

# **Teaching Communication in Capstone Design: The Role of the Instructor in Situated Learning**

**Marie C. Paretti, Department of Engineering Education, Virginia Tech**

## **ABSTRACT**

Calls for engineers to communicate more effectively are ubiquitous, and engineering education literature includes numerous examples of assignments and courses that integrate writing and speaking with technical content. However, little of this literature examines in detail how engineering students develop communication skills, and how those learning mechanisms influence classroom practice. To address this gap, this article synthesizes research on communication learning in college from the fields of composition and technical communication, and illustrates their relevance to the engineering classroom with a case study of a capstone design course. The principles of situated learning and activity theory, in particular, provide strong evidence that the ways in which course instructors and students interact around communication tasks plays a significant role in helping students develop transferable communication skills.

Keywords: communication, situated learning, writing

## **I. INTRODUCTION**

Reports from both industry and government repeatedly highlight the importance of strong communication skills for engineers entering the workplace (National Academy of Engineering 2004; ABET Engineering Accreditation Commission 2005; Sageev and Romanowski 2001; Davis and Beyerlein 2005; Robinson et al. 2005). Along with stand-alone technical communication courses and laboratory courses, design courses have long been a key site for

helping students develop these skills (e.g., Fornaro, Heil, and Peretti 2001; Ramachandran et al. 2002; Dannels 2003; Norback et al. 2002; Helbling, Lanning, and Madler 2005; McKenna and Hirsch 2005; Burnham, Auzeenne, and Jacquez 2005; Williamson and Sweany 1999; Brinkman and van der Geest 2003; Hirsch et al. 2001; Pet-Armacost and Armacost 2003; Shwom et al. 1999; Newell et al. 1999). In fact, in their 2004 national survey on capstone design, McKenzie et al. found that the ability to communicate effectively was the ABET Criterion 3 outcome most often deemed appropriate to evaluate in design courses (by 97% of respondents). It was also the outcome most often actually evaluated, with 94% of respondents incorporating oral communication, 91% incorporating a final written report, and 77% incorporating intermediate reports (McKenzie et al. 2004). With such widespread use of communication assignments in these courses, and the high demand for effective communication skills in graduates, educators have a marked interest in more fully understanding teaching and learning in this environment.

To date, engineering education scholarship surrounding communication in design courses has focused on describing course assignments and strategies for integrating communication into curricula (e.g., Artemeva, Logie, and St-Martin 1999; Hirsch et al. 2001; Boiarsky 2004; Aller and Clancey 2000; Alford and Rocheleau 1998; Thompson et al. 2005), and on providing assessment methods (Newell et al. 1999; Swarts and Odell 2001; Burnham, Auzeenne, and Jacquez 2005; McKenna and Hirsch 2005; Williams 2002; Brinkman and van der Geest 2003; Ramachandran et al. 2002). The literature includes far less discussion of classroom practices that support this integration, though recent studies by Thompson et al. (Thompson et al. 2005) and Yalvac et al. (Yalvac et al. 2007) have begun to probe such practices. Yet detailed attention to concrete classroom practice - as distinct from assignment, course, and curriculum design - is critical because current research clearly demonstrates that the development of communication

skills relies heavily on *situated learning*, in which the context surrounding an assignment can be as important as the assignment itself (Dias et al. 1999; Katz 1998). Moreover, empirical research on classroom versus workplace writing suggests that even when instructors incorporate “workplace assignments” (e.g. proposals, memos, and reports that mirror workplace formats), the context remains academic, and students may not be gaining the necessary metacognitive knowledge associated with transferable skills (Dias et al. 1999; Dannels 2003; Russell 1997). In particular, they may replicate specific document formats, but may not understand the function of those documents in professional contexts and consequently may miss the strategies needed to adapt them to new situations. Yalvac et al. address this gap in their 2007 study of writing in upper level engineering courses when they note that “faculty must do more than embed writing assignments into their class” and instead must “help [students] imagine themselves in a professional role” to help students develop effective communication skills (Yalvac et al. 2007). Engineering design courses are, by their very nature, ideal sites for creating this sense of professionalism, and instructors abilities to engage students in meaningful professional practice is a critical component of student learning. Yet little research to date has investigated instructor roles in this light. To address the gap, this article explores the following research question: *How do instructors’ interactions with students around communication assignments influence learning with respect to effective communication practices?*

Current scholarship on both learning to write and workplace communication practices provides a sound basis for addressing this question; this article synthesizes key theoretical and empirical research studies in these areas. An exploratory case study of interactions between a design instructor and student design teams supplements the literature review to illustrate the issues in design courses in particular. The qualitative case study does not generalize about

teaching practices in all, or even most design courses. Instead, it situates prior research on student development within a specific engineering context and exemplifies the ways in which faculty interactions around engineering design communication can both enhance and hinder learning. Qualitative case studies are well-established, frequently used methods of rigorous research for exploring communication learning (Kirsch and Sullivan 1992; Bazerman and Prior 2004; Mosenthal, Tamor, and Wolmsley 1983).

## **II. LITERATURE REVIEW: CURRENT SCHOLARSHIP ON COMMUNICATION LEARNING AND PRACTICE**

Two arenas of research are particularly helpful for understanding communication learning in engineering design courses:

- *Situated learning* provides the basis for understanding how students learn to communicate.
- *Activity theory* describes the functions served by various documents in a given project; in doing so, it provides a framework for understanding the communication practices in classroom settings and the difficulties students face when transferring academic skills to the workplace.

Both frameworks are used extensively in studies of writing, as described in the following sections.

### **A. Situated Learning and the Development of Communication Skills**

Several decades of research on both academic and workplace practices have clearly established that writing is fundamentally a social act, shaped by and shaping the contexts in which it operates (Bakhtin 1986; Bazerman 1994; Berkenkotter and Huckin 1995; Miller 1984;

Orlikowski and Yates 1994; Russell 1997; Spinuzzi 2003). In their book-length empirical study of writing in academic and workplace contexts, Dias et. al. explain the issue as follows: “The context is not simply the contingent circumstances within which we happen to switch on the writing motor. Writing is not a module that we bring along and plug into any situation we find ourselves in. Rather, the context constitutes the situation that defines the activity of writing; to write is to address the situation by means of textual production. Just as there is no such thing as just writing, only writing *something*, so all writing is a response to, and assumes as a starting point, a situation.”(Dias et al. 1999, p. 11). In these terms, writing bears a strong resemblance to engineering design; we could easily substitute “designing” for “writing” in the previous sentence. Cooper and Holzman, in *Writing As Social Action*, elaborate on the complexity of this situation by exploring the ways in which “writing is located in the social world, and, thus, is fundamentally structured by the shape of that environment,” and delineate the ways in which the act of writing is always situated in a complex set of interlocking systems of ideas, purposes, interpersonal interactions, cultural norms, and textual forms (Cooper and Holzman 1989).

