CLASSROOMS THAT WORK: TEACHING GENERIC SKILLS IN ACADEMIC AND VOCATIONAL SETTINGS

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PREFACE

This report documents the second of two studies on teaching and learning generic skills in high school. The studies were sponsored by the National Center for Research in Vocational Education (NCRVE), University of California, Berkeley. The initial exploratory study (Stasz et al., 1990) examined the teaching and learning of generic skills in vocational classrooms. The study reported here extends the earlier work by providing a model for designing classroom instruction in both academic and vocational classrooms where teaching generic skills is an instructional goal. The authors hope this study will contribute to future thinking about teaching generic skills and provide a starting point for designing curricula and courses that teach these important skills. The study should be of interest to educators, policymakers, and researchers who are involved in efforts to reform secondary schools in ways that better prepare students for education, work, and lifelong learning.

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Introduction

Many have contended that American secondary education needs to undergo fundamental reform if it is going to supply the American workplace with a flexible, highly skilled workforce. School reformers focus on two questions: What kinds of skills and knowledge should be taught in high school, and how should schools go about teaching them?

One common answer to the first of these questions is that schools should teach "generic skills"--problem solving, communication, teamwork, higher-order reasoning--as well as skills and knowledge specific to a single academic discipline or occupational field. Another answer is that schools should improve student attitudes toward work. Answers to the second question have implications for curriculum, pedagogy, school organization, and school relationships with other institutions, such as colleges and businesses.

We have conducted two studies on the teaching and learning of generic skills and work-related attitudes at the classroom level. The goal of these studies is to inform the design and conduct of courses that aim to teach generic skills and attitudes in addition to domain-specific skills and knowledge. The first study, reported earlier (Stasz et al., 1990), developed an approach to studying instruction in generic skills, particularly complex reasoning skills, and applied it in the analysis of several vocational classrooms.

The second study, reported here, extends the application of the approach to academic as well as vocational classrooms. This extension permits us to examine whether it is feasible to teach generic skills and attitudes in both settings and, if so, whether effective instruction in each setting is similar.

Because we focus our analysis on the classroom level, we necessarily limited the number of cases we could study. This reduces the generalizability of our findings, but it also provides rich information on teaching practices that practitioners need. In reporting this research, we concentrate on those classrooms in our sample that "work"--i.e., those that appear, on the basis of our observations and student perceptions, successfully to impart generic skills and attitudes.

Field Study Methods

Our research approach included case study, ethnographic, and survey methods. The case study approach permitted the intensive observation and analysis of a limited set of carefully selected sites. Ethnographic methods were used to deepen our understanding of what goes on in classrooms, particularly in the interactions of students and teachers.[1] By triangulating data collection methods, we attempted to strengthen the reliability of our findings.

We used site selection criteria suggested by our previous study: Candidate sites were classrooms that (1) have teachers who claim to teach problem-solving skills, (2) value students cooperating with each other and taking responsibility for their own work, (3) provide opportunities for group and project work, and (4) hold high expectations for student performance. We identified twelve candidate sites and narrowed the sample to eight after site visits revealed that some did not meet all criteria. (One of the eight classrooms, an interior design class "that works," is described in our earlier report [Stasz et al., 1990].) These eight classrooms were housed in three comprehensive high schools, were located in both urban and suburban communities, represented a mix of socioeconomic standings and ethnicities, and included both academic and vocational classes: interior design, landscape, English, electronics, architecture, manufacturing, and chemistry (two classes).

Following established ethnographic methods, our research consisted of five activities:

1. Descriptive observation and questioning to identify key teacher practices and student behaviors;
2. Focused observations and structured questions to expand and refine the list of practices and behaviors;
3. Selected observations and contrast questions to clarify differences among distinct practices and behaviors;
4. Indexing of data to place practices and behaviors in meaningful domains or groupings;[2]
5. Analysis of relationships among domains and generation of themes that compose the model of instruction for generic skills and attitudes.

Figure S.1--Research Approach for Developing Model of Generic Skills Instruction

Figure S.1 suggests how these analytic activities were used through the course of the fieldwork. We began with relatively "low inference" procedures--i.e., relatively unguided by theoretical constructs and hypotheses. Over time, increasingly inferential procedures became appropriate and were applied. Throughout the process we employed an iterative approach, cycling through the analytic activities as needed.

An Instructional Model for Generic Skills

Table S.1 displays the components of the model that we developed for the instruction of generic skills and attitudes. The model contains four major "themes": instructional goals, classroom design, teaching techniques, and school context. Within each theme, the model specifies subthemes that emerged from our data. We found the components of this model to be sufficient to permit us to understand and describe the practices and behaviors that we observed in the classrooms we studied.

Table S.1
Components of an Instructional Model for Teaching Generic Skills and Work-Related Attitudes

Instructional Goals	Classroom Design	Teaching Techniques	School Context
Complex reasoning skills	Situated learning	Modeling	Access to knowledge
Work-related attitudes	Culture of expert practice	Coaching	Press for achievement
Cooperative skills	Motivation	Scaffolding	Professional teaching conditions
Domain-specific knowledge, skills	Cooperation	Articulation	
	Teacher roles	Reflection	
		Exploration	

The four themes interact in ways that are suggested by Figure S.2: Instructional goals influence classroom design and teaching techniques; classroom design and teaching techniques influence each other; and school context influences goals, design, and techniques. We traced these interactions in our analysis of the classrooms in our sample.

Figure S.2--Lines of Influence Among the Components of the Instructional Model for Generic Skills

In the descriptions of classrooms that work we also attend to a fifth aspect that is not represented in the model, namely, student experience of the classrooms. Student perceptions of their classes (e.g., student perceptions of classroom design or teaching techniques) and of their own achievement were gathered through classroom observations and group interviews.

Classrooms That Work

Of the eight classrooms in our sample, five "worked" in the sense that they appeared to impart generic skills and attitudes successfully. We base this conclusion both on our observations of the instructional process and on student perceptions of learning. Brief synopses follow:

- Mr. Price's English class: A senior-level college-prep advanced composition course at a comprehensive high school. Provided an English credit needed for graduation and also met state college and university requirements.

- Mr. Benson's electronics class: A vocational class at a comprehensive high school. Students included ninth through twelfth graders of heterogeneous ability, one female and the rest male. Fulfilled an elective requirement for graduation. No academic credit.

- Mr. Benson's manufacturing class: A vocational class at a comprehensive high school. Students included ninth through twelfth graders of heterogeneous ability, all male. Provided a math credit toward graduation but did not meet state college and university requirements.

- Mr. Benson's architectural drawing class: A vocational elective. Provided a practical arts credit toward graduation but not college admission. Students included ninth through twelfth grade students of heterogeneous ability and a 50/50 mix of girls and boys.

- Ms. Adams's interior design class: An elective vocational course taught at a comprehensive high school. Male and female students included tenth through twelfth graders of heterogeneous ability and a 50/50 mix of girls and boys. Provided a fine arts credit needed for graduation.

Obviously, as a group these courses have little in common in terms of their subject matter or administrative characteristics. Nevertheless, we found that they resembled each other in important ways in terms of the four themes of our model for instruction in generic skills and attitudes.

Instructional Goals: Target Generic Skills and Attitudes

In all five of these classrooms, the teachers had a mix of instructional goals that included complex reasoning skills, cooperative skills, and work-related attitudes as well as domain-specific skills and knowledge. Relative emphasis among these goals varied by teacher and classroom, but in all cases generic skills and attitudes were explicitly targeted.

In the English class, for instance, writing was taught as a tool for thinking. Students were required to read and write about three difficult Latin American novels, but the focus of the class was not on domain-specific subject matter such as the history of the novel or Latin American literature. Rather, the reading of these books and the researching and writing of a documented critical essay were used as vehicles for teaching generic skills, social skills, and techniques for making work personally significant.

All three teachers strove to instill positive work-related attitudes. These varied by class but included taking responsibility for one's own learning and performance, being bold in decisionmaking, personalizing work in order to make it interesting and rewarding, and valuing lifelong learning.

These teachers stressed cooperative skills. In addition to being an important work-related generic skill, cooperation has benefits in the classroom: It can increase student responsibility for learning by holding the student accountable for contributing to group work and by requiring the student to help others. It can also enhance learning and engagement by enlisting students as additional sources of instruction and motivation for each other.

