computer science to denote an expert in a particular subject area. For instance, if a group was working on a project that required them to have sophisticated knowledge of the UNIX operating system they might try to locate a "UNIX guru" in order to get help.

implementation of the program and to constantly judge whether a design decision was worth spending time on. Would the decision really make a difference in the end? If not, the instructor pointed out, the decision wasn't worth dwelling upon and should be made quickly.

This model of intellectual work which we refer to as the ideological or prescriptive model[3] reveals a way in which intellectual work such as the development of a complex computer program can be described in retrospect (cf Latour and Woolgar 1986 for a similar point about retrospective accounts of scientific work). The model also describes a way in which intellectual work could and perhaps sometimes does proceed. It is conceivable that groups could rely on a logical, rational plan for carrying their work to completion. In fact, it may sound odd or unnatural to suggest that groups do otherwise. It is also plausible and natural-sounding that teams consistently carry out their work in relation to a vision of the to-be-developed program. Nonetheless, for the groups we followed the normative model did <u>not</u> obtain. This was true despite the explicit instruction that they were receiving.

In our ethnographic study of the groups' work practices we rarely saw an overview or overall plan for the project (logical or otherwise) created or consulted. Two of the groups became involved with specifying and meeting milestones, but only for a brief period.[4] More frequently, the groups oriented to events such as meetings or work sessions that were underway or to events such as required class presentations that were coming up soon. They translated their ideas and concepts of components of the program into diagrams, notes, manuals and other intellectual resources on the spot in an event or for an event that was soon to occur. (Some of) these intellectual resources--the diagrams, descriptions, new terms and concepts--created for and in these events--were used in turn to direct or guide the next round of work.

Group work was not always oriented to the program per se. Yes, group members were sometimes consumed by an interest in developing the logic of a component of the program or in making it more elegant. But, at other points their attention was directed elsewhere, e.g., to meeting institutional demands including ones they considered frivolous, reassuring the Client, and impressing the Boss. At other times they became caught up in problematic social relations within the group. At such points work on the program ceased to be the real focus of group attention and became instead a means for carrying out a struggle between and among members of the group.

These alternative perspectives on the work affected the production of intellectual resources--a manual that supposedly committed the group to a particular realization of their project, would be whipped up in a matter of hours from whatever resources were at hand, or a solution to a design problem would be hotly contested because of the person who suggested it. In the end the

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[3] We call it ideological because it is used to evaluate procedures as good or bad and it is promoted by important institutions such as universities, businesses and the military. The emphasis on rational teamwork is also in accord with a predilection toward rationality among organizational researchers. As Ouchi and Wilkins (1985:463), in their review of organizational research describe a long term trend, "...their [the researchers'] search was strongly motivated by an underlying belief that the fundamental contribution of large-scale economic organizations is to bring "rationality" to an otherwise overwhelmingly complex reality." There are, of course, exceptions; see, for example, Nils Brunsson's work (1982) regarding the value of irrational decision-making procedures for maximizing motivation and commitment in an industry setting.

[4] These points should not be taken to mean that the groups had no sense of time passing and deadlines approaching. We noticed there were periods where "things got serious." These were periods where the group felt a sense of urgency to get something done. They were precipitated by immediate deadlines and sometimes by group members who managed to convey their sense of urgency to the others. (See also Gersick (1988), for a findings regarding groups' sense of time on a project.)

submitted program bore the results of work produced from these orientations just as it bore results produced from periods of intense regard for the intrinsic logic of the program.

In the remainder of the paper we discuss and analyze these alternative ways of viewing and organizing work. We call these ways of constituting or construing work, "activity frames." An "activity frame" is the group's collective sense of the point or purpose of the work at hand.

In the ideological model "activity frame" is an unnecessary concept. The point of the work is assumed to be the same throughout the project: the writing of a program that has conceptual integrity, coherence, and otherwise meets high standards of programming. Group behavior is seen and judged as though it were always oriented to such a goal. Intermediate products are seen and judged for what they contribute to such a goal.