These and other studies establish that writing is a situated activity rather than an independent, abstract mechanical skill; more importantly, they delineate the ways that *learning to write* is a situated activity. Situated learning has roots in the concept of “legitimate peripheral participation” described by Jean Lave and Etienne Wenger (Lave and Wegner 1991), in which novices become members of a community not through formal lectures but rather through participating, with increasing responsibility and authority, in the practices of the community – including writing practices. Its “legitimacy” stems from the ways novices engage with authentic (rather than simulated or abstract) tasks associated with the community (in our case, engineering work); its “peripheral” nature reflects the fact that novices begin participating at the edges of

projects, taking on tasks of lower complexity or import, often under guidance from more experienced members of the community. Similarly, Lev Vygotsky's delineation of social cognition suggests that learning occurs not in isolation but through participation in social networks (Vygotsky 1978, 1962/1986). Stein, in synthesizing work on situated learning, identifies four key elements:

- “(1) learning is grounded in the actions of everyday situations;
- (2) knowledge is acquired situationally and transfers only to similar situations;
- (3) learning is the result of a social process encompassing ways of thinking, perceiving, problem solving, and interacting in addition to declarative and procedural knowledge; and
- (4) learning is not separated from the world of action but exists in robust, complex, social environments made up of actors, actions, and situations” (Stein 1998).

Situated learning is particularly critical in language development. Research at the level of vocabulary shows that children learn more effectively through everyday practice, when words are used in meaningful contexts, than they do through decontextualized classroom vocabulary lists (Miller and Gildea 1987, cited in Brown, Collins, and Duguid 1989; National Research Council Commission on Behavioral and Social Sciences and Education 2000). Similarly, numerous case studies of students learning to write in school as well as transitioning to the workplace demonstrate the ways in which writers develop expertise through situational mentoring and specific practice with the genres and audiences relevant to the writing contexts at hand (Katz 1998, 1998; Wardle 2004; Winsor 1996; Henry 2000; Dias et al. 1999; Freedman and Adam 1996; McCarthy 1994; Haas 1994; Anson and Forsberg 1990). These case studies delineate the ways in which individuals struggle with their writing as they enter new situations and learn by practicing communication tasks in meaningful contexts under expert guidance

rather than by simply transporting lower-level mechanical skills (e.g. grammar, punctuation, conciseness, formats) from one arena to another.

Within engineering, Dorothy Winsor's five-year case study of engineering students cycling between co-operative work experiences and academic courses stands as one of the landmark investigations of how engineers learn to communicate (Winsor 1996). Her groundbreaking work examined these students' growing understanding of communication practices in the engineering workplace and the process by which they became insiders in the engineering community. Her findings exemplify situated learning applied to the development of communication skills, demonstrating the ways in which the practice of seeing documents at work in real engineering contexts was critical to student development. Moreover, the student in Winsor's study who made the least progress in developing communication skills was the one who did not move beyond attention to mechanical skills to instead see his writing as a form of social action in the workplace. Julie Dyke Ford's work on the transfer of communication skills from a technical writing classroom to an engineering course highlights similar issues; Ford notes the limitations of transferring specific mechanical skills or document formats, and the subsequent importance of more developed analytical skills that enable students to adapt their communication practices to the exigencies of the situation (Ford 2004).

Taken together, this extensive body of research establishes that individuals learn to write through participating in *meaningful* social networks in which their writing operates. Design courses, because they typically engage students in authentic *engineering tasks*, provide ideal sites to engage students in authentic *engineering communication* to foster situated learning. In the course of developing a design, student teams must frequently communicate with one another, their advisors, and outside experts to succeed. Each of these interactions offer opportunities for

situated learning as students see the ways in which their documents and presentations function in the context of design activity. But in order for such learning to occur, course instructors must create classroom environments in which the design documents serve meaningful functions; elsewhere, I have described the criteria for assignments that facilitate this learning (Paretti 2006).

However, in addition to creating meaningful assignments, instructors must interact with students around those assignments in ways that highlight the associated social action – i.e. the work documents do in the design process and in the course. Well-designed assignments can help ground students in the kinds of situations they may encounter in engineering workplaces, but the social interactions between course instructors and students, and the ways in which the documents function within those interactions, are critical to shaping what and how students learn about communication. Situated learning requires the assignments to function as more than simply vehicles for grades; genre and activities theories, described below, help illuminate this functionality.

## **B. Genre Theory, Activity Theory, and the Classroom/Workplace Bifurcation**

Situated learning provides a useful framework for understanding *communication learning*. In recent years, genre theory and, more expansively, activity theory have become prominent frameworks for understanding *communication practice* (Bakhurst 1997; Dannels 2003; Freedman, Adams, and Smart 1994; Kain and Wardle 2005; Nardi 1992; Russell 1997; Spinuzzi 1996, 2003; Walker 2005). Carolyn Miller’s seminal 1984 article, “Genre as Social Action,” established the ways in which workplace genres (e.g. proposals, trip reports, progress reports) take their form not from any arbitrary or idealized set of “rules” or templates, but from the social situations to which they respond (Miller 1984). To illustrate Miller’s theory, the structure of the

project summary in a National Science Foundation proposal, with a paragraph labeled “Broader Impacts” and a paragraph labeled “Intellectual Merit” arose not because that structure is “right” according to some universal proposal format, but because those areas are the primary criteria used to evaluate proposals; labeling them as such facilitates the work of proposal reviewers and NSF program directors. The format is governed by the specific context and goals of the participants; summaries for proposals to other organizations apply different formats. Work by Bazerman, Berkenkotter and Huckin, Spinuzzi, and others have further developed Miller’s approach (Bazerman 1994, 1999; Berkenkotter and Huckin 1995; Spinuzzi 2003), and analyses of genres in academic, government, and industry sites have provided compelling insights into the ways in which the structure, tone, content, organization, and related features of documents support the human activities to which those documents respond (Orlikowski and Yates 1994; Cross 2000; Freedman and Medway 1994; Hunt 1994; McEachern 1997, 1998; Schryer 1993).

