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ABSTRACT

In a nontraditional engineering course students participated in internships in which they worked in teams for local industry or government clients to develop an engineering solution to an open-ended problem. This paper focuses on one of the teams as it solved the problem and explores the organization of the team's work within the constraints of the classroom, as well as their learning and its impact on the students' identities as engineers. Required class sessions included lectures by professors of English on report writing, public speaking, and information gathering. The team of 6 (later 5) students was observed 25 times over the semester in different settings. Student understanding and the team's organization of its work within the constraints of the classroom produced mixed results. Knowledge growth during the semester was substantial, but it was more a result of being a good student than of being a good engineer. Task organization, knowledge, and developing identity remained more academic than professional engineer. Replacing the entrenched engineering school culture with real-life experiences requires more than incorporating an engineering problem into a class. One figure illustrates the discussion. (Contains 16 references.) (SLD)

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Organization, Knowledge, and Identity: A Collaborative Team in a Nontraditional Engineering Class[1]

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Introduction

Instead of attending to his team's discussions, Paul[2] prepares for an exam in another class, his senior seminar on concrete structures. He is studying professor-prepared lecture notes - neatly handwritten equations, diagrams, and explanatory text. He focuses on one of these pages, especially a diagram near the lower left corner that is about three inches square. Dr. Smythe, a professor of English who team-teaches this sophomore engineering class where Paul is surreptitiously studying for his test, notices Paul's notebook and asks "What's that?," referring to the figure. Paul explains (Fieldnotes, 1-27, p. 5):

> Paul: It's a stress-strain diagram. It's hard to explain what it represents, but we use them to design supports and predict how a member will fail. For instance, when a concrete member is formed around an I-beam of steel, the design criteria is for the steel to deform elastically - bending, not breaking - and then a bulge in the concrete can be seen and the folks can be evacuated before it falls and crashes. If the concrete fails first, it is catastrophic.
>
> Dr. Smythe: Is that like the Oakland viaduct that collapsed?
>
> Paul: It's kind of like it, because the way the re-bar *[metal reinforcing rods embedded in the concrete]* was shaped *[and here he draws a sketch showing the re-bar shaped like an upside-down tulip]* caused the two levels to converge rather than standing apart. *[He reinforces his ideas by drawing a second sketch of the correct design which looks like a tulip that is right-side up.]*
>
> Dr. Smythe: Wow! That's really impressive.

As evidenced by Dr. Smythe's "Wow!" Paul's technical discourse has explanatory power. He named the kind of diagram he was studying, described its purpose, and gave an example of its importance in his engineering specialty. In addition, when Dr. Smythe asked about a specific catastrophe, Paul connected his "for-class" knowledge to the Oakland viaduct collapse (during the 1989 Loma-Prieta earthquake). His explanation was significantly different from those that his sophomore teammates gave during the class I studied. What did this difference in explanatory power mean for the students'

1 This research was funded in part by a Spencer Foundation Grant (1992) to Dr. Margaret Eisenhart. Tonso (1993) contains the ethnographic case study of this innovative engineering class.
2 All names are pseudonyms.

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knowledge growth and developing identities as engineers? How did the sophomore students' abilities to explain technical information and apply it to their team's project change during the semester? How did these changes in students' knowledge influence their developing identities as engineers? How did the organization of the team's task within the engineering course, students' growing knowledge, and developing identities mutually constitute one another?

In order to investigate these questions, I studied engineering students engaged in a required engineering course[3] designed to parallel authentic engineering work. The nontraditional engineering course incorporated internships where each team of students worked for a local industry or government client to develop an engineering solution to an open-ended problem. So, rather than being either a traditional engineering class where little real-world, hands-on engineering occurred, or an apprenticeship where no classroom practices existed, the nontraditional course combined features of traditional engineering classes with engineering work. In this paper, I focus on one of the student teams as they solve their client's engineering problem: their organization of the team's work within the constraints of the classroom, as well as their learning and its impact on their identities as engineers.

Conceptual Framework - Situated Learning

In unraveling the complex weave called learning, educational researchers seek a theory explaining cognition and its use in both schooling and real-world activities - assuming that one of the central purposes of schooling is to prepare students for the real world. Early educational research located cognition in the head. Working in laboratory settings, these researchers investigated learning as a context-free mental process that transferred across settings. Meanwhile, cognitive and educational anthropologists, studying learning *in situ* in everyday settings, found cognition inseparable from the processes of social interaction and its settings; that is, "'cognition'...is distributed - stretched over, not divided among - mind, body, activity and culturally organized settings (which include other actors)" (Lave, 1988, p. 1).

Lave (1988) expanded the discussion of context beyond cognitive psychological and phenomenological perspectives. Context for cognitivists focused on the "individual's mental modes and cognitive structures" (Engeström, 1993, p. 165) without accounting for social interactions. The phenomenological view overcame the lack of social interaction present in the cognitivist view, but was limited by "its discontinuities between the individual and social order" (Lave, 1988, p. 150). Context for phenomenologists was "the environment of social interactions," but "it is unable to account for macro-social, political-economic structures which, it appears, individuals can neither create nor negotiate directly" (Lave, 1988, p. 150). Neither perspective was adequate: "one has system without human experience, the other experience without system" (Lave, 1988, p. 150).