While we did find instances in which the teams we followed were oriented to developing a good program, we also found instances where they constituted their work in a different way. We will describe these different activity frames and then relate these frames to the kinds of intellectual materials or resources that the teams produced, arguing that activity frames have implications for technology, method, and theory.

Activity Frames And Intellectual Teamwork

We began to develop the concept of activity frame when we realized that there were marked differences among the groups that we were following.[5] All of them were engaged in what we defined as intellectual work--that is, all of the teams were engaged in the process of making ideas into (tangible) cultural resources (in this case, computer programs, user manuals) for a particular environment (context, audience). Furthermore all of them were engaged in translating ideas into more tangible products by superficially identical means, e.g., drawing diagrams on the whiteboard. However, it was clear to us that although the products of these practices were basically the same, the purpose and meaning of the tasks and the resulting products often differed among the groups.

In the same way that the various groups performed similar actions resulting in similar products (drawing program architectures on the whiteboard, dividing labor, writing documentation, etc.), they also participated in events (mandatory meetings with the Boss, for example) that were similar in outward appearance yet dissimilar in the meaning that was attributed to them by the different groups.

We attributed these complexes of differences among the groups to variations that we noted in the groups' orientations toward the work. The groups had different views of the purpose of their work and they constituted their work differently depending on their sense of its purpose. As defined above, a group's collective sense of the point or purpose of the work at hand is its "activity frame."

Figures 1 and 2 graphically present the place of activity frames in intellectual work. In Figure 1, the basic action of intellectual work is represented as the translation of ideas into more tangible products.

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[5] There were 7 groups whose workplace was convenient for us (3 additional groups were located in another university; the classes were broadcast to them). The groups that we followed were the three in which everyone agreed to participate. Of all the students in the class only four declined to participate in the research. It turned out that the four were assigned to separate groups leaving us with only three possible groups to follow.