Genre theory is particularly useful because it helps researchers and practitioners alike understand the work that documents, presentations, and other texts *do*, and thus more fully understand the nature of the situated activity to which texts respond (or fail to respond). Activity theory, as Russell explains, complements this approach and provides a larger framework for analyzing each situation (Russell 1997). Like social cognition, activity theory has its roots in the work of Vygotsky and his colleagues and followers (Vygotsky 1978, 1962/1986). Activity theory takes as its unit of analysis the entire system of individuals, constraints, and tools surrounding a specific project or problem, as shown in Figure 1.

The system (including communication) is affected not only by the individuals, the project, and the desired outcome, but also by factors such as laws and policies governing behaviors (“rules”); the particular social, cultural, corporate, and other communities the

participants belong to; and the ways in which the work itself is organized (“division of labor”). Within a given activity system – such as a capstone design course – texts such as progress reports, project notebooks, oral presentations, and final reports are among the “mediating artifacts” that subjects (i.e. the engineers creating the design) use to address the object (the problem the design addresses). In other words, written and oral texts are tools that mediate the exchange of information and ideas among participants. Documents circulating through a design project, for example, can mediate the interactions among design engineers to ensure that each individual has the information needed to make subsequent decisions, calculations, or modifications. They can also mediate the relationship between the engineers and the manager responsible for keeping the project on track (often the course instructor in academic settings), and between the designers and the client to insure that the emerging design is meeting the client’s specifications. The quality of a given report or presentation, therefore, is not determined by conformity to an ideal standard of “good writing,” but rather by the degree to which it successfully mediates the information exchange. In this framework, surface features such as grammatical correctness, smooth transitions, and informative headings, as well as appropriate content, targeted organization, and graphical representations, are important to the degree they support (or hinder) the exchange.

In light of these mediating functions, communication assignments in design courses offer critical opportunities for students to learn not “how to write a progress report,” but how to effectively construct reports, design notebooks, and other texts to best support the engineering work and exchange necessary information among subjects (teachers, students, engineers, managers, etc.) within the activity system. This mediated social interaction is central to situated learning. Such learning, however, requires instructors first to create assignments that support

design activity, and second to actively use those assignments to foreground and enact such support. *The assignments, that is, should serve meaningful functions within the course, and instructors response to those documents should highlight not where they are “right” or “wrong” but where they support or inhibit successful engineering work.*

When assignments are not designed or implemented in ways consistent with the larger activity system, or when the goals of the activity system are not clear, students find different aspects of their work at cross-purposes and key opportunities for effective situated cognition may be lost. In evaluating the difference between pedagogies that support and pedagogies that constrain communication learning in the design classroom, activity theory helps illuminate the challenges students face when they learn to write in the classroom and then attempt to transfer that knowledge to the workplace. School and work are fundamentally different activity systems, governed by different objects, different rules, different communities, and different working structures, as research has made clear (Spinuzzi 1996; Dias et al. 1999; Dannels 2003; Russell 1997; Hunt 1994; Freedman and Adam 1996); Table 1 highlights the key differences. In particular, the desired outcome of the classroom activity system is student learning and development; client-based design projects may also seek successful products or processes as outcomes, but the *primary* goal of the classroom experience is always student learning. Thus teachers typically read student writing not because they need to act on the information a given report includes in a material way – i.e. in relation to the design project itself - but because they need to determine whether or not the student has mastered the content and skills the course attempts to teach.

The desired outcome of an engineering design project in the workplace, in contrast, is a product or process that supports the company’s profitability. Thus in the workplace, managers,

clients, and coworkers read reports or listen to presentations to extract information required to make decisions about the project. Data from a test becomes the basis for subsequent design or process modifications; reports on project progress enable managers to allocate resources or report to clients; proposals allow those with money to determine how best to allocate it. The distinction between these two activity systems is critical because it shapes the ways in which faculty engage with and respond to student texts, and in turn it can inappropriately limit the learning gains students make with respect to communication.

This bifurcation between school and workplace activity systems persists even when courses attempt to mimic workplace genres (e.g. through progress reports, design reports, technical papers). As the research shows, students still understand that their primary audience is the teacher, not a mythical manager or client, and they write accordingly (Anson and Forsberg 1990; Dias et al. 1999; Freedman and Adam 1996; Freedman, Adams, and Smart 1994; Dannels 2003). Spinuzzi refers to such as “psuedotransactional writing – that is, writing that is patently designed by a student to meet teacher expectations rather than perform the ‘real’ function the teacher has suggested” (Spinuzzi 1996, p. 295), and he describes the conflict in terms of opposing activity systems. This psuedotransactionality can significantly limit students’ abilities to develop strong communication skills, in large part by creating false expectations and habits rooted in school-based writing that are not flexible enough to adapt to the demands of workplace practice.

Even when the course involves real external clients, as in the case of Dannels 2003 study of oral communication in an engineering capstone design course, students still clearly recognize the teacher as the final authority and articulate disjunctions between what they have to do for the course and what they think will be expected of them in the workplace (Dannels 2003). Her

findings pointed both to gains students made in understanding oral communication and to the contradictions in school and workplace activity systems that posed challenges for such learning. For example, students often dismissed intended workplace simulations in order to insure that they produced what the course instructor “really” wanted (and what they would ultimately be graded on). The constraints of the academic system often worked against the very workplace practices students were trying to learn.

As both Dannels and Spinuzzi note, however, the disjunctions between school and work do not negate the classroom as an important site of communication learning. Instead, they and others cogently argue for ways in which instructors can focus on analytical approaches to communication tasks, rather than approaches that emphasize mechanical skills or adherence to specific formats. The implications of this theory for the classroom do not suggest that we need to make school look like work, or even necessarily minimize the difference between the two. Instead, faculty can create and implement communication assignments that help students develop an analytical, metacognitive approach to reports and presentations that resembles, to a large degree, the engineering design process.