[3] This course has been required of all students for the last 12 years.

Rather than learning being devoid of contextual features, Lave envisioned learning as shaped by context, just as what one has learned (one's knowledge) shapes the context:

> On the one hand, context connotes an identifiable, durable framework for activity, with properties that transcend the experience of individuals, exist prior to them, and are entirely beyond their control. On the other hand, context is experienced differently by different individuals....Because a social order and the experience of it mutually entail one another, there are limits on both the obdurate and malleable aspects of every context. (Lave, 1988, p. 151)

Thus, contexts are not merely the physical receptacle where activities play out, nor transient face-to-face encounters, but a system which integrates participants, tasks, artifacts, and socioeconomic/sociohistorical structures of a community.

Lave and Wenger's (1991) theory of situated learning is such an integrative system, accounting for "theoretically generative interconnections with persons, activities, knowing, and world" (p, 121), where learning is located not in the heads of individuals, but in the processes of coparticipation (Hanks, Foreword to Lave & Wenger, 1991, p. 13). In their theory, persons (the first component) are participants or practitioners, "newcomers becoming old-timers, whose changing knowledge, skill, and discourse are part of a developing identity - in short, members of a community of practice" (p. 122). Even though a participant is not a full-fledged expert, s/he participates to the extent of her/his level of expertise at the time. This concept of person, as both a member of community and agent of activity, "links meaning and action in the world" (p. 122).

Activity, the second factor, is guided by participants' desires to become more proficient, and ultimately full, practitioners in their community of practice. Lave and Wenger called the kind of activity that allowed participants to be contributing members of the community, yet not full-fledged experts in the community, legitimate peripheral participation. In their model, all practitioners have access to the culture of the community, though at any given time or location, different practitioners could be (in fact, would be expected to be) at different stages of development or xpertise. Thus, participants move along a trajectory from newcomers to old-timers, developing mature identities, while engaged as productive members of their community.

The third factor, knowing, marks the movement of participants along their trajectory from newcomers to old-timers. This growth and attendant transformation of identities is evidenced in "relations among practitioners, their practice, the artifacts of that practice, and social organization and political economy of communities of practice" (Lave & Wenger, 1991, p. 122). Thus, knowing is part and parcel of identity and activity. Knowledge holds value because of its use in moving along trajectories, rather than its value as a commodity for exchange.

Social world, the fourth and final aspect of Lave and Wenger's theory of situated learning, is the location of these dialectically constituted practices. Lave and Wenger understood learning as being influenced not only by the immediate surroundings or relationships, but also by larger structural features, the backdrop against which communities of practice operate. Historical, political, and economic circumstances provide constraints on the one hand and opportunities on the other, and in this climate, communities of practice systematically constitute and transform themselves.

In addition, Lave and Wenger's theory of situated learning allowed for knowledge to be conjointly held among several individuals - a point made even more apparent by Hutchins' (1993) study of navigation aboard a naval vessel. He studied navigation as one example of a process of coparticipation. In navigating, the "fix cycle" - plotting the ship's position, projecting its path of travel, and gathering new data to update the location after a specified time - continues around the clock. When traveling in restricted waters (near land or other vessels), very frequent observations are required. In order to fix the location minute-to-minute, the work of making observations and performing computations is distributed across six people: two bearing takers (one stationed on either side of the ship), the bearing timer-recorder, the plotter, the keeper of the deck log, and the fathometer operator. In progressing from novice to expert, navigation team members move from bearing taker, to bearing timer-recorder, and then to plotter. Thus, more experienced team members verify the work of novices. For instance, as bearings are relayed from the observation posts to the pilot house, both the bearing timer-recorder and the plotter, as former qualified bearing takers, check the reported bearings. Similarly, the plotter, as a former bearing timer-recorder, provides a check on the bearing timer-recorder's work. Another check comes from the fathometer operator who measures the depth of water under the vessel contemporaneously with the bearing measurements. Comparing this measured depth to the expected chart depth at the plotted location gives an additional check on the ship's position.

In addition to checking lower-level tasks, team members learned about the higher-level tasks performed by other sailors. Bearing takers communicated directly with the bearing timer-recorder and came to know something about the tasks done at the next higher level of expertise, bearing timer-recorder. Likewise, the bearing timer-recorder knew about, but was not competent to perform, the plotter's tasks. Distributing the knowledge across the team members created a flexible system where redundant expertise of the entry-level tasks allowed more-experienced team members to substitute for novices. Also, the access to each other's tasks made it possible for team members to monitor and assist each other in a robust system with error-checking routines compatible with the necessity of continuously updating the ship's location. Here, the demands of the activity, its constraints and opportunities, played a substantial role in the delineation of tasks and in participants' interactions.