Figure 1: Basic Action of Intellectual Work

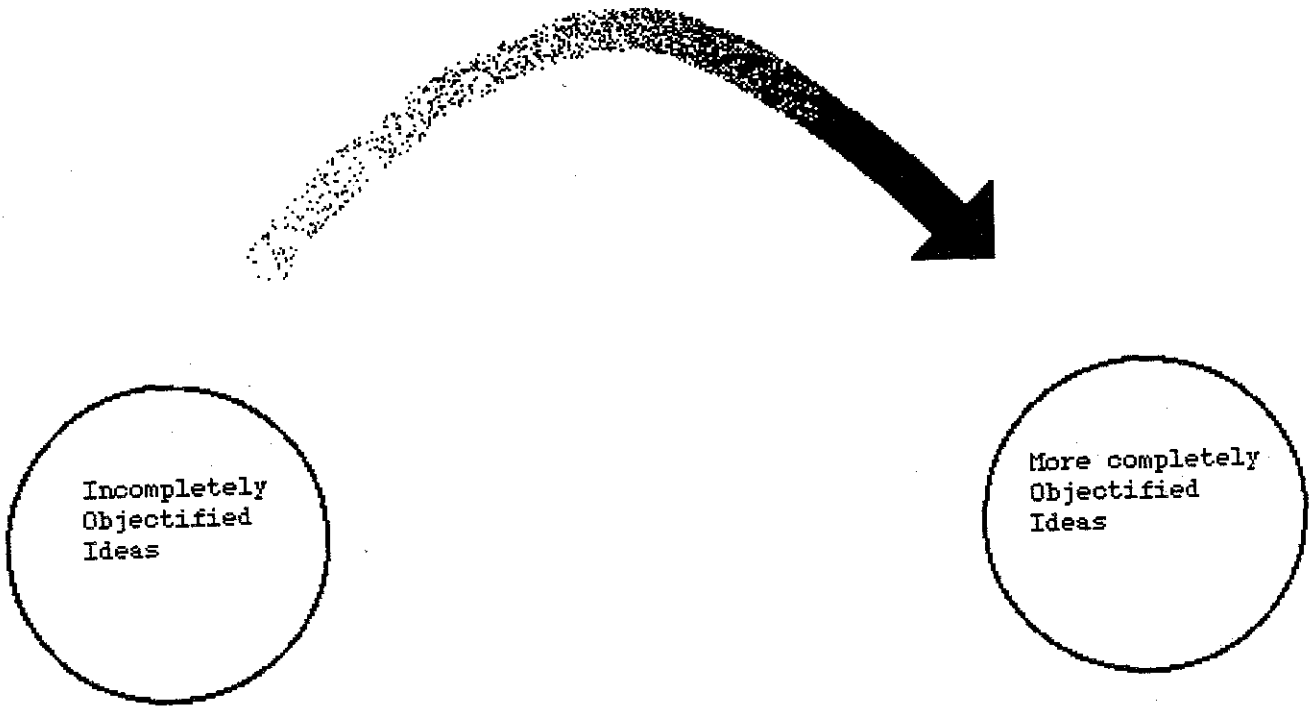
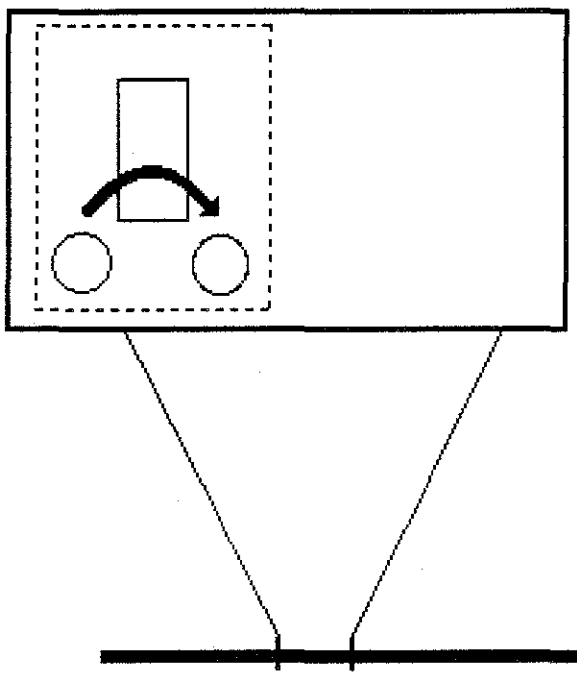


Figure 2: The Embedding of Intellectual Work
in Events and Activity Frames



Beginning:
Initial Project
Definition
and some vague
ideas

Duration of Project -->

End:
Formalized
Artifacts and a
Computer
Program

Intellectual work takes place in events such as meetings, informal exchanges in the hall, telephone conversations, or work episodes before the computer.[6] This embedding of intellectual work in events is depicted in Figure 2. The inner rectangle represents an event. The events (and the intellectual work), in turn, are situated in an activity frame. In Figure 2, the outer dashed rectangle represents an activity frame.

In our study of programming teams we identified three activity frames or three ways of constituting the work at hand. They are:

1. product logic/aesthetics

2. institutional demands and rewards

3. struggle

Product Logic/Aesthetics: The focus of a product logic/aesthetics orientation is the evolving computer program. Group members with this orientation were committed to (and often fascinated by) the ideas and concepts of the product or the problem posed. Work not directly related to the actual functioning product, (administrative work, writing documentation, relating with Boss and Client, etc.) was considered secondary and much less effort and concern was spent on those tasks. Planning for, and awareness of, deadlines was low. Work directly related to the product (design, coding, and testing) was primary. The ideas embodied in and the structure of the product--its logic and aesthetics--motivated the group and held the group together.