To illustrate these issues, the following case study of faculty/student exchanges highlights the limitations and possibilities for situated learning vis-à-vis communication offered by engineering design courses.

### **III. METHODOLOGY: A CASE STUDY ILLUSTRATING THE IMPLICATIONS OF TEACHER TALK FOR STUDENT LEARNING**

As the preceding review of theoretical and empirical research on the communication practices of students and professionals makes clear, context is everything when it comes to understanding

what “good writing” is and how students learn to craft it. But while multiple case studies exist for students in other fields, few major studies have focused specifically on engineering students; work by Winsor and Dannels are notable exceptions. Fewer still have analyzed the engineering classroom as an activity system to examine how instructors introduce, discuss, and use communication assignments, and how those interactions support or hinder situated learning for communication. Yet prior research on the development of communication skills makes it clear that this interaction is critical.

To illustrate the relevant issues and explore the interactions possible in engineering design courses, I adopted a case study approach using a year-long capstone design course in a small engineering program (fewer than 50 graduates per year); the research was conducted with the approval of the university’s Institutional Review Board. Data collection combined field observations of in situ practice with reflective interviews to triangulate findings. The qualitative case study approach is routinely used in studies of writing and speaking development (Dannels 2003, 2000; Anson and Forsberg 1990; Dias et al. 1999; Freedman and Adam 1996; Freedman, Adams, and Smart 1994; Haswell 1991), and its value as a means for understanding student learning with respect to communication skills is well-established. In addition to adopting the models set out by prior researchers, this study also incorporates the methodologies described by Leander for analyzing the relationships between talk and text in situated practice (Leander and Prior 2004), and follows the general practices for case study research defined by Yin (Yin 2003). These systematic approaches to coding and data analysis, following well-established practices of prior researchers, insures the rigor of the findings.

The research question addressed by this article is well-suited to the qualitative case study approach. In her 2007 study, Borrego identified the value of qualitative research, long practiced

by scholars in the fields of education, to emerging research in engineering education (Borrego 2007), and deep explorations of individuals and small groups have provided critical insights in several recent studies (Borrego 2007; Foor, Walden, and Trytten 2007; Tonso 2006). It is particularly appropriate for this exploratory study of instructor roles in communication learning, both because of prior work in the field (noted above) and the criteria for qualitative case study research. Yin (Yin 2003) defines three conditions under which a case-study approach is particularly valuable; Table 2 summarizes those conditions, mapped to the conditions of this research:

This case study focuses specifically on meetings between the course coordinator and each design team because this student/teacher exchange is a critical site for the mentoring associated with situated learning. It provides a useful venue for analyzing the design course activity system to determine what functions the communication assignments served in the students' relationship with their instructor and in the students' own practice of design. Importantly, as noted earlier, the teaching practices identified in the case study are not assumed to represent the way all or most design instructors discuss communication. Instead, the rich description offered by the qualitative approach to research illuminates key features of the activity system in open-ended design courses, suggests opportunities and challenges for enhancing situated learning, and highlights areas for future investigation. Moreover, the findings match prior research on communication learning in other academic contexts, and thus instantiate theories of situated learning with respect to communication skills in engineering courses.

### **A. Study Site and Participants**

The case study explored a two-semester capstone design course of 21 students. The course

structure is relatively common for design projects. A single instructor (the course coordinator, referred to as CC hereafter) acts as a “project manager” and oversees the course, providing lectures, assignments, and workshops on engineering design, project management, collaboration, and communication. He also grades all student work. Students work in teams of 2-6 on year long projects; each project has its own faculty advisor (FA) responsible for providing ongoing technical support as well as input into the course grades.

During the case study year, the course included 8 projects, all of which involved either real external clients or ongoing research by the FA, reinforcing their position as sites for situated learning. Each team completed several communication assignments during the year:

- 1) A project notebook reviewed by both the CC and the FA multiple times during the course.
- 2) A series of formal reports (termed “progress reports”), sequenced to build toward the final design report at the end of the year. The reports included discussions of the scope of work (including deliverables); resources needed; safety, regulatory, and environmental concerns; a work plan; and a literature review. The final report included the detailed design along with test results and related supporting materials. The executive summaries from the final report were published in a departmental newsletter for the advisory board.
- 3) Two oral presentations, open to all faculty – one at the end of the fall semester and another in the last third of the spring semester.
- 4) A poster summarizing the project, displayed during an end-of-the-year session open to the entire department. The poster session began with each team presenting a 5- minute overview of their project; faculty then had an hour to walk around, talking to each team and rating the projects.

The notebooks and progress reports formed the basis for meetings between the CC and each

team. These meetings are the focus of the study because they represent concentrated instances of individualized interactions between the CC and each team around communication assignments, and as such are ideal sites for situated learning with respect to design communication.

## **B. Data Collection**

My role as a researcher in this course was observer with limited participation. The data collected includes:

- *Surveys:* To identify students' initial expectations and final attitudes about communication in school and at work, I conducted pre- and post-course surveys. Responses were anonymous, and all students in the course responded to each survey (n=21). The surveys included both Likert-scale and open-ended questions. The survey findings are not intended to provide statistically significant results, but rather to suggest general trends that enrich the case study.
- *Notes and observations of communications-related course lectures:* I observed lectures and discussions by CC on communication assignments; these observations oriented me to the assignments and to the CC's approach. In return for access to the study site, I provided general lectures on communication (writing style and report guidelines); these lectures helped students get to know me informally before I observed their meetings with the CC.
- *Observations of CC/Team meetings:* The CC met with each team once during the fall and once during the spring to talk about project progress in general and the communication requirements in particular. These meetings occurred after teams had turned in a written report and received feedback. During the fall, I observed meetings between the CC and 4

teams, taking extensive written notes and refining my observation protocol. In the spring, I observed all 8 meetings. In general, I did not play any active role in the meetings, though occasionally the CC or the students would question me, or I would question something I didn't understand. These observations were analyzed using an open-coding approach, with both the topics of discussion and the uses made of the student documents as sensitizing concepts.