My study of engineering students, working collaboratively to solve an engineering problem for an industry or government client, appeared to provide a fertile context for learning where the organization of their task, the students' growing knowledge, and their movement along a trajectory from engineering student to engineer would be mutually constitutive. The nontraditional engineering course was designed to parallel the work of real-life engineers; that is, the problem to be solved would be an "everyday" activity for a team of engineers. Nonetheless, because a college course incorporated the internship, my research site was a hybrid setting. In studying the engineering course, I was

Week #	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*
WRITTEN															
Meeting Minutes	A	B	C		D	E		A	B	C		D	E		
Draft Area Report						x									
Area Report								x							
Draft Project Report													x		
Project Report															x
ORAL															
Client Meetings		x						x							x
Staff Meeting				x											
Cross-Examination											x				

Primarily ethnographic methods were used to collect data in the nontraditional class: participant observations, in-depth interviews, my personal journal, collection of documents describing the course, and collection of written materials and other tangible artifacts used or produced by the students and/or professors. As I gathered data and performed analyses of the data, I did not take the perspective of a disinterested researcher, but situated myself in engineering education as a researcher committed to understanding the learning in this nontraditional course. My experiences as an engineering student on this campus (25 years ago) and as an engineer (for 15 years) provided a vantage point informed about engineering skills and students' development.

During the semester, I observed Team A a total of 25 times in three different settings: 1) in the classroom with three professors and the entire class of approximately 45 students present, 2) in meetings the team had with their clients, and 3) in meetings the team had with the faculty. Table 2 lists the student and faculty participants. Team A began with three men and three women, though Paul (the

Table 2. Students and professors studied closely.[6]

Professors	*Team A*	*Team B*
Dr. Jarrett	Amy	Eduardo
Professor Mason	Chuck	Fred
Dr. Smythe	Doug	Jeff
	Franci	Louis
	Jennifer	Robin
	Paul (dropped)	

senior student in the introductory vignette describing the stress-strain diagram from his concrete structures course) dropped the course early in the semester. Team B had four men and one woman (Robin). Professor Mason was male and Drs. Jarrett and Smythe were female.

[6] For the professors, I include the appellation used most often in the classroom.

particularly interested in the organization of the team's work and in whether learning was stretched over participants, activity, settings, and social world, as well as whether knowledge was held conjointly among several individuals. I wondered whether growth along a trajectory from novice to expert and indicative of students' developing mature identities would be evident.

Methodology - Site Selection, Data Collection, and Analysis

The classroom studied was at a state-supported engineering college of 2700 students (two-thirds undergraduates) in the Rocky Mountain region. Admissions criteria were selective and typical of engineering: all entering students had high school grade point averages above 3.0, SAT scores for the mid-50% ranged from 570-690 for math and 470-600 for verbal (ACT scores of 24-28), and high school class ranks in the top one-third of their graduating classes (CEEB, 1992). The school has a tradition of academic excellence and a reputation for producing capable engineers.

The course studied was the fourth in a sequence of courses required of all students during their first four semesters at college. The first three semesters in the sequence provided introductions to word processing, computer spreadsheets, computer-aided design, FORTRAN programming, graphic visualization, and technical writing, as well as oral communication, teamwork, and professional ethics. In each of the first three semesters, students worked in teams to solve one open-ended problem for one shared client, but in the fourth semester, each student team worked on a different problem with their own client. In the fourth semester, "all writing, oral communication, and group work is integrated with the project. Project work strongly emphasizes self-education, integration of graphics, computing, and subjects taught outside of [this program], teamwork, professional ethics, and effective use of evidence" (Bulletin, 1992, p. 110).

Within the class, I selected two (of the eight) teams based primarily on two criteria - similar projects, but different gender makeup. In this paper, I focus on Team A to track their activity during the semester[4]. Students met with the professors for regularly-scheduled classes two hours, twice a week during the 15-week semester. In the first part of each class, one of the three professors (one professor of engineering and two professors of English) lectured about report writing, public speaking, or information gathering. During the rest of the class period, student teams met and discussed their progress and plans. The vast majority of my research data came from these required class sessions. Table 1 summarizes the work (written and oral) that the students and student teams were required to present during the semester:

Table 1. Summary of the required student and team products.[5]

[4] Tonso, Miller, & Olds (in press) compared the teams' activities, noting how the gender makeup (among other things) contributed to differences in each team's organization.

[5] Under Meeting Minutes, "A" indicates that student "A" wrote the minutes the first week, student "B" the next week, etc.

Ethnographic interviews were held twice during the semester. During the seventh week of the semester, I interviewed Jennifer and Chuck (Team A). At the end of the semester, I interviewed all ten students and the three profe· ·ors. Analysis of the ethnographic data proceeded using Spradley's (1979, 1980) systematic procedures of semantic domain analysis and Van Maanen's (1988) literary ideas about constructing vignettes. Late in the semester, I surveyed 39 of the 42 students enrolled in the class to gather information about student demographics, high school academic preparation for engineering school, and attitudes toward 1) perceived competencies in math and science, 2) skills used or learned in the innovative course, and 3) the perceived utility of the course. The survey was analyzed statistically. While studying students' conversations during team meetings, it became apparent that the students' level of technical explanation improved dramatically during the semester. I developed an instrument (Table 3, after Scardamaglia, Bereiter, Brett, Burtis, Calhoun, & Smith, 1992, p. 62) to score the technical language use and depth of explanation of the st dents during their team meetings and oral presentations. Repeated, careful readings of the data were used to strengthen the findings and to rule out competing conclusions or theories. The research results incorporated different perspectives and methods which allowed for triangulation of the research results.