Although these teachers all taught domain-specific skills and knowledge, they had the freedom to define their instructional domains in broad terms. Their view of relevant class content was not constrained by curriculum frameworks, standardized tests, textbooks, or follow-on courses.

Classroom Design: Situate Learning in Authentic Practice

All three teachers pursued their instructional goals by situating learning in authentic practice: That is, they designed their classrooms so that students learned skills and knowledge by performing tasks that reflected the complexities of real tasks performed by adult practitioners. This meant that students engaged in projects rather than exercises. In the interior design class, students designed and furnished a Victorian house; in the manufacturing class, they designed and manufactured toy trucks. Project work ensured that specific learning was motivated and made useful by the context of a larger goal. Project work was also typically group work, requiring students to learn and apply cooperative skills.

These classrooms promoted a culture of practice, simulating actual working cultures to varying degrees. Mr. Price's English class asked students to participate in the cultures of the reader (the adult who reads fiction for pleasure), the critical writer, and the college student. Mr. Benson's electronics classes drew on the culture of the adult hobbyist. His manufacturing class recreated the culture of the shop floor. Ms. Adams's class most resembled an interior design firm. The cultures were rich enough to permit instructors to teach a full range of both domain-specific and generic skills and attitudes. (This was in contrast to the landscape classroom in our sample, one of those that did not work, which used the road crew as its reference culture.)

Teachers in these four classrooms focused on intrinsic motivation. They deemphasized grades and did not discuss performance criteria in terms of grades. Each has a true avocation for their subject area and modeled enthusiasm, engagement, and persistence for their students. Each expected students to take responsibility for a large portion of their own learning. Students were asked to make choices about what they would do: what topic to research and write about, how to manufacture the truck, what colors and fabrics to use. The classrooms were well-stocked with "tools of the trade" (the problem of acquiring sufficient resources is addressed below).

In classrooms that worked, learning was cooperative and students worked together in self-managing groups. Ms. Adams taught specific techniques to enhance cooperation (e.g., consensus building) and had groups evaluate their own performance. Other teachers had less structured approaches. Cooperative activities were initially most difficult for students in the English class, who appeared to enter the classroom with an expectation that the teacher would provide all instruction and motivation and that students would work in isolation. But Mr. Price successfully taught them to use each other--and himself--as resources.

Teaching Techniques: Foster a Working Relationship

The role of the teacher in these classrooms was predominantly that of master to the students as apprentices. Typically teachers moved from group to group monitoring progress and offered limited assistance, encouragement, or advice, much as an "expert consultant" might. Instruction was offered opportunistically in response to specific student needs.

Teachers did little lecturing. One-on-one tutoring and master-apprentice-like interactions were the main techniques of instruction. As with other master-apprentice relationships, there was no discrete distinction between teacher and student but rather a continuum of expertise (in some areas, some students might have greater expertise than the teacher, a fact that was acknowledged and exploited to the classroom's benefit) and a shared focus on achieving a common goal.

These teachers relied heavily on modeling to demonstrate how an expert practitioner carried out a task. This included the modeling of attitudes, mentioned above, as well as procedures and thought processes. For example, teachers shared heuristics that experts use to help them make decisions, such as how to tell whether one has done enough research for a paper.

These teachers also used "coaching," "scaffolding," and "fading." In his electronics classroom, Mr. Benson primarily used highly interactive coaching, i.e., guiding students through problems with focused questions and suggestions. Mr. Price provided scaffolds in the form of physical supports (diagramming three ways to structure a paper). Fading is the gradual withdrawal of teacher support (coaching or scaffolding) as the group (or student) reaches a point from which they can proceed alone.

All three teachers also asked students to articulate their learning, i.e., verbalizing their perceptions of or conclusions about their own performance. This technique helped students to understand themselves as learners and to integrate their learning. Similarly, reflection was a technique by which students analyze and assess their own performance.

These classrooms permitted a great deal of exploratory learning by students. Learning was highly personalized and not expected to proceed in lock-step according to a lesson plan or textbook. This technique accommodated individual differences in ability and interest. It also required teachers to offer flexible, highly individualized instruction.

School Context: Provide Autonomy and Resources

The classrooms that worked owed their success to their teachers and students. Nevertheless, some elements of school context importantly influence these classrooms.

Access to knowledge in these classrooms was affected by the resources provided by the schools. Ms. Adams's class received additional funds because it was sponsored by a state vocational program. In other classrooms, school-provided resources were supplemented by the teachers themselves and sometimes even by the students. Mr. Price used his own money to purchase books. Mr. Benson arranged to borrow against future class budgets in order to obtain additional equipment. In the manufacturing class, students could build some tools needed for use in later stages of their project. All of these classes would have benefited from additional resources to support learning.[3]

These classrooms also varied in the degree to which their school context supported their press for achievement. Vocational classes were less valued than academic classes in the schools where Ms. Adams and Mr. Benson taught, but their personal views about students and their acknowledged success challenged the school's view.

Similarly, as a vocational teacher, Ms. Adams did not enjoy strong professional teaching conditions. She was isolated from the school faculty generally and did not participate in activities that can foster professional growth, such as collaborative staff planning, intellectual sharing, and teamwork. However, she was strongly supported by the vocational program administrator on campus. Mr. Benson fared better: He socialized with the other members of the faculty and was active in professional organizations. Ironically, the positive aspect of being vocational instructors in comprehensive high schools is that these teachers enjoyed more autonomy than would be typical for academic instructors. This extra measure of autonomy contributed to their ability to design classrooms that worked.

Student Perceptions: A Strong Classroom Culture Engages Students

In all cases except the English course, students entered these classrooms with a wide range of expectations, abilities, interests, and goals. Many were unmotivated to learn or participate. However, according to the students' own reports, these teachers were successful in engaging and teaching them. Moreover, the students came to understand their classrooms: They knew what their roles were, what they were expected to do, what they could expect the teacher to do, why they were learning the way they were, and what was valued. In a word, they had been "enculturated" into the culture of practice in the classroom. They had positive attitudes toward learning by participating in that culture and reported they had learned many of the skills and attitudes that teachers aimed for.

Research and Policy Implications

This study has important lessons for practitioners who wish to design and conduct classes that impart generic skills and attitudes. It also has research and policy implications.

- **Generic skills can be taught in academic and vocational classrooms.** Although only one of the five successful classrooms that we studied was an academic one, we observed no reason why other academic classrooms could not also target generic skills and attitudes as Mr. Price did.

- **Designin classrooms to provide authentic practice is key.** For both academic and vocational classes, the key to imparting generic skills and attitudes is to design classroom instruction around project work that situates learning in a particular context and provides opportunities for authentic practice in a domain. Authentic practice will usually reflect an occupational culture, but an important reference culture for Mr. Price's classroom was that of the college student. The reference culture should be rich enough to permit the learning of complex reasoning and cooperative skills.

- **Situated learning enhances student learning and engagement.** When students learn by performing tasks that are situated in authentic practice, their learning is made meaningful by its context. Specific lessons are immediately applied and integrated; success is rewarded by progress toward a larger goal. Learning is not abstract or decontextualized.

- **Teachers need to hold high expectations for students.** When teachers do not hold high positive expectations for student performance and behavior, they do not design and conduct the kinds of rich and challenging classrooms that can foster the learning of generic skills and attitudes. The teacher of one of the successful classrooms in our sample also taught the least successful: In the latter, his low expectations for the enrolled students caused him to abandon many of his teaching skills and focus instead on playing "therapist." While this class did in fact include many students with low ability and emotional or behavioral problems, we observed some of the same students behaving appropriately and engaging in learning activities in other classes.

- **Teacher training and staff development need change.** Teachers are not currently trained to design and conduct classrooms based on a culture of authentic practice. The teachers in the classrooms that worked had personal avocations or nonteaching professional backgrounds that they could combine with their teaching expertise. Programs that enhance teacher experience in reference culture--for example, through summer apprenticeships in local firms--might increase the number of teachers who are capable of teaching classes reflecting authentic practice.

- **Teachers need autonomy and additional resources.** Teachers need the freedom to create a culture of practice within their classrooms that fosters learning and engagement. They also need resources to provide an environment that will support authentic practice and highly individualized, exploratory learning.

- **Assessment needs to measure generic skills learning.** We found that teachers can effectively impart generic skills and attitudes both in academic and vocational settings. If school reform is to move in this direction, the incentives must be in place to encourage and reward teachers and students to focus on generic skills. Current standardized assessments do not measure these skills and attitudes.