- *Interviews*: At the end of the spring semester, I invited teams to participate in voluntary confidential interviews. Two teams responded; both were teams I had observed fall and spring. In both cases, the entire team was present at the interview. The interviews were guided by four questions regarding communication practices in the course, but were semi-structured to allow for in-depth follow-up. As with the observations, the interview transcripts were analyzed and coded according to key themes. These interviews represent a critical mechanism to confirm or contradict the observational findings.

#### **IV. FINDINGS: TEXTUAL PRACTICES AND SITUATED LEARNING IN A CAPSTONE DESIGN**

##### **ACTIVITY SYSTEM**

The analysis presented here focuses on the observation and interview findings; brief notes regarding the surveys frame the discussion.

##### **A. Surveys: Opportunities for Situated Learning**

The surveys illustrate two key points: 1) students' willingness at the beginning of the course to engage in communication tasks and to see those tasks as useful to engineering design, and 2) students' frustrations with assignment structures that, in their minds, did not consistently support the design project or mirror their expectations about communication in the workplace.

*1) Pre-Course Surveys:* The survey at the beginning of the course gauged students' expectations about course assignments. Students had relatively high expectations for the assignments listed on the course syllabus. Students were asked, "How useful do you think the following assignments will be in actually completing your design project?" with possible responses from 1= Not useful at all to 5 = Extremely useful. The average score for every assignment was above 3.5. Notably, no students rated any assignment at 1, and only five ratings of 2 appeared (two each for the scope of work and the safety, regulatory, and environmental concerns, and one for the oral presentations). These data suggest that at the outset, students were open to seeing the communication assignments as useful tools to help them complete their design projects. These findings agree with similar surveys conducted in other engineering design courses and reported elsewhere (Paretti and Burgoyne 2005).

*2) Post-Course Surveys:* The end-of-course survey presents a different picture, with students expressing frustration regarding communication assignments. This survey included two sets of questions. The first set asked students to rate the importance of specific elements of communication (e.g. grammar, format, tying content to audience needs) in the course and in their expected jobs. The second set asked students to identify the most and least valuable communication assignments in the course, and provide a rationale for each choice.

With respect to elements of communication, on average in every area students saw these elements as less important in the course than they expect them to be on the job. Approximately half the students saw a notable mismatch between the standards expected of them in the course and the standards expected at work, with work being the more rigorous of the two. Students' sense of differing expectations aligns with the findings of published studies on the differences between school and work activity systems.

Despite some frustrations, however, 19 of the 21 students identified at least one assignment that they found particularly useful. By far students perceived the oral presentations as the most valuable, with two themes emerging. First, the presentations represented an opportunity to practice speaking in public – something most of the students considered an essential skill but not one they were comfortable with. Second, several students saw the oral presentation as a tool to help them pull the projects together.

The two assignments consistently deemed least useful, in contrast, were the project notebooks and the intermediate reports:

- Students felt that the format of the notebook did not effectively match the format they felt would most benefit the project – whether it was the difficulty of keeping one notebook among multiple team members, the challenges associated with transferring electronic information to the handwritten notebook, or more generalized comments about other forms of record-keeping being better suited to the project.
- Students consistently struggled to match their concept of a “progress report” (the term used by the CC) to the actual structure of the report required by the assignment; as with the notebook, they found significant mismatches between what they wanted the report to do and what the course required it to do.

These findings coincide with prior studies regarding student attitudes toward communication assignments (Dannels 2003, 2000).

## **B. Observations: Unrealized Potentials**

The survey findings suggest 1) students’ willingness to view communication as useful within design projects and, 2) their frustration over the tensions between the potential usefulness and the

constraints of the assignments themselves. The observation data illuminates these frustrations.

As noted, each team met with the CC once during the fall and once during the spring. Meetings lasted approximately 20 minutes, and occurred after the teams had received written feedback on one of the intermediate reports required for the course. In addition, the meetings occurred immediately after (fall) or immediately before (spring) students turned in their design notebooks for review; teams had both their report and their notebook at the meeting. The meeting observations were coded for two phenomena: topics covered and ways the documents were used; the codes emerged from multiple reviews of the transcripts. As might be expected, the topics covered fell into three major categories, as summarized in Table 3.

Among the topics covered in discussion, project management issues were the most numerous (59 references), followed closely by discussions of communication practices (54 references). Discussions of the timeline dominated the project management category, while discussions of the content of the reports and notebooks dominated the communication category. Detailed technical discussions accounted for far fewer comments (34), as might be expected given that each project had an expert faculty advisor to consult on technical matters.

The time devoted to discussing both how to manage the project and how to communicate project details reinforces the potential for these meetings to serve as sites for situated cognition. As the CC helped students understand how to conduct engineering design projects (rather than merely apply technical concepts to specific problems), he had the opportunity to simultaneously help students understand the communication practices associated with design in professional settings. Moreover, in his role as project manager, the CC required information about the progress of each project, particularly with respect to the timeline and the teams' ability to complete the deliverables before the end of the year. In his role of supporting the students, such

information was important to his ability to enable them to succeed in their projects, something he clearly wanted to do. This requirement, and the extensive discussion of project timelines in the observed meetings, implies a clear potential role for the team reports and notebooks to serve as useful mediating artifacts within the activity system. As in the workplace, such reports help managers insure that work is progressing on schedule so that all stakeholder will be satisfied with the results.

The potential for the team reports to mediate the project management activities of the course also emerges from the number of times comments about the content of communication assignments overlaps with comments about project management. Of the 54 comments about the content of communication, 23 addressed issues of project management. In almost every team meeting, for example, the CC asked for more detail on the timeline in the next report. He also frequently requested more information in both the project notebook and the reports on the process by which the team reached a particular decision. The instructor's need for such information echoes workplace needs, where written records of engineering activity may be required either for patent applications or as a hedge against future lawsuits. Similarly, managers often require such justifications to persuade clients or supervisors regarding a pending action.