Table 3. Technical language use and depth of explanation

Levels Used to Assess the Technical Language and Depth of Explanation in Students' Team Meetings and Oral Presentations
1. Absence of technical language, inarticulate; use of vague descriptors such as "things" or "stuff."
2. Technical language used, but sparsely and without evidence of meaning.
3. Technical language used and connected to isolated facts, but not related to other facts.
4. Local integration of facts, especially in one area of technical expertise or in one site or instance.
5. Networks of related facts indicating a preliminary explanation, especially connecting information from two areas of expertise.
6. Elaborate description or explanatory account, knowledge extended to a novel situation.

Organization of the Task, Knowledge Growth, and Identity Formation

Throughout the semester, the class met twice weekly for two-hour sessions. Attendance was required of all students and, on a typical day, only one or two of the students missed class, none on a regular basis. Class began with whole-class lecture by one or more of the professors and ended with time for student teams to meet and discuss their projects. The professors' lectures covered the logistics of due dates and required meeting times, as well as detailed information about how to deliver oral presentations, how to write technical reports and meeting minutes, and how to function as a group. Though the students generally listened quietly to the lectures, their lack of note-taking and their failure to respond to questions indicated a disregard for much of the lecture. After the lecture portion (usually the first 30-45 minutes of class), student teams discussed their projects. It was not uncommon for a team to pack up and move next door to another, smaller classroom or to leave and visit another campus location, such as the library, copy center, or computer center. However, most of the teams remained in the classroom. Team meetings during regularly-scheduled classes accounted for over 80% of all team meetings and provided the vast majority of research data about student discourse in a collaborative setting.

<u>Organization of the Task</u>

Throughout the semester, the course schedule motivated the student team's work. Faculty distributed the schedule covering all 16 weeks of classes at the first class and students never deviated from it. A portion of the coursework schedule is included in Table 4.

Table 4. Portion of the Coursework Schedule - Spring 1993.

Week # Date (Mon.)	Monday or Tuesday	Wednesday or Thursday	Assignment Due Friday
#0 Jan. 4		Mtg. 1-Course and Project Info	
#1 Jan. 11	Mtg. 2-Assign Projects, Minutes	3-Prep. Client, Time Mgmt., Photos, Exercises 1,2,3,4	Minutes by A
#2 Jan. 18	4-Client Meeting	5-Client Letter	Client Letter by B
#3 Jan. 25	6-Area Decisions Ex. 5,6,7	7-Oral Instructions #1 & #2	Minutes by C
#4 Feb. 1	8-Oral Status Report (Taped)	9-Oral Tape Review	

At the sixth class meeting, the faculty directed the team to divide the project into areas of expertise - one per student, a process Professor Mason called "divide-and-conquer." The structure of the student team was modeled on industry engineering project teams where teams are formed by bringing together engineers or scientists with different technical expertise. However, the student teams could not be formed in this way, because the engineering students were [illegible] et technical experts. Instead, the professors assigned students to teams based on student project preference, while maintaining diversity in students' college majors, gender, and GPA. Rather than assigning technical expertise to a team, the course was structured so that each student developed technical expertise during the first half of the semester.

Team A students were working for a local mountain town's city government to provide a summary of needed renovations to bring the town's National Historic District into compliance with the Americans with Disabilities Act (ADA). The division into distinct areas of expertise was very informally accomplished on January 25 (the beginning of the third week of classes). Rather than creating a comprehensive list of potential project areas as suggested by the faculty, a student made a suggestion and one of the team members volunteered to cover that area. For instance, Doug suggested that "we need to do ADA," and Amy replied "I'll do that." There was no discussion about what this category might encompass or how it related to the other areas. This was continued until each of the students had a topic. The team agreed to these areas of expertise (Fieldnotes, 1-25, p. 5):

Amy	ADA rules and regulations,
Chuck	Buildings covered
Doug	Attitudes of the townspeople
Franci	Renovation expenses
Jennifer	History of the town and National Historic District policy
Paul	Previous renovations in National Historic District buildings

Within two weeks, Paul dropped the course and his area of expertise left with him; that is, none of the remaining team members pursued information in his area.

The students understood the "divide-and-conquer" task very differently from the professors. For the professors, the task meant a thorough explication of all facets of the project and then parceling these facets among the six team members, ensuring that no important areas were overlooked and that all team members shared the work equitably. For the students, the task was to name areas of expertise, volunteer for one, and stop when six topics were assigned. This conclusion is strengthened by noting that, if the professors' understanding were used, Paul's area should have been essential to the successful completion of the project, but after he left, his area disappeared. By not challenging the student team's omission of Paul's area, the professors implicitly reinforced the student team's understanding of the "divide-and-conquer" task and weakened the professor's earlier statements.