Institutional Demands/Rewards: The focus of concern in this frame is on achieving institutional success, in this case as measured by grades. Groups with this orientation sought to impress the Boss and satisfy the Client. The group members were not particularly motivated by the challenge of the program, nor were they particularly committed to their own ideas and concepts for the developing program. The emphasis on fulfilling course requirements led to a concern with meeting deadlines, producing good documentation and support materials as required by the instructor, and otherwise maintaining good relations with the Boss and Client.

Struggle: In this frame the work is viewed in relation to a struggle--either a struggle within the group or a struggle between the group and outsiders vital to the success of the group's work.

Groups caught up in internal relations struggled over intra-group politics. Battles over leadership, concern over control of the product, and personal differences dominated over other concerns. During periods of internal struggle the work pace slowed dramatically as decisions were continuously challenged and commitment to design was low. Members sometimes adopted more formal means of communication and in some cases stopped speaking altogether. (See Reder and Schwab [1989:186-7] for changes in communication device in a case of a critical interaction.)

External struggle is characterized by a focus on a dispute or a difficulty between the group and someone or something outside of the group. The group might be engaged in an effort to acquire a difficult to get resource or might be in contention with the Client or Boss. Work pace can slow here also as the group awaits the outcome of the struggle. There is an emphasis on making contingency plans and redefining the project if necessary.

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[6] Defined technically, events are sets of socially and culturally organized actions that take place in a physical setting. This definition as well as our definition of activity frame and intellectual work derive from the theoretical frameworks of practice and activity theory. More details are included later in the paper.

Shifts of Activity Frame: To some degree teams oscillated among these frames, but out of the three groups we followed, two of the teams maintained one frame most of the time. The other one and the one that we followed by interview switched between frames more frequently.

Being in one activity frame does not exclude attending to concerns associated with another frame. But there is generally a predominant frame at any particular time and that frame affects the time and attention left to devote to the additional concerns. A group meeting might be primarily oriented to product development, for example, with a small amount of the meeting time devoted to difficulty with securing a needed resources (an external struggle).

Of the groups we directly observed, the following predominant orientations were noted for each group:

Group #1: Primary frame--product logic. This frame was consistent throughout entire project except for an internal struggle that developed toward the end of the project and a final flurry of activity to get the project in the shape most likely to secure a good grade.

Group #2: Primary frame-- institutional demands and rewards. A secondary internal struggle developed about half way through the project over leadership.

Group #3: Primary frame--struggle. There was considerable oscillation of activity frames during the project. The team began in the product logic frame, but that frame rapidly became secondary in the face of external struggles. The length of the external struggle and its ramifications led to an internal struggle. In the last quarter of the semester, the primary frame switched to a concern with institutional demands and rewards, during which the bulk of the project work was completed.