At the same time, the meetings suggest ways in which faculty interaction can limit situated learning by not explicitly leveraging the dynamics of the activity system. Specifically, while the interplay of project management issues and required content in reports and notebooks highlights the *potential* for situated cognition, often the conversations between the CC and the team failed to leverage that potential by explicitly connecting the requirements to the ways the CC hoped to use that information or the ways such information could help the team advance the project. Occasionally, the CC would couple discussions of a more detailed timeline with his

desire to see the teams complete their design prior to spring break – a clear link between text and use. More often, however, the discussion involved only simple statements asking for a more detailed timeline or work plan, without explaining the functions that work plan might serve for all participants in the activity system. Subsequent student interviews, described below suggest that without a clear understanding of why such information was useful or necessary, students tended to perceive the content as merely decontextualized requirements, and situated cognition about why and how to communicate such information failed to develop successfully.

With respect to the ways in which documents were physically used in the meetings, the findings further support the notion of unrealized potentials. Often, the documents were simply referred to through the discussions described above. At some point during almost every meeting however, either the instructor or the student team looked specifically at either the current report or the notebook. Rarely, these instances coincided with detailed discussions of technical information. More often, they involved the readability of the CCs comments or specific questions about what the team “should” do in a particular location to meet the assignment requirements. With several teams, the documents became key reference points in arguments about the content – students believing they had included content the CC missed, for example, or referencing material in their notebook or other reference source to answer a question or explain a point. In short, the content of the notebooks and reports operate almost solely as classroom requirements mediating school grading rather than as relevant information mediating the management and conduct of a workplace-oriented design project. The assignments thus represent an instance of missed potential; they hold information necessary to the success of the design activity, but only rarely are they leveraged to explicitly tie the information requirements to the design process requirements.

### **C. Teams A and B: Conflicting Activity Systems**

The follow-up interviews supported the sense of unrealized potential suggested by the observations, and clarified the bifurcation between classroom and workplace activity systems. Two teams volunteered for group interviews near the conclusion of the course. Both were teams I had observed in the fall and spring meetings, and both teams completed their projects successfully and worked well together throughout the year with no notable conflicts. Interestingly, the two groups represented divergent poles in the course. In both meetings observed, the students on Team A were very resistant to the communication requirements laid out by the CC, openly challenging requests for certain kinds of information and certain formats, and clearly differentiating meaningless school requirements from meaningful project needs. The students on Team B, in contrast, were very receptive to comments from the CC and eager to make sure their reports and notebook aligned with the requirements. They came to both meetings having carefully reviewed the written comments from the CC, and open to understanding where and how they needed to revise their work. They were very willing to see the ways in which the school system prepared them for the workplace system.

But while the teams differed in their superficial attitudes towards the assignments, both expressed similar frustrations over tension between the nature of their project and the requirements of the assignments. That tension formed a dominant theme in both interviews.

*1) Team A: Open Rebellion:* Team A resisted the communication requirements in each meeting with the CC and again in my interview with them, explaining that they never looked at the assignment handouts and only added certain requirements to the reports and the notebook when they were pushed multiple times. In meetings, they argued openly that certain requirements (e.g.,

mass and energy balances for their system, a process flow diagram) not only did not make sense, but were meaningless with respect to the scope of their project. They raised the issues again in the interview in response to questions about the relationship between their project work and their communication assignments, expressing frustration over having to include a decision matrix, mass and energy balances, and process flow diagram. One of the team members noted explicitly in the interview that they adamantly refused to provide a Gantt chart because the CC “couldn’t give a good reason” and they saw the requirement as “dumb.” Obviously, Gantt charts serve a critical purpose in managing engineering design projects in the workplace, but to a team of two students working closely together, that purpose remained invisible. Similarly, they admitted openly that they had “made up” a decision matrix because they had to, but it had no bearing on their work.

Despite their frustration with what they considered meaningless requirements, though, Team A was not blindly antagonistic. They felt, for example, that the fall presentation was an important tool for pulling their work together coherently at the end of the semester and preparing for more focused work in the spring. They did not, that is, resist all communication activities, but they were frustrated by activities that did not serve a clear purpose for their project but appeared merely as course requirements.

They found these requirements not only frustrating, but counterproductive to the work they were attempting to accomplish. They considered the assignments something “totally different” that “interrupted the project.” For example, the team maintained a three-ring binder for their project that included all of the background literature they reviewed, computer printouts of results, and their own notes. They referred to this binder at several points during the meetings to look up information or answer technical questions. But while they found their own binder

helpful, they considered it tedious and time-consuming to “hand-copy” that information into the bound design notebook required by the instructor. When they were required to turn in their design notebook, they always turned in the binder as well because they consider it their major working resource, and in the interview they expressed frustration over the fact that the CC did not seem to value the binder in the way they did. Notably, none of the observed meetings or lectures included discussions of intellectual property or design notebooks as patent evidence – the primary reason for bound, dated, signed notebooks - despite the fact that the team was working on a novel project funded by external research. Neither the CC nor their advisor appeared concerned with the legal record-keeping function of such documents. Instead, the team considered these requirements senseless hoops to jump through – hoops that hindered rather than supported their engineering work. During the interview, they directly connected these requirements to the “political games” they associated with school, and saw them as a way to “appease the gods” of education. Their comments reinforce a clear division in their minds with the activity system of project work, in which texts serve meaningful mediating functions, and the activity system of the class, designed to produce grades.

2) *Team B: Writing for School:* Team B, in contrast, adopted a very positive attitude toward the course and the CC, and clearly wanted to fulfill requirements and provide necessary information. They came to both meetings very prepared, having read through the CC’s comments on their report and ready with questions that would help them better address the course requirements. Unlike Team A, Team B stated their respect for the CC at several points in the interview, noting that they valued his opinion, respected his ideas on writing as well as on engineering, and tried to learn from both his comments and the sample reports he provided.

Still, both the meetings and the interview were characterized by a series of disjunctions between the goals of the project and the requirements of the assignments. While Team B did not have the same struggles with the design notebook exhibited by Team A, they did struggle with the requirements of the reports themselves. In the interview, for example, even as they talked about valuing feedback from the CC, they noted the ways in which they wrote specifically to “please him” and “cover all the angles” they thought he might ask about or want to know. Throughout the meetings, their conversations about the communication assignments tended to focus specifically on what the CC wanted; when he asked, for example, for more detail on their work plan, they responded with a clarifying example: “You want things more like ‘work on mass balance for 3 weeks.’” The discussions were often very detail oriented; at one point they asked about the requirements for upcoming presentations and reports, wanting a clear outline of what was expected, and at another they wanted to make sure they were following the rules correctly on all citations and references. Even their discussions of organization focused on making sure they produced what the CC wanted; in one instance, they cited a comment by the CC about the order in which information appeared and asked him exactly what he was looking for. He described a specific outline of ideas, and one of the team members responded with “Ok, I just want to make sure we’re talking about the same thing.” Similarly, they found the class session in which the CC explained the poster requirements, using sample posters from previous years, particularly useful because they got a very clear sense of what he liked and didn’t like.