In addition, Professor Mason's "divide-and-conquer" model promoted individual (and not collective) ownership for technical information which he phrased as advice to the students: "Don't do anything that's dependent on others" (Typical class vignette). The students interpreted each area of expertise as the sole responsibility of its expert which made synthesis of information between areas of expertise difficult. Even though the area reports were designed to promote exchange of technical information, the students used these for this purpose only to a limited degree. There was little effort made by teammates to become familiar with the technical information detailed in another student's area report. None of the students I interviewed read the area reports that his or her teammates wrote except in a very cursory fashion. Instead of informing each other, the area reports served as each student's personal reference text when he or she was asked a specific question about his or her area of technical expertise. Amy said:

> In our group, I know that each of us didn't pay a whole lot of attention to what each person wrote in their area. If we needed to know things, we did look at area reports, but usually it was more like the person that wrote it used it as a manual to relay information back. So if you have a question about somebody else's area, you don't necessarily go to their report, you ask the person, and they go to their area report. (Interview, 4-21, p. 8)

Chuck noticed that "we're [his team is] working apart" writing area reports (Interview, 2-25, p. 4). He felt that even though they were "keeping in touch with each other, [they were] not really sharing as much information as [they] could be" (Interview, 2-25, p. 4). He expected that his team would "pass all the information around" when they began to write their project report (Interview, 2-25, p. 4). However, this did not happen later in the semester when they wrote the project report. Instead of distributing the knowledge contained in the area reports to all team members, the "divide-and-conquer" model of technical expertise isolated and codified each area of technical expertise and made it the sole responsibility of its expert.

Gay and Grosz-Ngate (in press) studied three collaborative engineering teams, each team designing a different subassembly of a larger apparatus. They reported that collaboration (among the three different teams) was not understood as related to developing the discrete subassemblies, but was understood as related to the connection of each group's subassembly to the single, final product (p. 18). The engineering students I studied acted in much the same way. The area report was the responsibility of its individual area expert and its production was not discussed by the team. The project report was the responsibility of the group, but collaborative effort was limited to discussions of the order in which the information from each area report would be included and the mechanics of "stitching together" individual reports created on different software. Discussion of technical information was limited to what renovations to recommend for each building. By holding expertise individually, the students in Team A distributed the knowledge needed to complete their project among the team members. However, because the students were at the same skill level, the opportunities for learning about higher level tasks did not exist, nor did the redundancy in entry-level tasks reported by Hutchins (1993).

Knowledge Growth

Throughout the semester, most of the discourse at team meetings possessed no clear evidence of a leader or an agenda - both mandated by the professors. If an agenda had been used, topics of conversation might have followed each other sequentially; e.g., Topic A would be introduced, discussed, and finalized; Topic B would be introduced, discussed, and finalized; and so on, until all topics were exhausted. One could envision this model of discourse by imagining a different colored ribbon for each topic tied together end-to-end in one long string of ribbons. This was not the model of discourse that best fit the students' conversations. Rather than topics being considered in series, they occurred in parallel; that is, Topic A was introduced and discussion begun, but before it was fully discussed, or finalized, Topic B was introduced and its discussion begun. This continued with additional topics being introduced and previous topics being re-addressed, and in some cases finalized, in a continual mixing of exchanged information (Tonso, 1993, p. 29-37). Here the ribbon model would not be one long strip, but would be a complex braid of ribbons. In their team, the students deviated considerably from faculty expectations by using a more informal discourse model. This model allowed for significantly more give-and-take among students than the "delivery of a final result" model he professors expected[7].

The technical content of team meetings increased dramatically over the semester. Early in the research observations, students seemed to use little or no scientific language in their conversations. As an engineer with over 15 years of industry experience, I listened for technical vocabulary or information that the students used. The imprecise vernacular of the student conversations obscured their knowledge. The nature of discourse about the ADA regulations and historic buildings provide examples of this. During the first oral presentation (February 1), Team A met with Professor Mason in a campus conference room for a "staff" meeting - a role-playing exercise where Professor Mason played the part of an engineering supervisor, listening to a status report from each student on his or her area of expertise. Amy, who was becoming the expert on ADA regulations, stated that the team must "inform the client about the ADA regulations, elucidate them, and tell the consequences" for inaction (Fieldnotes, 2-1, p. 3). She followed this with an overhead slide showing the ADA-given priorities for implementing the ADA. It listed, in order of priority, "1) entrances, 2) goods and services, 3) restrooms, and 4) additional access" (Fieldnotes, 2-1, p. 3). Amy offered little specific information about the requirements of the ADA regulations that her teammates could use in their areas of expertise, a faculty goal for the first oral presentation.

During his interview on February 25, Chuck also spoke about the ADA regulations. Though his area of expertise was the identification of historic buildings to be studied and their ownership, one could expect that he would, after seven weeks, have information about the ADA regulations (Chuck, Interview, 2-25, p. 4, 6):

<u>Chuck</u>: Paul's given me information, like some regulations for handicapped buildings....

<u>Interviewer</u>: ...You mentioned that you[r group] got a bundle of stuff from ADA. If you were to think about the items you get from the library and the things you get from ADA, are those similar or different?