- **Teaching generic skills connects to other school reforms.** We believe that classrooms that successfully impart generic skills could also contribute toward other reforms often called for today, such as improved school to work or college transition and a focus on "foundation skills."

- **Focus on generic skills can help integrate academic and vocational education.** Because generic skills and attitudes can be taught in both academic and vocational settings, the focus on generic skills may be an important strategy in the current reform to integrate academic and vocational education. Generic skills and attitudes could provide a common core for an integrated curriculum, and the elements of classroom design and the teaching techniques that we have identified could provide the basis for an integrated pedagogy. In this sense, a focus on instruction in generic skills and attitudes could be one model for integrating academic and vocational education.

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1. LEARNING TO WORK IN SCHOOLS

There is growing consensus that American education needs fundamental reform. The widespread dissatisfaction with secondary education, in particular, is partly based on two concerns about skill demand in the workplace. One is that America is losing its competitive edge over other nations that educate and train a higher-skill workforce (Commission on the Skills of the American Workforce (CSAW), 1990). The second is that changes in the workplace will continue to demand highly skilled and more flexible workers (Bailey, 1991). These concerns have spawned dozens of new proposals for restructuring secondary education to improve the connection between school and employment and ensure student readiness for high-skill employment opportunities and lifelong learning (e.g., Council of Chief State School Officers (CCSSO), 1991; U.S. Department of Labor, Secretary's Commission on Achieving Necessary Skills (SCANS), 1991).

Two questions hold center stage for school reformers:

- What kinds of skills should be taught and learned?
- How should schooling be organized to teach these skills?

The answers to these questions are the topic of much debate among educators, policymakers, researchers, the business community, and the general public. Recently, the question of which skills should be taught was the focus of a widely cited commission report sponsored by the Secretary of Labor (SCANS, 1991). That report recommends that students be taught generic skills--problem solving, communication, teamwork, higher-order thinking--in addition to subject-matter or domain knowledge. It also notes that students' attitudes toward work need improvement.

The "how" question is being addressed at two levels. At the program level, one sees the development of many models to improve the "school to work" transition (cf. Stern, 1990; Bodilly et al., 1993). These models often require changes in curriculum, pedagogy, and organizational structure in addition to new relationships between secondary schools and institutions that provide postsecondary education and training. Program level changes often entail changes in the classroom as well. Policymakers and researchers have paid considerably less attention to the classroom level--in particular, to the identification of teaching practices and policies that will support learning new kinds of skills. This lack of attention has occurred despite new theories of student learning that call for changes in teaching practices to support learning these skills (Raizen, 1989; Collins, Brown, and Newman, 1989).

Research Objectives and Approach

We have conducted two studies that focus on the teaching and learning of generic skills at the classroom level. The main goal of these studies is to inform the design and development of courses that aim to improve the connection between school and employment by teaching generic skills and attitudes in addition to domain-specific skills. We focus on the classroom level of program implementation in the belief that the design of classroom activities and selection of pedagogical practices are essential to improved instruction and learning.

The first study, whose results were published earlier, developed an approach for studying instruction in generic skills and attitudes and applied it in several vocational classrooms (Stasz et al., 1990). We made a number of findings regarding how generic skills and work-related attitudes are imparted in vocational education settings and how these settings differ from academic ones. These findings implied that lessons learned about teaching generic skills and attitudes in vocational settings may not transfer easily into academic classrooms or programs that integrate vocational and academic education.

The present study directly addresses potential differences between academic and vocational classrooms in the teaching and learning of generic skills and attitudes. Our sample of case study sites includes both academic and vocational classrooms. This extension permits us to address several relevant issues, including whether generic skills are taught in academic domains and how teacher training and work experience influence the teaching of such skills.

As in the previous study, we use ethnographic field methods to observe, record, and analyze the classroom activities directed toward the teaching and learning of generic skills and attitudes. We also developed a framework for thinking about how to enhance attitudes toward work through the design of the learning environment. That framework purposely blurs the distinction between school and work to consider what studies of traditional apprenticeship (cf. Lave, 1977) and work design (cf. Hackman and Oldham, 1980) imply for classroom instruction.[4]

When comparing all the classrooms, we found strong similarities among those that appear, on the indices developed, to succeed in conveying generic skills and attitudes. There are also strong differences between these classrooms and those that fail to do so. Through these comparisons, we are able to identify a large set of common practices associated with the teaching of generic skills and to organize them into an instructional model that can help guide the design and development of courses that aim to provide improved instruction in generic skills and attitudes. We describe in detail three well-designed vocational and academic classrooms where teachers successfully impart generic skills and work-related attitudes.

Since the questions above--regarding what generic skills are and how to teach them--motivate our research, we explain them more fully before proceeding.

What Skills and Attitudes Should Be Taught?

Spurred by observed changes in the workplace and employers' dissatisfaction regarding the skills of high school graduates, researchers have developed new conceptualizations of skills that attempt to separate different types of skills into discrete categories. The first cut separates domain-specific or occupationally specific skills from "generic" skills. For the most part, this distinction is not controversial. A second cut separates "basic" and "higher-order" skills. This distinction is debated in the education and research communities, and current work challenges the assumption that skills underlying complex performance can be sequenced from basic or low level to complex or high level (see Stasz et al., 1990 for further discussion). For the purposes of our research, we define two broad categories of generic skills:

- **Basic or enabling skills** include such abilities as reading, doing simple mathematics and such "life skills" as reading a schedule or filling out an application. Rudimentary prosocial behaviors can also be considered basic skills. Basic skills are often used in the service of more complex tasks requiring higher-skill levels.[5]

- **Complex reasoning skills** comprise the second category of generic skills. Some tasks require formal reasoning: the problem to be solved specifies all premises or given information in advance. Other tasks require informal or everyday reasoning: Premises are not completely supplied for the problem, and everyday thinking activities must be invoked (e.g., planning, making commitments, evaluating arguments, choosing options; see Galotti [1989] for a detailed discussion). Complex reasoning skills are the types of skills needed in "flexible" work arrangements (U.S. Congress Office of Technology Assessment (OTA), 1990; SCANS, 1991; CSAW, 1990).

These generic skills can be applied in a variety of domains or vocations and in combination with domain-specific knowledge and skills that define competence in a particular area.

A third component of our conceptualization identifies work-related skills and attitudes that individuals bring to a task. These can influence how any skills are acquired and learned.

- **Work-related skills and attitudes** include cooperative skills; personal qualities such as individual responsibility, self-esteem, self-management, and sociability (cf. SCANS, 1991); "habits of thought" that can lead individuals to engage in higher-order thinking (cf. Resnick, 1987a); and psychological factors that influence a person's motivation to respond to a task in either adaptive or maladaptive ways (cf. Dweck and Leggett, 1988).

These three categories of generic skills and attitudes often overlap and it is difficult to determine exactly what proportion of different skills or attitudes contribute to skilled performance. We do know, however, that individuals faced with school-related, work-related, or everyday life tasks bring a constellation of knowledge, skills, and attitudes to bear in accomplishing them.[6] Knowledge, skills, and attitudes interact with each other and with the task in complex ways to produce degrees of success or failure. While skills define a person's competence or ability to do a task, attitudes influence willingness and the effort expended to perform a task (Stasz et al., 1990).[7]

While this conceptualization does not sort out distinctions between "levels" of skills or the precise relationship between skills and attitudes, it provides a useful starting place for thinking about generic skills, their relative importance, and their teachability. It seems clear that individuals may not be able to bring their basic and complex skills to bear on a task effectively if they lack attitudes conducive to work. Conversely, a person who is unskilled but bubbling over with positive work attitudes may be a good candidate for education or skill training. However, we argue that those with only basic skills and prosocial attitudes, although perhaps readily trainable, will have limited roles in the workplace and limited ability to adapt to workplace change. Complex reasoning skills and work-related attitudes, in particular, appear to be key attributes for adapting to changes in the workplace. These are the attributes that employers value and school reformers hope to impart.[8]

To guide our observation and analysis of the teaching and learning of generic skills and work-related attitudes, we developed a conceptual approach that posits how the learning environment can affect (a) the individual's attitudes toward engaging in the task and (b) the teacher's ability to cultivate attitudes that enhance task performance. This conceptualization draws on research findings from two domains, cognitive science and organizational behavior.