However, these interactions were marked by a focus on the requirements themselves, not on the value they might bring to the project or the ways they might facilitate the work of either the student team or the CC. The team adopted a very positive attitude throughout the course and was eager to do well, but in the way that all “good students” are eager to make sure they do what

the teacher wants. The tenor of both the meetings and the interview suggest that the communication assignments were clearly within the classroom activity system; none of their comments pointed to ways the assignments furthered their own design work. During the interview, they described having to “add sections that don’t make sense” with respect to the project; they were anxious to fulfill the requirements correctly, but expressed consistent confusion over requirements, rationales, and formats. Despite this confusion, though, they did not dismiss the CC as a helpful resource. They stated, for example, the CC could have been a much more valuable resource for resolving problems that arose in managing their project had they kept him more informed about a key conflict. They indicated that they could have benefited from more one-on-one time with him because they weren’t sure he fully understood their project or the conflicts. Importantly, though, they did not point to either their written reports or their notebook as a vehicle for communicating more effectively. Those remained assignments for grades, not tools for exchanging critical information.

Hence even in the team with a very open, accommodating approach to the course, both the meetings and the interview suggest a sharp divide between the design activity system and course activity system. This team was clearly open to the course system, but like Team A, their comments and actions imply significant limits on the degree to which the assignments represented experiences of situated learning with respect to communication. Both teams struggled against what they perceived as rigid requirements that didn’t seem to match the needs of their project, and those struggles represent lost learning moments.

## V. CONCLUSIONS

As the literature demonstrates, situated learning is a critical mechanism for the development of

engineering students' communication skills, and activity theory provides a useful lens for understanding how such learning unfolds in the design classroom. The case study confirms and expands the work of prior researchers on communication learning in engineering curricula. Specifically, it highlights the opportunities design courses offer for developing communication skills through situated learning and illustrates the barriers to fulfilling those opportunities posed by conflicts between school and professional activity systems. As faculty manage open-ended team design projects, they need information from students to effectively support student learning; communication assignments can provide that information and, by mediating this information exchange, function as sites for legitimate peripheral participation. The positive feedback associated with presentations in the case study, for example, demonstrates that students find value in these assignments both as practice for professional situations and as tools to help them more effectively manage their own work. But for students and faculty alike, the constraints of the classroom activity system and the need to fulfill requirements can dominate such assignments, and communication tasks can become meaningless busywork rather than opportunities to enact professional practices. Assignment requirements can appear arbitrary or confusing if instructors do not explicitly connect those requirements to the real information needs of those involved.

Both the literature review and the case study, in short, point to the critical role instructor actions play in helping students develop communication skills. This role involves designing and evaluating meaningful assignments, and, equally important, creating an environment that connects assignments to meaningful project needs and helping students understand the functions reports and presentations serve in supporting engineering design. Elsewhere, I have introduced guidelines for designing assignments that help students learn the metacognitive skills associated

with workplace communication:

- Creating assignments that meet real faculty and student needs
- Make those needs explicit within the assignments and the evaluation rubrics
- Engage students in the process of designing appropriate texts rather than simply fulfilling prescribed formats (Paretti 2006).

Such assignments should support efforts to manage design projects, rather than simply mirror generic workplace formats.

An activity theory analysis of the engineering classroom, however, also makes clear that creating effective assignments is only one component. Faculty must also ensure that the classroom discourse around those assignments clearly connects the document or presentation to the engineering work of the course so that students can connect document design to document function. Both the literature review and the case study presented here thus suggest several additional steps faculty can take in the classroom to support meaningful learning:

- Explicitly verbalize the differences between school and workplace documents to help students understand that they are learning a communication process, not a rigid set of formats or stylistic rules.
- Explain the functionality of classroom documents and clearly link assignment requirements (e.g. required content or organizational) to information use (e.g. tracking a project or evaluating design decision-making) to help students understand the relationship between design and function.
- Use documents to mediate critical exchanges of information within the engineering design process to help students see and experience the complexities of information exchange in practice.

- Emphasize the need to continually adapt communication practices to situational exigencies to help students develop the flexibility needed to transfer skills learned in the classroom to skills needed in the workplace.

These strategies enable instructors to leverage situated learning in the design classroom, not by making the classroom look like the workplace, or even trying to minimize the differences between the two, but by being explicit and open about the needs, constraints, and goals of each context. Students need to understand how people use information to further meaningful work. For example, when meeting with students and/or responding to student texts, instructors can facilitate learning by contextualizing comments about requirements in terms of functionality and explaining how participants can or should use the information contained in the document or presentation to support the design project itself. The difference is perhaps shockingly simple – something as slight as replacing “You need to include more detail in your timeline” with “I need to see more detail in the timeline to have a better sense of what you’re actually planning to do, what kind of help I can provide, and whether you can realistically meet your deadline.” Similarly, faculty can respond – in class and more casually in the hallways or similar settings – to the content of students’ reports: “Your Gantt chart showed that you were supposed to start testing this week, but I haven’t seen you in the lab – what’s up?” “Your progress report said you were having problems with your suppliers; have you gotten the new sensor in yet?” “I couldn’t figure out, from your schedule, when you planned to begin building the prototype; what’s your timetable for that?” “In trying to assign grades for the design process component of the course, I couldn’t figure out from your report how you applied the decision matrix; I need that information in the next report so that I can grade you accurately.” “In the workplace, you probably wouldn’t include this section, but since I need to evaluate your process, I need the details here.”

In short, we need to help students understand the “why” of communication, because only then can they begin to grasp the “how.” The value to students of even slight changes in our own conversation can be substantial, as the research on the development of students’ communication skills demonstrates. “Teaching communication” means more than creating report and presentation assignments; how we talk about communication assignments plays a significant role in how well students transfer their experiences from our classrooms to their workplaces.