<u>Chuck</u>: Stuff we got from the library, of course, we can't take from the library, which was a problem. That's why we sent away for it [the ADA *Handbook* on computer disk].

"Some regulations" and "stuff" became the descriptors for the specific knowledge about the ADA regulations during the early part of the semester.

This lack of technical vocabulary also was evident in discussions about the definition of a historic building. At the first oral presentation (February 1), Chuck described what information he would acquire in gaining expertise in the historic buildings:

<u>Chuck</u>: I will find out which buildings [are to be studied] and who owns the buildings. How I get information will be to call the historical society,...call the president of the historical society,

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[7] I am indebted to Kathy Davinroy for drawing my attention to the different purposes of these two discourse models.

[read] the paper [with the city walking tour] which describes the history of the buildings, and from the video tape we made when we visited [the town]. (Video tape, 2-1).

These comments were typical of the ways that Chuck talked about his area of expertise during the first eight weeks of the semester and at no time did he speak about criteria for a "historic" building. On January 20, Chuck's teammate Doug made what was to be the most technical statement (related to this class) to be found in the early data. He explained why an "old" building might not be a "historic" building saying, "[The client] called [the building] 'non-contributing' meaning that there has been too much remodeling and not enough renovation" (Fieldnotes, 1-27, p. 6). In other words, whatever made the building historic had been remodeled away, something the team wanted to avoid in their recommendations. The inarticulate or undeveloped technical language failed to provide more than a vague notion of the ADA regulations or the codes for historic buildings. These vague notions about the applicable regulations indicated that, at this point in the semester, the students' knowledge was limited which prohibited any cross-pollination between the two areas of expertise - ADA regulations and historic buildings.

When I compared this vague language with Paul's description of the stress-strain diagram (in the introduction), I became aware of significant potential for growth in the sophomore students' depth of explanation. As the semester progressed (after Paul dropped the course), the sophomore students began to use more technical language in their team meetings and oral presentations until they could report isolated facts, such as doors must be 32" wide for wheelchair access. After mid-term, the students began to integrate information from more than one area of expertise to inform their decisions. Figure 1 is a plot of the average depth of explanation versus time. The scale ranged from one to six: 1 - an absence of technical language, 6 - an elaborate explanation.

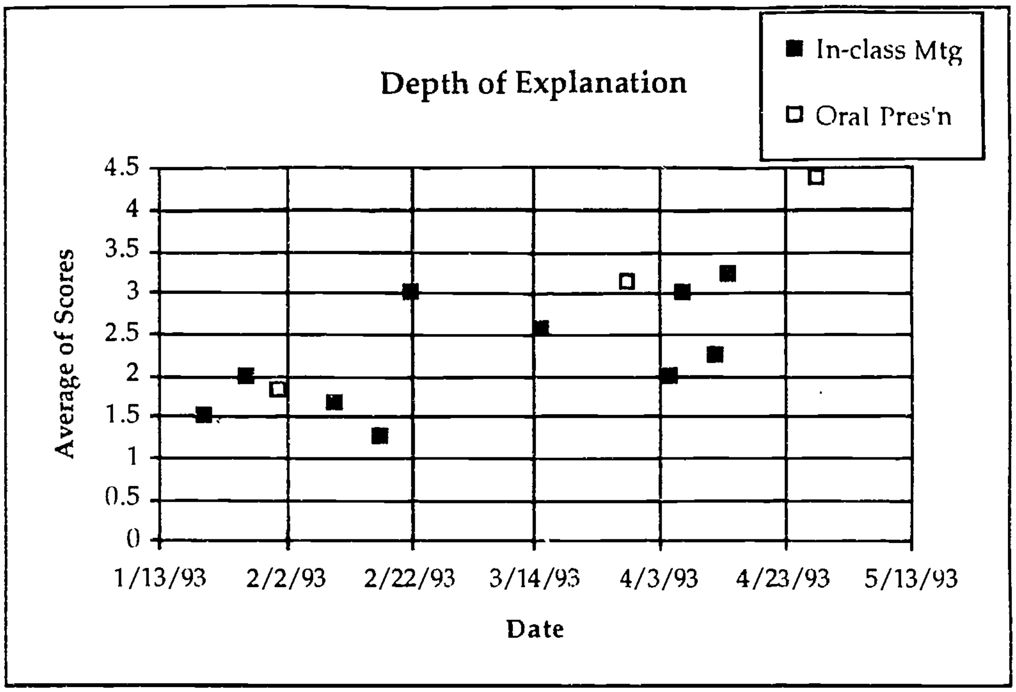
Though the sophomore students began to develop a network of related facts (a level-five score) by the end of the semester, they never reached the level-six stage of elaborate descriptions or explanatory accounts represented in Paul's explanation of a stress-strain diagram. One example of a level-5 explanation came during the team's final presentation on April 29. Professor Mason asked Amy about how the certificate of appropriateness (required for renovations on historic buildings and issued by the town's Historic Preservation Review Committee) fit into the town's ADA review procedure (p. 7):

Professor Mason: We were talking about the issuing of a certificate of appropriateness and also building certificates. Where, Amy, does that fit in to the ADA review? Is it in both cases that the historical society ought to do an ADA review of appropriateness as well in the process of issuing a certificate? Or is it in the process of issuing the building certificate?