Cognitive science research emphasizes the benefits both to learning and motivation of teaching theories and facts in the context of "real-life" problems and activities that can include group work and hands-on use of relevant tools (cf. Resnick, 1987b). This research on "cognitive apprenticeship" suggests that the instructional environment should support a culture of "authentic practice" where students and teachers can actively communicate and engage in the skills involved in expertise, including solving problems and carrying out tasks in a domain (Collins, Brown, and Newman, 1989).

Research in organizational behavior provides insights into how task design and other aspects of the working environment can enhance worker motivation and performance (Hackman and Oldham, 1980; Bailey, 1991). A "socio-technical systems" approach focuses attention on the design of work itself: for example, defining "flexible" work designs to replace more traditional ones as a means to achieve the "high-performance" workplace (CSAW, 1990; SCANS, 1991).

How Should Generic Skills and Attitudes Be Taught?

Broad descriptions of needed workplace skills and attitudes are a necessary, but not sufficient, step in changing education to improve the connection between school and postsecondary education or employment. Educators will need to design new programs that prepare students for careers that may very often not fit the old categories of managerial or entry-level work (Capelli, 1990; OTA, 1990). Teachers--who have the ultimate responsibility for carrying out any curricular reform--must design activities and use teaching practices that impart generic skills and attitudes.

At the program level, educators facing the challenge of how to prepare students for the new workplace can build on a solid base of existing programs in vocational-technical education.[9] In "cooperative education," for example, schools and businesses work together to promote learning that extends what is taught in the classroom by providing students' experience in paid jobs. This method gives students direct practice in learning at the workplace. Vocational programs also offer important learning opportunities through operation of school-based enterprises. Significant new approaches include career "academies" and the "tech-prep" movement that offer high school students rigorous courses of study focused on specific occupational areas while giving more students the option to go to college (Stern, 1990). Such programs represent a departure both from traditional academic programs, which are faulted for being too "decontextualized," and traditional vocational education, which keeps work and school too separate.

Practices that place students in college-bound, vocational, and general tracks may not provide comparable opportunities for learning generic skills. Programs that combine school and work can challenge existing education practices that separate academic and vocational curriculum, teachers, and students. Academic and vocational teachers may need to collaborate to develop new curricula (cf. Grubb et al., 1991; Bodilly et al., 1993). For these reasons, it is important to examine school- and district-level policies and practices of the sorts that have been shown to affect the teaching context and are amenable to policy interpretation: (1) teaching conditions, (2) press for achievement, and (3) access to knowledge (Oakes, 1989).

Less is known about specific classroom level practices that support learning in school-to-work programs or individual courses that aim to teach generic skills. Many practitioners and researchers agree that learning through the work process itself is an effective method for acquiring work-related knowledge (Resnick, 1987a, 1987b; Collins et al., 1989; Brown et al., 1989; Raizen, 1989). In the absence of direct experience, the same research supports "situating" learning in the context of real-life problems suggested by the culture of authentic practice (as discussed above). This requires that teachers revise their role as lecturers and become the students' guide, model, or coach in the learning process. It also requires students to take a more active role in learning--to learn how to apply abstract concepts, work in teams, use tools effectively, and communicate their knowledge to others. Because situated learning, informed by the culture of practice in a profession or trade, aims both to improve learning and engage students, it provides a powerful model for designing programs and classroom activities that can enhance generic skills and dispositions. In short, students learn to work in classrooms where skills and attitudes are taught in the context of complex, realistic tasks.

Research Scope

By focusing our analysis at the classroom level, we necessarily limited the number of cases we could study. On the one hand, the small sample size reduces the generalizability of our findings. On the other hand, our case study approach provides rich information on teaching practices and student behavior and perceptions that practitioners sorely need.

In reporting this research, we pay particular attention to "classrooms that work"--i.e., that appear to be successful in imparting generic skills and attitudes, based both on observations of the instructional process and student perceptions of learning--while using classrooms that achieved less success as sources of illuminating counter-examples.

Although our work is addressed primarily to teachers and administrators who wish to improve the teaching of generic skills and attitudes, it will also be of interest to policymakers. In addition to classroom practice, we also examine the policy contexts for classrooms in order to gain insight into what kinds of policies can facilitate--or hinder--instruction in generic skills and attitudes.

Organization of the Report

Six sections follow this Introduction. Section 2, which presents our research methods, will primarily interest researchers. Section 3 is of more general interest: It compares the classrooms we studied across a comprehensive set of domains and suggests an instructional model for generic skills and attitudes. Sections 4, 5, and 6, which provide detailed descriptions of three classrooms that work, will be of particular interest to practitioners. Conclusions and implications are presented in Section 7.

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2. FIELD STUDY METHODS

To observe the learning and teaching of generic skills in vocational and academic settings, we conducted intensive field studies of both kinds of classrooms. Our efforts to understand these classrooms focused on answering several questions:

- What teaching practices do vocational and academic teachers use to teach generic skills and work-related attitudes?
- How do the practices employed by vocational and academic teachers differ? Why?
- What is the broader context within which these practices arise? How are the practices supported or hindered by elements of this context?
- What positive aspects of the context are amenable to intervention--by staff development, policy, and so on?

We addressed these questions by examining teaching of generic skills in vocational and academic classrooms with a combination of research approaches that included case study, ethnographic, and survey methods. A case study approach permitted the intensive observation and analysis of a limited set of specifically targeted sites. We used ethnographic methods to deepen our understanding of what goes on in classrooms, particularly the interactions among teachers and students (Dobbert, 1982; Woods, 1986). By triangulating data collection methods--using participant observation, formal and informal interviews, student focus groups and survey, and collection of artifacts--we attempted to strengthen the reliability of our findings within classrooms (cf. Goetz and LeCompte, 1984).

As described in Section 1, our previous study of vocational classrooms produced a framework for analyzing the learning and teaching of generic skills (Stasz et al., 1990). The present study further develops the framework and applies it to the analysis of a variety of vocational and academic classrooms that purport to engage students in learning generic skills and dispositions, but that differ in significant ways--the students, teacher, subject, and school. In both studies, we use theory and previous research to develop the framework and refine it based on our classroom research experience. Our intent is not to test a particular theory but to use theory as an initial guide for data collection and for interpreting the results.

Our approach leaves open the possibility that factors not explicitly identified in our framework may be important in some classrooms and contexts in explaining the activities observed. It also permits the discovery of issues important to understanding classrooms that are not accounted for *a priori* by an analytic perspective. In our previous study (Stasz et al., 1990) this approach proved valuable, enabling us to identify an unexpected emphasis by teachers on shaping and supporting development of work-related attitudes in students.

This approach to studying classrooms also accepts the view that reality in a social setting--the classroom, in this case--is constructed by individuals through interactions that reflect their understanding about the world (Geertz, 1973). When individuals share a classroom over time, they develop mutual understandings and expectations about the classroom. These constitute the classroom culture. The classroom is also embedded in a wide school and community culture that further affects teaching and learning.

Site Selection

In keeping with our goal to test the framework produced from our previous study (Stasz et al., 1990) in both vocational and academic settings, we used site selection criteria suggested by that study's findings. Initially we sought to identify classrooms of both sorts where teachers claimed to (1) teach problem-solving skills, (2) value students' cooperation and responsibility for their own learning, (3) provide opportunities for project and group work, and (4) hold high expectations for students' performance.

We employed a "snowballing" or "chain-sampling" approach to locate potential sites (cf. Patton, 1980). We began by contacting high schools, skills centers, and community colleges throughout Los Angeles County based on leads from ongoing research and other professional contacts. We developed a slate of twelve candidate classrooms and secured permission for a prestudy visit to each. Two members of the research team conducted the visit, which included classroom observation, informal discussions with students, and an interview with the teacher. Based on a written report of the prestudy visit and subsequent discussion by the research team, we identified eight classrooms and negotiated entree with the school principals. (Again, one of these classrooms--an interior design class--was reported on in our preceding study.)

We rejected two candidate math classrooms because the curriculum relied on traditional classroom practices to help students acquire skills that were prerequisites for the next level. We also rejected a candidate science classroom when district budgetary problems led to overcrowding and delayed delivery of supplies, spoiling the teacher's planned use of cooperative projects. In the final candidate site, the teacher resigned before we could conduct a visit.