At the same time, while the case study described here instantiates generalized research about the development of communication skills in one engineering context, much work remains regarding learning mechanisms and learning systems in this important arena. Building on the work of Winsor, Dannels, and other scholars, future research questions include:

- What communication assignments provide the best opportunities for situated learning in design courses?
- How do communication practices in design courses support students’ technical development?
- What variations occur across design settings – from one discipline to another as well as from freshman to senior projects, and how do those variations influence communication learning?
- What types of education do faculty need to enable them to effectively support students’ communication learning? What roles should faculty in composition, technical communication, and writing across the disciplines play in partnering with engineering faculty to support student work?
- What, if any, learning variations occur across oral communication, written communication, interpersonal communication, and informal communication such as

email, chat, design notebooks, and sketching, and how can faculty best engage those variations?

- What opportunities for situated learning occur in other components of the engineering curriculum? How might instructors in other courses actively support the development of communication skills?

These and related questions offer multiple opportunities for both qualitative and quantitative research in engineering communication.

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#### AUTHOR BIOGRAPHY

Marie C. Paretto is an Assistant Professor of Engineering Education at Virginia Tech, where she co-directs the Virginia Tech Engineering Communication Center (VTECC). She has a background in both chemical engineering and English. Her research examines engineering communication in both industry and academic contexts, with a focus on pedagogy and student learning. Her recent work has included a series of studies of communication practices in interdisciplinary, cross-cultural, and virtual student design teams.

*Address:* 660 McBryde Hall, Virginia Tech, Blacksburg, Virginia, 24061; telephone: (+1) 540.231.1812; fax: (+1) 540.231.6903; email: [mparetti@vt.edu](mailto:mparetti@vt.edu)

## Figures and Tables

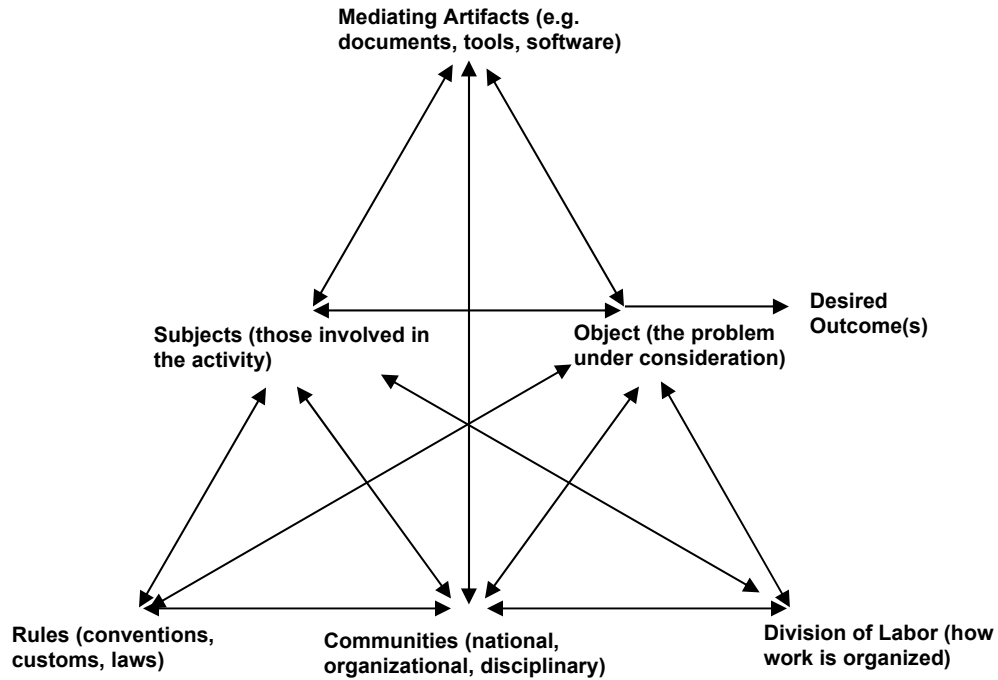


Figure 1. An activity system (Kain and Wardle 2005)

	<i>Classroom</i>	<i>Workplace</i>
<i>Primary System Goal</i>	Student Learning	Corporate Profitability
<i>Primary Document Function (Mediating Activity)</i>	Evaluation of Student Learning	Decision-making to insure project profitability

Table 1. Comparison of classroom and workplace activity systems

Case Study Condition Defined by Yin	Research Study Conditions
The research addresses “why” or “how” questions	RQ: <i>How</i> do instructors’ interactions with students around communication assignments influence learning with respect to effective communication practices?
The researcher has no control over behavior	As an exploratory study of an ongoing phenomenon, this study did not attempt to influence participant behavior; rather, it sought to explore existing practices in light of current theories.
The focus is on a contemporary phenomenon in real time	Instructor/student conversations around communication assignments and design projects occur in real time in the context of an ongoing design course.

Table 2: Case study conditions as applied to this study

Major Category	Subcategories
<i>Technical Issues</i>	None
<i>Project Management</i>	<ol style="list-style-type: none"> <li>1) <i>Advisor</i>: Interactions with the project’s technical advisor (e.g. whether teams were meeting regularly with their advisors, strategies they could use to work more effectively with their advisors)</li> <li>2) <i>CC</i>: The course and ways the CC could help support the project</li> <li>3) <i>Decision process</i>: The decision-making processes, including decision matrices (also often coded as <i>technical issues</i>, but considered under project management when the discussions focused specifically on the <i>process</i> of reaching decisions)</li> <li>4) <i>Project deliverables</i>, particularly as a tool to structure team activities</li> <li>5) <i>Project timeline</i>, including any issues related to scheduling work</li> <li>6) <i>Team structure</i>, including team interactions and how work was divided among team members</li> <li>7) <i>Other</i>.</li> </ol>
<i>Communication Practices</i>	<ol style="list-style-type: none"> <li>1) <i>Content</i> of reports and notebooks</li> <li>2) <i>Organization</i> of these texts</li> <li>3) <i>Mechanics</i>, including the use of headings, proper labeling of graphics, units used (the instructor required SI units), page numbers, and related surface features.</li> </ol>

Table 3: Coding categories for meeting topics (content)