Amy: I'm not sure what your question is; I'm not understanding what your question is.

Jennifer: I think that I may understand it. The ordinance, the review commission, it's really not their task to see if the buildings are going to comply with ADA. It's the individual business owners. They're *[the review commission]* just established there to make sure that any suggested

Figure 1. Average depth of explanation score versus time.



> changes will conform with the historical integrity of the buildings and they're *[the building owners]* not causing any harmful ramifications. So I don't know that it's exactly the commission's view to look at the ADA regulations. They will have to take some of that into *[and she is interrupted by the town's mayor]*

> Mayor: No, that's not their *[the review commission's]* position *[to do an ADA review when issuing the building certificate]*. She's right. She's 100% correct. That position *[doing the ADA review]* belongs to the building owners.

Amy, the expert on the "what" of the rules and regulations for building renovations, was not familiar with the way owners of historic buildings held responsibility for ADA compliance. However, Jennifer, the expert on the town's historic district policies, understood how the demands of the ADA and the Historic Preservation Review Committee were combined. Specifically, Jennifer knew that the business owners were responsible for ADA compliance and the Historic Preservation Review Committee was responsible for ensuring that renovations proposed by business owners met historic society guidelines.

The growth of explanatory power in discourse at team meetings did not rise steadily during the semester, but appeared to change in a step function. For the first six weeks of the semester, team discourse remained below level 2 (technical language was used sparsely without evidence of meaning). On February 22, the team's discourse jumped to level 3 (technical language with evidence of meaning and connected to isolated facts) and remained between level 2 and level 3 for the next seven weeks (until April 14, two days before the draft project report was due). The dramatic increase in explanatory power that occurred on February 22 followed the students' required area reports due on February 19. The students procrastinated in writing these reports and many barely made the deadline by working through the night on February 18. Thus, the due date for the first draft of the area reports provided the motivation for student's increased technical knowledge which they subsequently displayed in their team's discussions.

Neither the student teams nor the faculty had input into this due date mandated by the department-prepared schedule for the semester. Later in the semester, the student team scrambled to write their draft project report before the deadline. Unfortunately, there were not required team meetings between the due date for the draft project report (April 16) and the final presentation to the client (April 28), hence no data exist to substantiate another increase in discourse explanatory power during team meetings. However, if the explanatory power exhibited at the oral presentations was indicative of the team's discourse capability at that time (and I believe it is), then the increased explanatory power exhibited at the final oral presentation (April 28) was related to the team's writing their project report. The jumps in students' knowledge (indicated by the level of explanation in team meetings and at oral presentations) resulted from writing reports required by the department's schedule for the class. Thus, the writing experience, being required to explain one's expertise in an area in some detail, produced more growth in knowledge than discussions in team-managed regular meetings.

Identity Formation

Lave and Wenger's (1991) situated learning theory posited that identity - where a participant fits along the trajectory from novice to expert - was linked with knowledge or skill level and, as noted above, evident in the discourse. As a former engineer, I could see students' knowledge growth in areas that an engineer would require. However, the engineering students' perception of their identity did not shift away from that of a student toward that of a nascent engineer as knowledge grew. Throughout the semester, students seemed genuinely surprised, and sometimes intimidated, to be considered engineers whose work would be used by their client(s). First, the students arrived at the fourth-semester course expecting it to be like the first three semesters. Jeff thought that the projects undertaken in the earlier courses were "simplistic projects that nobody really cares about" (Interview, 4-16, p. 12). Robin echoed Jeff's concerns when she said that "every class [in the earlier semesters] did the same project. You know they're not going to use it for anything, so it's just a waste of time" (Interview, 4-15, p. 15). Chuck agreed, saying "A lot of times it seems useless, like especially [the classes taken in the first three semesters of the sequence]. They give you these projects. You know that nobody's ever going to look at them again once you submit them for the final time. You know all your work is basically useless" (Interview, 2-25, p. 13). By the time the students reached the fourth semester, their experiences in the first three semesters led them to expect that the projects would be simple and their work useless.

Even when a client explicitly mentioned how the reports would be used, Amy only recognized the possibility that it might be used:

of those practices, and the student team's organization of their work within the constraints of this classroom setting produced mixed results. Knowledge growth during the semester was substantial, though it indicated more proficient engineering students and not more proficient engineers. The student teams held somewhat more control over their team's work than would be typical of many engineering classrooms, but their control was limited in ways that were consistent with being an engineering student. For instance, most deadlines were inflexible and not linked to their project, as deadlines would be in "real-life" engineering work. Knowledge developed not through genuine desire to solve their client's problem and, in so doing, to become better engineers, but as a result of being a "good" student, such as writing required reports on schedule. In this classroom, the identity trajectory (suggested by Lave & Wenger, 1991) had engineering student as its "end-point," not engineer. In this classroom setting, albeit an innovative one, the student team's organization of their task, the knowledge they acquired and shared, and their developing identity mutually constituted an activity that was more academic than engineering. Replacing the entrenched engineering-school culture with "real-life experiences" requires significantly more than incorporating an engineering problem that would be typical of engineering work. In addition, attention is needed to providing interaction with engineers representing different stages of development, using the project itself as the motivation for the work, and inextricably linking the team's work with the project's goals.