In spite of the selection process, observations culled from a single visit were insufficient to fully assess our prerequisite criteria. For instance, all the teachers in our sample *stated* that they held high expectations for students in all the classes they taught and nothing revealed during a single visit suggested otherwise. However, in the three classrooms that we judged not to work, we *observed* learning expectations for students to be low. This conclusion came as a result of many and repeated classroom observations and subsequent analysis. This, of course, reinforces the appropriateness of the extensive and in-depth ethnographic methods we employ to understand classrooms.

Site Characteristics

School and Community Context

Characteristics of the resulting sample of eight classrooms are summarized in Table 2.1. The classrooms were housed in three different comprehensive high schools with a predominantly college preparatory curriculum. Thus, the vocational and ROP (Regional Occupational Program) classes were on the margins from the schools' main focus. The chemistry classes were in a special academy program that maintained the school and district's college preparatory focus. In subsequent sections we discuss the characteristics of this marginality and analyze how it affected teaching and learning.

Five of the eight classes were in largely suburban communities; the chemistry and interior design classes were in an urban setting.

Students' socioeconomic status was mixed in the urban schools. The school housing the remaining five classes was in an upper-middle-class community on the border of Los Angeles County. While this school's population was primarily Anglo (i.e., non-Latino Caucasian), the urban school's was primarily African-American and Latino. The interior design class' school was changing, with an increasing minority, particularly Latino, population.

Table 2.1
Site Characteristics

Site	SchoolType	Location	Socio-economic status	Ethnicity
Interior design	Comprehensive high school	Urban	Mixed	Anglo, increasing African-American, Latino, Asian
Landscape	Same	Suburban	Middle to high	Primarily Anglo
English	Same	Same	Same	Same
Electronics	Same	Same	Same	Same
Architecture	Same	Same	Same	Same
Manufacturing	Same	Same	Same	Same
Chemistry (2 classes)	Academy within comprehensive high school	Urban	Mixed	Primarily African-American and Latino

Teachers and Students

Four teachers taught these eight classes. Below we summarize their backgrounds and relevant experience:[10]

- *Ms. Adams,* the interior design teacher, had seven years of teaching experience and was a practicing professional in the field. She held a vocational teacher certification.
- *Mr. Price* taught landscape/horticulture and English literature and composition.[11] He had botany and English degrees and

was certified to teach both science and English. He had taken a year off to study writing at a local university and conducted workshops for teachers on cooperative learning techniques. He began teaching when the school opened twelve years ago.

- *Mr. Benson* taught industrial arts--electronics, architectural drawing, and mechanical drawing--and Algebra I at the same high school as Mr. Price. He had over twenty years of teaching experience and was certified to teach math and physics, as well as vocational education. He had an M.S. in industrial technology and an M.A. in fine arts (furniture design). He was active in a statewide consortium on teaching manufacturing.

- *Mr. Stone* taught chemistry in the academy program. He was a relatively new teacher with only three years of experience. This was his second year teaching full time. Mr. Stone had a Master's degree in seismology and had worked in the seismology lab at a local university. He held a temporary teaching credential, but was working toward certification in math and science.

The eight classes also varied as to the students who enrolled in them. All the vocational classrooms included limited-English-proficient (LEP) and special-education students in keeping with the school placement policies, as well as students with specific vocational interests. Ms. Adams's interior design class enrolled a heterogeneous group of tenth to twelfth graders. Mr. Benson's three industrial arts classes also drew a heterogeneous mix of students in ninth to twelfth grades, including students in the lower third of the school's ability distribution and others with emotional and behavioral problems. In electronics, all the students were male. The tenth grade students in Mr. Stone's chemistry class were also a heterogeneous group because the academy had a diversity strategy and selected students with different academic profiles, including limited-English-proficient and special-education students. Mr. Price's classes were homogeneous but had decidedly different characteristics. The English students were college-bound seniors. The majority of the landscape/horticulture students were in the lower third of the school's student ability distribution and most had emotional and academic problems.

In all cases, the students have enrolled or been placed in a class for various reasons, which tie into students' aspirations, teachers' and schools' expectations for students, and the course's place in the overall school curriculum. These are complicated stories that we address in the sections on specific classrooms.

Analytic Procedures

The goal of the field study was to develop a model of generic skills instruction based on an understanding of classrooms that "worked"--i.e., that appeared successful in the attempt to impart generic skills and attitudes. During the course of the present study we considered the three teachers sequentially and carried out intensive, six-week case studies of five classrooms (landscape/horticulture, English, electronics, and two chemistry) and shorter case studies of two vocational classrooms (architectural drawing; mechanical drawing/manufacturing). We targeted all three academic classrooms (English and the two chemistry classes) for intensive study since our previous research had been based solely on vocational classrooms. The intensive case study of the interior design classroom, as indicated above, was carried out as part of the preceding project.

Following ethnographic methods as described by Spradley (1980), the analytic process for understanding these classrooms was organized into five activities:

1. Descriptive observation and questioning, which identified key teacher practices and student behaviors.

2. Focused observations and structural questions, which expanded the list of practices and behaviors and their differences.

3. Selected observations and contrast questions, which clarified the differences that separate practices and behaviors.

4. Indexing data, which placed practices and behaviors in meaningful domains.

5. Analysis of relationships between domains and generation of themes, which composed the model of instruction.

Figure 2.1 suggests how the analytic activities progressed over time (details of the figure will be explained in the following pages). We began our analysis during early stages of the fieldwork with "low inference" procedures so as not to bias or close off our observations: that is, we attempted to observe with little theoretical guidance, not inferring initially that we understood and could describe in theoretical terms what was occurring. Over time, increasingly inferential procedures became appropriate and were applied.[12] As we became ethnographically familiar with classrooms, we returned to our conceptual framework and explored cognitive science and motivation literature to derive hypotheses to explain what we were observing. We reviewed literature on work design and sociotechnical systems to help us frame questions about the design of the classroom and the teacher role as we were beginning to understand these elements as explanatory of the classroom culture. Throughout the process we employed an iterative approach to develop deeper understanding of the classrooms (Spradley, 1980). The iteration involved blending and staging the data collection and analytic procedures as represented in the figure.

Figure 2.1--Research Approach for Developing Model of Generic Skills Instruction

We conducted training sessions to prepare fieldworkers for each task. This training included practice opportunities prior to going into sites, modeling by an experienced member of the team, and feedback on field notes.

All five members of the fieldwork team collected data for each intensive case. Teachers were scheduled sequentially over a year, spring 1991 to summer 1992. Two fieldworkers visited each classroom twice weekly for six weeks and submitted field notes of their observations.[13] The fieldwork team met weekly to review their notes, discuss role management (i.e., how to be an effective classroom observer),[14] review potentially useful literature, discuss observations and reconcile discrepancies between observers, and plan the week's observation agenda. After completing observations, we conducted formal interviews with teachers and administrators and focus group discussions with students. Before the focus group discussions, students completed the survey instrument.

Descriptive Observation

Experience with microethnography has shown that nine-tenths of what goes on in a social scene is captured in interactions (Spradley, 1980). To collect this data, ethnographic fieldwork relies on an iterative strategy of observation and questioning. Repeated observation of interactions begins to expose the "meaning-making" behind behavior (Spradley, 1980; Geertz, 1973). The observer's understanding of this meaning is sharpened through questioning of the participants.

We observed students in various classroom activities, paying particular attention to their interactions and their context. At first we focused on making participants familiar and comfortable with fieldworkers while we became familiar with the classroom environment and identified key informants, individuals who would serve as our early guides, provide informal introductions to other students, and supply an "insider's" view into the inner workings of the classroom. We then structured our descriptive observations by "shadowing" these key informants, joining their work groups as an observer and questioning them during the course of their activities. In all cases the teacher was a particularly important informant, and one researcher in each classroom shadowed the teacher to observe specific teacher/student interactions. We collected classroom artifacts such as assignment sheets, lab experiments, and drafts of student work. Finally, through informal discussions with teachers and students, we attempted to gain understanding of the meanings that they attached to the activities and practices that we observed.