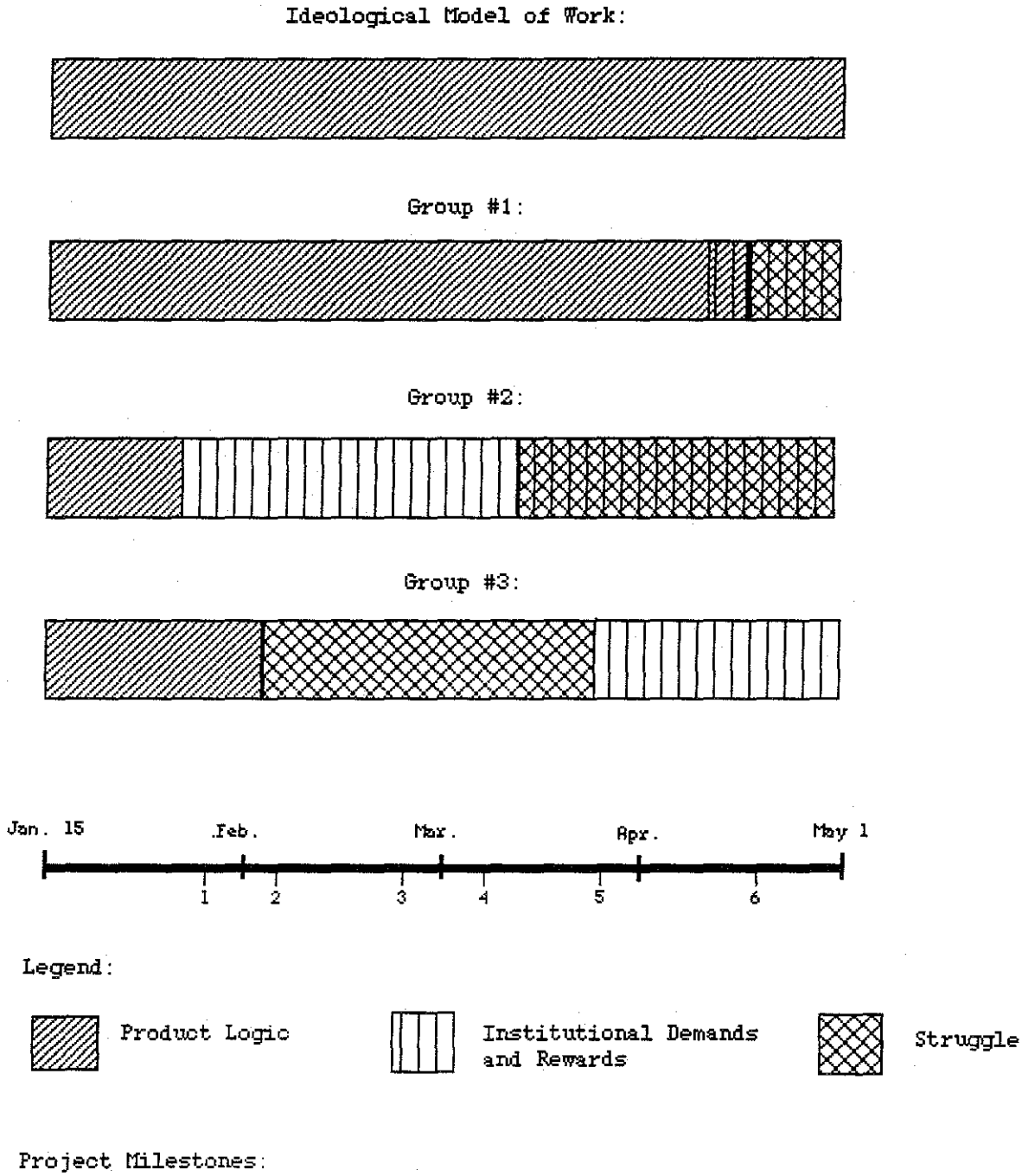
Figure 3 depicts the shifting activity frames of the three groups as contrasted with the assumptions of the ideological model.

The Significance of Activity Frames for the (Non) Use of Cooperative Work Tools

The significance of the activity frames is that a group's primary frame affects their orientation to events and to the intellectual artifacts that they are producing. Social relations are also valued in different ways. When oriented by a product logic frame groups produced many informal notes and diagrams about the design and developing program. Typically these intellectual resources were scrawled notes or diagrams on scratchpaper that were meant to aid a specific task. Often these artifacts were discarded immediately after they had served their purpose. These artifacts were intended for the group and for individual group members. These types of artifacts were produced in a variety of settings. Members of group #1 would sit together during class and pass a piece of paper back and forth between them with design comments and drawings. Group meetings tended to be design discussion sessions where many alternatives were proposed and the program was thought through from different perspectives: from that of the user, the integrity of the program, and the relationship of the program to supporting hardware. Communication of ideas through graphic means (including an abundance of hand gestures) was frequent.

For groups in this frame, there was a low emphasis on formal documents. The program was considered substantial and innovative enough that the importance of formal supporting materials seemed fairly trivial. For example, Group #1 "discovered" that a draft of the implementation manual (a required formal document) was due the next day. The group quickly assembled the draft from the various informal design artifacts and personal working notes group members had retained.