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It's so real. Especially this semester. When we talked [with our client], he talked about how he was looking forward to seeing our paper because he wants to see what we have to say. It's so much pressure. We're only college students who are only trying to do this for a grade, and they want to use this as their back–up to what they're going to do for these buildings. It's scary. In a way, we kind of feel like we don't know what we're doing. (Interview, 4-21, p. 7)

Late in the semester, Chuck expressed his skepticism that the report would be used:

> I think our client's going to use parts of it [the report], the part that's about what's wrong with the buildings. I don't know how much they'll take into regard of our recommendations. I don't know how much I would have faith in a bunch of college kids, who were just out doing this for a grade. I would have more faith in an actual engineer who has had twenty years experience doing things like this. (Interview, 4-22, p. 9)

Students were unsure of their engineering skills and reluctant to believe that anyone would actually use their reports. In fact, they categorized themselves as college students doing the project for a grade and not "actual engineers."

Second, organization of the course and its enactment by the professors persistently treated the students like students and not like engineers. For example, in practice, the needs of the project (as determined by the engineers) determine meeting times and report due dates; in this class, the department mandated the schedule. Similarly, practicing engineers are motivated by successful project completion; in this class, students "were just doing this for a grade." It bears repeating that the students on this campus, and thus in this class, were well-selected for their skill at doing tasks for a grade. Treating students as students effectively disconnected the team's actions from the project's needs and attached their actions to the needs of the course schedule.

Third, there were no engineering role models available to the student teams, making a trajectory toward an engineering identity considerably more abstract that Lave and Wenger (1991) envisioned. Because engineering courses are generally sequential, there were no students participating who were older or more experienced, students who represented higher levels along the trajectory from novice to expert engineering students. Though limited data indicate that Paul (the senior student who dropped the course after a few weeks) might have served as this role model, he departed before he had any impact on the sophomore students. Professor Mason, the only engineer observed by the student teams, was not performing engineering tasks during class, but professorial ones. Thus, he also failed to fill the old-timer niche. Therefore, these three factors - the students' beliefs about the project being simplistic and useless, the faculty's treatment of students as students, and the lack of role models at varying levels of engineering expertise - precluded students thinking of themselves as engineers.

Summary

In spite of far-reaching goals to provide students with what Professor Mason called "real life experiences" (Interview, 4-21, p. 4), the engineering school classroom practices, students' understanding

References

Bulletin [College Name] (1992). [College name] bulletin 1992-93. p. 110.

CEEB (College Entrance Examination Board) (1992). College Handbook - 1993. NY: College Board Publications.

Eisenhart, M. (1992). The construction of scientific knowledge outside school. Small Grant Proposal to the Spencer Foundation.

Engeström, Y. (1993). Work as a testbench of activity theory. In S. Chaiklin & J. Lave (Eds.) Understanding practice: Perspectives on activity and context (pp. 64-103). New York: Cambridge University Press.

Gay, G., & Grosz-Ngate, M. (In press). Collaborative design in a networked multimedia environment: Emerging communication patterns. Journal of Research on Computing in Education.

Herndon, J. (1971). How to survive in your native land. New York: Simon and Schuster, Inc.

Hutchins, E. (1993). Learning to navigate. In S. Chaiklin & J. Lave (Eds.) Understanding practice: Perspectives on activity and context (pp. 35-63). New York: Cambridge University Press.

Lave, J. (1977). Cognitive consequences of traditional apprenticeship training in West Africa. Anthropology and Education Quarterly 8(3): 177-180.

Lave, J. (1988). Cognition in practice: Mind, mathematics, and culture in everyday life. New York: Cambridge University Press.

Lave, J., & Wenger, E. (1991). Situated learning: Legitimate peripheral participation. Cambridge: Cambridge University Press.

Scardamaglia, M., Bereiter, C., Brett, C., Burtis, P. J., Calhoun, C., & Smith, N. S. (1992). Educational applications of a networked communal database. Interactive Learning Environments, 2(1), 45-71.

Spradley, J. P. (1979). The ethnographic interview. New York: Holt, Rinehart, and Winston.

Spradley, J. P. (1980). Participant observation. Orlando, FL: Holt, Rinehart, and Winston.

Tonso, K. L. (1993). Becoming engineers while working collaboratively: Knowledge and gender in a nontraditional engineering course. Report to the Spencer Foundation.

Tonso, K. L., Miller, R., & Olds, B. (In press). Student learning and gender issues in a nontraditional engineering class: Implications for engineering education. Proceedings of the 1994 American Society for Engineering Education Annual Meeting, Edmonton, Alberta.

Van Maanen, J. (1988). Tales of the field: On writing ethnography. Chicago: The University of Chicago Press.