Indexing of Observational Data

At the close of descriptive observations in each case, we began indexing raw field data. Indexing involves identifying and tagging segments of field-note text. Suspending observations for a week, as a group we developed a list of index terms as a first attempt at describing the classroom: Examples include classroom policies and practices, feedback, and infractions. This involved a process of reading and noticing the interesting things in our data and variation within a classroom. In addition, the list included concepts or issues identified in our earlier study: Examples are problem solving and motivation/disposition. Over the course of the fieldwork and after several discussions, we reached consensus on a list of low-inference terms and definitions that each researcher-fieldworker used to tag their field notes--e.g., affect toward learning/classroom/teacher; extraordinary engagement, trust/respect, stress, acting out, and horseplay. For further examples, see Appendix B.

To achieve reliability in reading, noticing, and tagging, we calibrated the indexing task. Each fieldworker indexed several field notes, written by different fieldworkers, and we compared our results. As a group we clarified definitions and identified previously neglected areas. We used *The Ethnograph* (Seidel, Kjolseth, and Seymour, 1988), a computer-based analytic tool, to help manage the indexing task. The computer program made it possible to number lines of text and then sort text lines by index terms. *The Ethnograph* permitted organization of our data set, some 1,000 plus pages of text, into relevant categories--using our index terms--while establishing an audit trail. It facilitated data reduction by permitting assignment of index terms to sections of text. The text then could be sorted according to these index terms to reveal patterns across the separate observations. As domains were identified, index codes could be recoded and merged. Thus, we were able to index complex passages of text while maintaining the whole and merge data as domains were developed.

Focused Observation

By the third and fourth week, we were able to account for a broad and varied range of classroom activities, practices, and behaviors, using our developing index terms. At this point we sought to understand how each of these worked or was employed. We moved from asking descriptive questions (e.g., "what are you doing now?") to posing structural questions that were directed at reasons for behaviors and the conditions in which they were considered appropriate (e.g., to the teacher, "when do you use one-to-one instruction? when do you use cooperative groups?"). We planned for observation opportunities to obtain answers to structured questions by engaging in participant observation with a specific project group or to shadow the teacher during teaching rounds.

Selective Observation

During the final weeks of fieldwork we moved to selective observations to clarify the differences and relationships among core skills taught in the classroom, student behaviors, and practices teachers employed. During our weekly meetings we developed contrast questions that would look at two or three teaching practices and explore how they differed or resembled each other (for examples see Table 2.2). Interviews with teachers and student focus group discussions provided a final opportunity to account for differences and relationships among similar key observed characteristics of classrooms.

On the final day of observations, we surveyed students to gather personal background information and data on classroom motivation and beliefs about their own self-efficacy for learning. The questionnaire was designed as a series of statements against which students could rate their own level of agreement on a scale of 1 (strongly disagree) to 4 (strongly agree). For example, the statement "Working in groups is a good way to learn" refers to students' assessment of the educational benefit of group work.

Following the survey we conducted focus group discussions to understand student grades, expectations, and experiences.[15] Two fieldworkers, one leading the discussion and the other taking notes, held a discussion with a group of 10-12 students. Multiple groups were held simultaneously over 30-40 minutes. To encourage students to speak freely about the class, the teacher was absent from the classroom. During the weeks following classroom observation, we interviewed teachers and school administrators to better understand classroom and school contexts, respectively. Our formal interview instruments were designed to carefully assess respondents' perceptions about and experiences with the learning of generic skills and how they viewed school policies and teaching practices that potentially influence classroom instruction and curriculum. Because we had already spent many weeks in the classrooms, we were able to fold our observations into the interview questions, asking for explanation and insights. During interviews we asked respondents first about their perceptions, then sought specific examples or probed for issues known to affect vocational and academic settings.

Domain Analysis

Domain analysis involves understanding patterns of behavior or practices. A domain is a category of meaning that includes other smaller categories; for instance, the domain of *student goals may include easy grade, graduation credit, preparation for work,* etc. Similarly, the domain of *teacher tactics* includes subcategories such as *scaffolding, fading,* and *articulation.*

Table 2.2
Examples of Contrast Questions Used to Define Teaching Techniques Observed in the English Classroom

Contrast Question	Observation

When do scaffolding, fading, and articulation resemble each other?	Never.
How are the three different?	When scaffolding, the teacher verbalizes or performs a process. When fading, the teacher "hands off" verbalization or performance to the student. During articulation, the teacher prompts the student to verbalize understanding of a concept or process.
When are any two related?	Scaffolding and fading are used sequentially. Articulation might result from scaffolding, but also in response to other prompts, e.g., a question. Teachers fade, students articulate.

As we progressed from focused observations to selective observations, our domains shifted from "folk domains" (terms used and recognized by participants--e.g., *seat-of-the-pants instruction, "negative capability," trial and error*) to more "analytic domains" (terms adopted or created by the research team--e.g., *master/apprentice roles, work-related attitudes, generating alternative solutions*) (see Table 2.3). We determined that nineteen domains sufficiently accounted for understanding the eight classrooms we studied (see Appendix C for full list). In Section 3 we compare the eight classrooms along these nineteen domains.

Generation of Themes

We began our final analytic procedure by comparing classrooms by domain. Establishing relations between domains in certain classrooms led to generation of themes (e.g., the importance of having instructional goals that explicitly target generic skills and work-related attitudes). We report these themes in the section that follows and use them to organize our descriptions and analyses of the successful classrooms in later sections. Taken together, these themes compose a model of generic skills instruction. In classrooms that are organized around these themes, the teaching and learning of generic skills and attitudes appears to be successful.

Table 2.3
Three Examples of Shifting from Folk Domains to Analytic Domains

Folk Domain	Analytic Domain	Research Literature
"Seat-of-the-pants" instruction	Master-apprentice role	Cognitive apprenticeship (Collins et al., 1989)
The use of "negative capability"	Work-related attitude	Generic skills (Stasz et al., 1990)
The skill of "trial and error"	Generate alternative solutions	Complex reasoning skills (Stasz et al., 1990)

We designed and conducted the study to ensure a high degree of reliability and validity of findings. In particular, we triangulated our data collection methods, required interobserver reliability among the five-member research team during within-site and cross-site analysis, staged analysis by suspending high-inference procedures until we had spent sufficient time in the field to understand fully how participants make meaning of their classroom activities and learning, and delineated characteristics of teachers and classroom practices to establish clear differences between generic skills classrooms and traditional classrooms. These methodological procedures were set to support translatability and comparability across sites. Whereas translatability and comparability are factors that contribute to generalizability in experimental studies, they are the foundation for generalizability and causal claims in ethnographic research (cf. Goetz and LeCompte, 1984 and Lincoln and Guba, 1985).

Although the sample of eight classrooms is too small to permit statistical inference needed for a claim of generalizability, our findings hold across many observations of teacher and student behaviors in the eight classrooms that purport to focus on generic skills. Our level of analysis informs teaching practices in these classrooms. Moreover, because several classrooms we studied "did not work," we were able to use these cases to contrast with our findings of "what does work" and to generate an instructional model for generic skills.

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3. WHAT MAKES CLASSROOMS WORK

This section first summarizes the results of our domain analysis of the eight classrooms. Nineteen domains sufficiently accounted for describing and understanding the eight classrooms we studied. We compared classrooms along each domain to distinguish between those that were more or less successful in teaching generic skills. Table 3.1 summarizes findings for each classroom by domain.

Since the discussion of Table 3.1 is lengthy, we will take a moment to look ahead. The comparison of classrooms reveals that they fall into two groups, five that enjoyed a strong measure of success in imparting generic skills and attitudes (interior design, electronics, manufacturing, architectural drawing, and English), and three that were markedly less successful (landscape and two chemistry classes). The similarities that we observed among the five successful classrooms permit us to identify key domains for describing successful classrooms (these are summarized in Table 3.2). From these similarities we derive several themes regarding how to design and conduct a classroom that works. We organize these themes into an instructional model for generic skills. In succeeding sections we present detailed descriptions of three of the successful classrooms. These descriptions are organized according to the components of the model.

Instructional Goals

Our comparison first considers the instructional goals in the classrooms--the particular kinds of knowledge, skills, and attitudes that teachers want students to learn. We begin with goals because research on teaching (Collins and Stevens, 1982; Leinhardt, 1983; Leinhardt and Greeno, 1986) and one-on-one tutoring (McArthur, Stasz, and Zmuidzinas, 1990; Putnam, 1987) reveals that teachers' planning, instructional activities, and teaching techniques are organized around their instructional goals.