Figure 3: Shift in Activity Frame Over Course of Project



The Boss and the Client did not play a large role for groups in this frame. Group members' satisfaction with the program was more important than conformity to the desires of the Boss and the Client.

The group that was primarily focused on course requirements and institutional rewards (grades) expended their energy producing formal documents. Well done formalized documents helped the groups with programs that either did not work out or were not particularly challenging from the start. Group #2 produced a systems analysis in the format of a formal technical report as part of a project that ended up requiring remarkably few lines of code. Group #3 focused on trying to produce superior documentation when it appeared that their program might not work at all. The Producer of Group #3 basically stated that great documentation could save their grades.

This frame can also involve a significant effort to keep the Boss and Client satisfied. Group #2 met extensively with their Client for this purpose and the Boss and Client played a very active role in the design and planning efforts of the group. Group #3 kept the Client satisfied by managing his expectations of the project.

Group #3 became virtually paralyzed by an external struggle to acquire a critical resources for their project. They spent a great deal of time focused on negotiations with people outside of the group. When Group #3 finally received the resource they had been waiting for they had to seriously scale down their project in light of the few weeks remaining in the semester.

In another case the external struggle was a muted one with the Boss. There was an effort at presentation management: the group took the Boss "out of the loop" and did not give him a clear idea of how the project was actually progressing.

In cases where group work took place in the midst of an internal struggle, there were attempts to control intellectual resources already produced as well as attempts to control the means of producing more artifacts. In Group #2 one of the members refused to share books and other resources obtained from the Boss and Client and also attempted to monopolize resources such as the whiteboard during meetings.

Consequences of These Different Activity Frames for Computer Support of Intellectual Teamwork

Our project was undertaken in part to inform the development of a system of computer support for collaborative work. The system is addressed, in part, to the creation, storage, structuring, and retrieval of the intellectual resources and products that are created during a project. Our observations suggest that activity frames affect the ways these intellectual resources and products are valued, stored and linked to the end product. Each group would be likely to have a different set of tools they would find most useful. Group #2's emphasis on formal artifacts suggests that tools to support the development of documents, such as high quality word processors or desktop publishing programs would be most valued and therefore most useful. Such a system would have had held much less attraction for Group #1. Group #3 might have become more attracted to such tools when they were forced to abandon hope of creating an outstanding program and decided to move instead to good documentation in the hopes of at least obtaining a decent grade.

More generally activity frames help to explain why seemingly simple transfers of technology may prove more complicated than might be imagined. An example is provided by the translation of a shared drawing surface such as a whiteboard from its current manifestation in meeting rooms to a shared drawing tool on a computer-supported collaborative work system. It would seem that the apparent functionality of the whiteboard could simply be transferred to the drawing tool: a number of participants should be able to draw on a surface clearly visible to all.

But is the transfer so simple? Should research devised to study such a design be based upon the ideological model of intellectual work that assumes a constant focus on the team on product logic and aesthetics? Should, as in the case of research conducted by Tang and Leifer 1989 (see also Tang and Minneman 1989; Tang 1990), the workspace activity and the role of gestures always be interpreted in relation to its contribution to design or conceptual work? In our own research we have observed that groups use whiteboards not only to further the conceptual work on their projects, but also to control the group in a struggle. Tools are not just used for their obvious, surface functionality in a product logic frame, but in other ways as well. The drawing tool is likely to be appropriated in ways different than those imagined as a result of shifting activity frames.

Results of this type did apparently occur in the case of the Capture Lab (Mantei 1988; Erickson 1989). Efforts were made to make the electronically supported meeting environment as close as possible to the original meeting environments of the intended users. Nonetheless there were some significant changes in behavior among managers using the Capture Lab. Most of these changes were directed toward maintaining power and control as opposed to engaging in conceptual work. The concept of activity frame helps to account for these results.

Implications For Methods In The Study Of Intellectual Teamwork

Our findings, based on the study of groups carrying out entire projects, point to some limitations of the type of research described by McGrath (see page 1, above) which focuses on one or two specifiable, repetitive tasks assigned to the team by management or by an experimenter. Experimentally designed research sometimes creates groups with no history and, as we would put it, tries to set the activity frame to that of product logic (see Austin, Liker, and McLeod 1990, for an example of this type of research methodology. In addition to McGrath 1990, see Ancona 1987 and Lave 1988 for critiques of this type of methodology). Such research may enable predictions as to whether groups of strangers who are convinced to work on a particular task will use the type of technology studied, at least at first. But we cannot be sure how groups that have constituted a different activity frame (e.g., struggle or institutional demands and rewards) will use it or how groups will use it as they develop a history of working together.

Implications For Theory

"Activity frames" also have relevance for theory. Our research has been guided by practice theory in anthropology (e.g., Bourdieu 1977, 1990) and a compatible theory from the cultural historical school of psychology associated with neo-Vygotskian and activity theory (Wertsch 1981, 1985; Vygotsky 1962, 1978, 1987). A pivotal assumption of this family of theories is that cognition is situated (Suchman 1986a, 1986b, 1986c; Suchman and Trigg 1990; Engestrom 1987, 1990; Lave 1988; Wertsch 1981, 1985, 1991).[7] Attending to the fact that intellectual work always occurs in a context, this perspective describes cognition--collaborative or individual--as "distributed over the social and physical environment" (Suchman 1990; Suchman and Trigg 1986; Hutchins 1990; Goodwin n.d.; Goodwin and Goodwin 1991). As we would put it: Intellectual work--that is, the making of ideas into cultural objects which are then used to guide the further objectification of ideas and practice--takes place in and bears the traces of events that are socially

[7] The theoretical approach has been extended in a very productive way to learning as well (see, e.g., Lave and Wenger 1991).

and culturally constituted in a physical setting.[8] The concept of "activity frame" further specifies the notion of "situatedness."

We have used the term "activity frame" to suggest that events and the objects produced in events are given significance by their embedding in larger contexts--in webs of relationships, institutions, and meanings that transcend single meetings, work sessions before the computer, and other such events. "Activity frame" refers to the group's collective sense of this embedding of its work. The work is situated in an activity frame and the frame is important because it provides the meaning of and motivation for the work at hand.

"Activity frame," it should be noted, differs from "activity," a concept that has been developed and applied by Lave (1988), Wertsch (1985, 1991), among others.[9] In fact, "activity" is a central concept for these theorists. They hold that problems will be viewed (and even solved) differently when the context or activity is "work" rather than "school", "play", "family" or some other basic form of human activity.

We do not use the term "activity" for what we call activity frames because all of the teams we followed were engaged in the same activity--work. We needed a term for different ways of orienting to the same activity.

Activities have very deep cultural historical roots. "Work," for example, is an activity that has developed in particular ways in the industrialized world over several hundred years. "School" is another form of activity with deep roots in the West. These are basic concepts grounded in institutions of long duration that we in the industrialized West, at least, use to interpret our lives. The concept of "activity frame," in contrast, is more particular, more localized. It refers to a group's conceptualization of an activity and its place in the activity as it is realized in the particular circumstances. Activity differentiates between institutional forms; activity frame differentiates within institutional forms.[10] The computer groups we observed all construed what they were doing as the activity of work in particular, the writing of a computer program; they differed, however, in the ways they oriented to or framed that work. These activity frames were important because they affected the outcomes of their work. Intellectual labor, in short, is situated in events and constituted by activity frames.

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[8] See Linde (nd) and Jordan (1990) for relevant studies that analyze the construction of these events through technological and social resources.

[9] See these references for descriptions of the roots of the concept in activity theory.