Table 3.1

Comparison of the Eight Classrooms by Domain

Domain	Interior Design	Electronics	Manufacturing	Architectural Drawing	Landscape	English	Chemistry I Chemistry II
Complex reasoning	Repair skills and learn from errors; analysis of problems and generate solution paths; evaluation and monitoring	Analysis of problems and solution generation; repair and trouble-shooting; deemphasis on evaluation and reflection	Problem analysis; generate solution; repair; evaluate	Problem analysis; generate solution; repair; evaluate	Rare; at impasse students "give up" or go to teacher to solve problem; teacher gives solution to avoid student frustration	Critical thinking skills; nonlinear thinking; generate ideas; evaluate ideas; thinking heuristics	Rare; teacher assigns lab experiments with prescribed steps; repair skills practiced on occasion

						and strategies	
Work-related attitudes	Make decisions; take responsi-bility and devalue appeals to authority in decision-making; boldness; workplace parameters	Responsibility for own actions; use personal interests as guide; focus on functionality	Make decisions; take responsi-bility for actions	Persistence; make decisions; parameters of workplace	Majority of time involved in keeping behavior in check; it is important to behave sometimes	Make decisions; take responsi-bility and devalue appeals to authority; boldness; persistence; learn workplace parameters	Learn to trust lab observations; complete lab assignments
Cooperative skills	Consensus process within group; group distributes work among members	Contributing partners	Distribute evaluative responsibility among work teams; work out own differences	Use others as resource	Generally conflict-ridden but occasionally used group as a resource	Use others as resource	Teamwork to turn in one neat copy of lab report
Domain-specific aspects	Deemphasis	Electronics is integrated discipline with math and physics; circuitry logic; technical knowledge	Integrates math, drafting, woodworking, computer-aided design (CAD), computerized numerical control (CNC)	Architectural principles and facts; geometry	Landscape; how to water deeply; encourage deep root system; pesticide use and equipment; water conser-	Research skills; deemphasis on composition rules; facts; literature and cultural base for reading and	Chemistry facts; vocabulary; balancing equations; oxidation reduction

					vation; botany; common and proper plant names	composition		
Design of classroom	Integrated activities; authentic practice; group projects; self-managing teams	Basics and integrated activities; authentic practice; group projects; coacting and self-managing	Basics and integrated activities; authentic practice; group projects; self-managing teams	Basics and integrated activities; authentic practice; individual projects; self-managing	Incremental tasks; low-level authentic practice; group task assignment; coacting teams	Integrated; actual authentic practice; individual projects; self-managing	Incremental tasks; no authentic reference/practice; partners for labs; coacting	
Teacher approach	Master-apprentice; adult learning method; teacher and student as equals	Master-apprentice; best motivator is to prepare and support student for task	General manager and master-apprentice; best motivator is to prepare and support student for task	Master-apprentice	Therapist; Mr. Price is "dad"	Facilitator/ guide; all the students are equal	Missionary/traditional teacher role	
Teacher goals	Learn to "be bold"; take responsibility for own learning	Exploration	Accomplish a major project using skills	Exploration of their interests and talents	Complete the task; behave	Learn to become "nonlinear" thinker	Finish task, even if teacher does it for student	
Learning expectations	High; everyone starts with "C"; teacher is	Mixed; if sees effort then high expectations	Mixed; if sees effort then high expectations	High; everyone is average; student with	Low; just get them through the semester	High; everyone starts at C; teacher is	Low; grouped by low math skills; lower	Low; grouped by higher math skills

	friend but will also fail you			talent will excel		friend but will also fail you	expectations than chem II	
Student evaluation	Group contribution; project completion	Project completion; lab writing	Project completion	Project completion	Points for daily task completion	Final paper	Bureaucratic C; homework; labs; mastery tests	
Classroom environment	Classroom/lab; high levels of social talking; good student cohesion/ rapport; little acting out or "off task"	Classroom/lab space; high levels of social talking; some classification on basis of skill; some "off task" behavior	Classroom/lab space; high levels of social talking; good rapport and cohesion; some "off task" behavior	Classroom space; low social talking; good rapport and cohesion; little "off task" behavior	Classroom/lab space; high social talking; cliques; low rapport and cohesion; high level of "acting out"	Classroom space; low social talking; good student rapport and cohesion; little "off task" behavior	Classroom/lab space; high social talking; good student rapport and cohesion; some "acting out" and "off task" behavior	
Postsecondary focus	Employment; career exploration; preparation for college	Career exploration	Career exploration	Career exploration	None	Preparation for college	Preparation for college for some students	Preparation for college
Teaching tactics	Individual teaching; rarely lectures; scaffolding and fading; articulation; modeling; war stories; avoid giving "right"	Individual and group teaching during walking rounds; articulation; modeling; scaffolding and fading; coaching; real	Individual and group teaching during walking rounds; no lectures; modeling; articulation; scaffolding	Individual and group teaching during walking rounds; rare lectures; scaffolding and fading;	Individual or group teaching during walking rounds; occasional traditional didactic	Lectures; handouts; avoid giving the "right" answer; articulation; modeling; scaffolding	Didactic lectures; do homework problems for class; demonstrate "cookbook" lab; read complex technical information aloud; outline daily schedule	

	answers	world references	and fading	articulation	lectures; modeled conflict resolution; articulation about conflicts and misbehavior; set bounds on infractions; ignored some unacceptable behavior	and fading; coaching; provide analogies; individual instruction	
School context	Fine arts requirement; ROP class	Elective; college-prep school	Elective with math credit; college-prep school	Elective; college-prep school	ROP class in college-prep school; avoid transfer to continuation high schools	College preparation with variety of "advanced" English courses	Academy program
Teacher experience	Worked as designer; vocational certificate	Certificate in industrial arts and math; MS/MFA	Certificate in industrial arts and math; MS/MFA	Holds credential in science; BS degree in botany	Holds credential in science and English; BS degree in botany; writing certificate	MS degree in geology; worked in seismology lab; teaching certificate program in progress	
Classroom resources	Sample books; demonstration board materials	Computers; robot arm; electronics; CNC and CAD	Woodworking and fabrication equipment; computers;	Greenhouse; ROP funds for some materials;	Teacher donated two novels for each student	Borrowed textbooks from another school; limited lab equipment	

		software; components	CNC and CAD software; drafting equipment Drafting equipment; special texts on building codes and standards	limited and inexpensive equipment				
Student background	Eleventh and twelfth grade, many college- or work-bound	Primarily ninth and tenth grade, mix of college-bound and general track students	Primarily tenth and eleventh grade, mix of college-bound, voc ed, and general track students	Primarily ninth and tenth grade, mix of college-bound and general track students	Class is used as alternative for students who are science credit deficient; behavioral problems for special educa-tion placement, eleventh and twelfth grade	College-bound (already accepted), twelfth grade	College-bound, tenth grade	Mix of college-bound and non-college-bound students, tenth grade
Student goals	Need credit; easy class; related to work goals or college plans; specific learning goals	Easy class; work interest; specific learning goals; no goals (placed by counselor)	Math credit; easy class; general vocational skills; college preparation; no goals (placed by	Need credit; easy grade but found class is difficult; career exploration; college preparation	To get biology credit; few interested in botany or horticulture	All college-bound; improve writing skills	Oriented to postsecondary opportunities in multiple and primarily unrelated careers, e.g., marine biology, lawyer, engineer, psychology; also preparation for	

			counselor)	skills			college and exposure to computers	
Student expectations	Will do well if make an effort; expect individual attention	Will do well if a personal effort made; individual attention available from a knowledgeable and fair teacher	Receive individual instruction from a knowledgeable teacher	Grades reflect effort; individual attention by teacher and cooperation by students with teacher	Teacher will take care of students and not fail them	Big effort will lead to good grade; teacher is willing to assist and teach	Broad; earn grades to pass the class; goals and learning go together; teacher will provide individual instruction plan for student mishaps; makes it easy to learn; any question is appropriate; chemistry II demands spoonfeeding	
Student (outcomes) accom-plishments	Think through and plan complex design problems; mix of useful and negative cooperative roles in groups; creative/ adaptive tactics for uncon-strained problem-solving tasks; valued coopera-tion as part of a group to	Integrate various forms of technology to produce electronic devices; some focus on building complex devices, some on abstract representations ; facile technical language; cooperation skills are useful; groups provide good resource	Think through complex problems; planning is a useful work-related skill; cooperation with a group added to the interest and challenge	Knowing design options allows you to come up with a "fresh" design; using texts as resources is helpful; problem solving is difficult but its benefits are worthwhile; accomplishing the project gives a good feeling	Negative work-related behaviors; individuals work intermittently on group assignment; "look out" for the teacher; protect loafers from teacher (little snitching, some peer pressure); rarely persist; repeatedly discuss/pursue blind or	Critical thinking and writing skills are intertwined; reading and appreciating literature; research and library skills; learn to cooperate with other students; college preparation; deemphasis on grades and punishment	Passive problem solving; ask the teacher (oracle); use lab partner to do half the work	Receive "extra credit" for minimal effort; incomplete problem solving, e.g., answer only a portion of the lab questions; use lab partner to finish the work more quickly and do half

	achieve a goal and importance of justifying one's opinions with facts				empty solution paths; complete daily repetitive assignments; examples of accomplish-ments: water plants, not weeds; arrange pots for efficient watering; caring that plants may need water over a long weekend; award of a passing grade on basis of completing exam	provided; effort is made		the work