[10] Clearly "activity" and "activity frame" are not mutually exclusive. There is not the space here to follow out all the ramifications of this distinction or to point out how our concept differs from similar ones such as that provided by Lave (1988, for example). Holland and Eisenhart (1987, 1990) discuss a similar phenomenon on the part of individuals. They found several different orientations to schoolwork that profoundly affected the students' interpretations of college and the work that was given to them to carry out.

Summary And Conclusions

If McGrath's (1990:27) report is correct, our studies of intellectual teamwork are somewhat unusual in that we were able to follow teams over the entire life of a project. More commonly, teams are studied as they conduct a particular task that may not even be part of a larger project. This type of research, it could be argued, assumes without investigation that intellectual work actually proceeds according to what we have referred to above as the ideological or rational model of intellectual work. Our research--as well as other research, similarly guided by practice and activity theory--raises doubts about the wisdom of accepting the ideological model as useful theory. Work does not necessarily proceed according to a rational sequence. Groups do not always spend their time oriented to achieving the conceptual integrity, coherence and elegance of the product they are trying to produce.[11]

In this paper we identified three activity frames or orientations to work of the teams that we studied. Sometimes groups worked to develop their product (in this case, a computer program) according to standards of conceptual integrity, coherence and elegance; sometimes they worked to satisfy course requirements and affect their grades; and sometimes they worked to support or oppose factions inside the group and/or problematic figures outside the group. Phrasing these activity frames in more general terms, we could say that groups were sometimes oriented to product logic/aesthetics, sometimes to institutional demands and rewards, and sometimes to struggle.

We found, in brief, that, contrary to what the rational model of work might suggest, intellectual teams are not always focused on problem-solving with regard to product logic/aesthetics. Even when the talk among members of a group in a meeting is seemingly about the product it may be conducted in such a way that the status of a particular member is attacked. In such situations, ideas become the means to affect social relations not the actual focus of the discussion. Or, for those oriented to course requirements, the wishes of the Client may dictate the group's efforts to the point that they never consider other ways to design the program. These orientations, as we have argued above, affect the conduct of events and the intellectual products and resources that are produced in these events .

The groups we followed differed in which frame predominated. The groups also differed over time in terms of which frame was most important. We argued above that the differences between groups and the shifting of frames for each group over the life of the project suggests that

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[11] McGrath's (1990:29) formulation of intellectual teamwork is interesting in regard to the ideological model. He argues that project activities involve a series of stages: goal choice, means choice, policy choice, goal attainment. But he qualifies this rational sequence by the following: "Project activities involve a series of stages, but those stages should be regarded as a logical template for potential project activity, rather than as an endogenous set of inevitable developmental phases." It is unclear from this passage whether he means that groups that are logical will follow this pattern, that groups are sometimes able to achieve such a sequence of work, or whether the intellectual work of groups may be retrospectively cast in such a sequence.

McGrath's model intersects with ours in some respects and not in others. His approach delineates aspects of group life (e.g., status) that may become the source of a struggle and he delineates aspects of group behavior (i.e., output) that may be important to an institution. On the other hand, the underlying theoretical approaches differ. While we are interested in the group's constitution of its work and thus in accounting for group behavior by the meaning attached by the group to its intellectual products, McGrath takes a structural-functionalist view of groups as entities which have needs and develop over time. Structural-functionalist models have been found useful for some purposes, but not so useful for an understanding of conflict and change.

technology developed to support intellectual teamwork must be flexible enough to handle these shifts.[12]

Finally we suggested that the concept of "activity frame" be used to further specify the theorization of intellectual work as situated.

[12] It is possible, of course, that our groups were unusual. Perhaps student programmers do intellectual work in unusual ways. Perhaps the groups we observed differ significantly from those to be found in different institutional settings and from those composed of members with longer experience in collaborative teams. Possibly groups are better controlled in the software industry, for example, so that group behavior does cohere to the ideological model. Nonetheless, our work suggests that such coherence is not automatic, that it must be brought about in some way and that this control is likely to affect the work in a significant way.

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