Instructional goals can be either domain specific or generic (i.e., applying to more than one domain). For example, a domain-specific instructional goal is learning certain chemistry facts; another is learning how to wire a circuit. In this study we are particularly concerned with instructional goals related to fostering generic skills and work-related attitudes. Generic skills and attitudes help learners make use of domain knowledge and skills (facts, concepts, and procedures) needed to solve problems or carry out tasks (e.g., troubleshooting a faulty circuit and solving a math problem). Other generic skills include applying effort to a task, cooperating with peers, and displaying prosocial behavior. An example of a generic work-related attitude is taking responsibility for one's own work.

The teachers in our sample had a mix of instructional goals for students that included domain-specific knowledge and skills, complex reasoning skills and problem-solving strategies, work-related attitudes, and cooperative or group skills. Each teacher placed a different emphasis on these goals.

Complex Reasoning Skills

In five of eight classrooms, generic problem-solving and thinking skills were included as instructional goals. The vocational classes--interior design, electronics, manufacturing, and architectural drawing--all provided opportunities for students to learn and practice several generic problem-solving skills, including problem analysis, generation of solution paths, evaluation of solution paths, repair, and troubleshooting. Teachers did not necessarily name these skills as instructional goals, nor did they use these terms with students. Rather, the use of these skills was implicitly built in to project work (designing a house or an electrical circuit, and designing and manufacturing a wooden truck), such that students had to exercise the skills while solving problems.

Similarly, students in Mr. Price's English class learned complex thinking skills that resemble these problem-solving skills. A critical essay project required students to read three novels and to generate and evaluate ideas about their meaning. Mr. Price also taught specific heuristics and strategies to aid students in idea generation and evaluation and was quite explicit in discussing a particular composition process that he wanted students to learn. Research suggests that such explicit teaching and naming of skills is more advantageous than an approach where skills are tacitly exercised by students as they complete a task. Once this knowledge about problem solving is made explicit, it can become an object of inquiry and discussion among a group of learners. In this way, students can begin to understand the nature of expert practice in a domain and, with practice, learn to use the strategies and processes that underlie such practice (Collins et al., 1989).

In contrast, students in the landscaping and chemistry classes had little opportunity to practice complex reasoning or problem-solving skills, since teachers emphasized domain-specific skills (discussed below) and organized activities around concrete tasks rather than projects. In landscaping, students worked at specific short-term tasks, such as pruning roses, weeding, or watering. If some difficulty arose, students tended to give up or go to their teacher for help in solving their problem. Mr. Stone, the chemistry teacher, also provided little opportunity for students to practice these generic skills. His students worked in pairs to complete laboratory experiments, each of which presented a well-defined problem that students had to solve, following a proscribed sequence of steps. At most, students practiced repair skills when, for example, the chemicals did not produce the reaction suggested on the lab worksheet. Students proceeded in unison on these labs and used data from the experiment to solve math problems associated with the lab. But students did not generate new problems or make investigations beyond what was asked for on the lab sheets.

Work-Related Attitudes

Ms. Adams, Mr. Benson, and Mr. Price (English class) stressed the importance of students taking responsibility for their own learning and for completing their assigned tasks. As a result, they all gave students opportunity to work on their own and solve their own problems, and often exhorted students to "take responsibility" or "figure it out." Mr. Price and Ms. Adams also stressed a number of other attitudes and dispositions toward work, such as making "bold" decisions and questioning authority, and they tried to foster an appreciation of the contingencies of the world outside school.

Ms. Adams, as a practicing interior designer, made the strongest and most frequent links between class work and school work. She frequently told "war stories" from her work experience to illustrate a point or to justify her behavior toward a student. For example, she did not accept students' "bad luck" excuses for incomplete work because such excuses would not be accepted by a customer or a boss.

Mr. Price and Mr. Benson--perhaps because they lacked actual work experience in their domains--did not use workplace-based examples to support the development of work-related attitudes. Their appeals to be responsible or persist on a hard task seemed to rest on the value of effort to achieve success. Students who apply themselves are more likely to succeed and, in turn, to become motivated by their success. In Mr. Benson's case, these lessons were implicit in the design of his classrooms where electronics students learned to "use the tools of the trade" and manufacturing students learned about roles, teamwork, and tool use as they designed and manufactured their prototype.

In English class, Mr. Price appealed to the notion of lifelong learning. He reinforced a particular disposition toward reading and thinking that he believed would help students in college and beyond. In his landscape/horticulture class, however, Mr. Price failed to impart any work-related attitudes. Many of the students in his class did not even comply with basic standards for classroom behavior, let alone acquire relevant work-related skills or attitudes. He spent a great deal of class time "managing" inappropriate behavior, including instances of leaving the school grounds, fighting and arguing among students, and persistent nonperformance of required tasks. With Mr. Price's attention focused on managing inappropriate behavior in some students, he had little opportunity to teach generic skills and attitudes to the remaining students who at least attempted to carry out assigned tasks. Mr. Price's primary goal in this class was to enhance students' prosocial behavior and teach specific knowledge about gardening or plants. It seemed that Mr. Price was in a bind. On the one hand, he needed to teach enough domain knowledge for students to earn the life science credit attached to the course. On the other hand, he knew that some students had behavior problems that precluded class participation and learning. For these students, behavioral change was his goal.

Work-related attitudes were also not stressed in the chemistry classes. In the laboratory exercises, Mr. Stone encouraged students to learn to trust their observations and to record the data associated with those observations or to observe safety precautions. He also expected students to complete their lab assignments. But this learning seemed task-specific and not linked, for example, to actual work in a laboratory or related "scientific" work. In addition, we observed that students did not pay much attention to the safety precautions presented on their lab sheets. Although Mr. Stone had work experience in a seismology lab, he did not use that experience to place classroom assignments in a broader work-related context.

Cooperative Skills

There are several good reasons to teach cooperative skills. In addition to its value as a work-related generic skill, cooperation can increase student responsibility for learning by holding the student accountable for contributing to group work, or requiring the student to help others. Cooperation can enhance learning efficiency, because team members are additional sources of information/instruction. Finally, cooperation can enhance motivation, since team members are additional sources of motivation and team membership can increase commitment to a project and engagement in a task.

In five classes, teachers had enhancing student cooperation as an instructional goal. Ms. Adams had students work in groups on their design project and explicitly taught a consensus process that students used to make a design decision (e.g., selecting fabric) and to justify a decision (the rationale). In electronics, Mr. Benson wanted students to become "contributing partners"; in manufacturing, he expected students working in groups to learn to resolve differences on their own. Students in the architectural class worked individually on their projects, but learned to use each other as resources for information or for help in solving problems. Again, we note that Mr. Benson was less explicit about stating his expectations as goals. Rather, the expectation for cooperation was implicit in the classroom design. Working together was just part of the classroom culture. Mr. Price wanted students to learn how to use each other as "resources" and designed several group exercises where students assumed different roles (e.g., reader or critic).

In contrast, Mr. Price had a difficult time fostering cooperation in his landscape class. For many students, he focused on improving appropriate individual behavior in class. For others, he wanted students to learn to work together and, on some occasions, gave individual grades based on performance of the group. This practice was applied inconsistently, however, and students often squabbled with him about the points received for a day's work.

Mr. Stone did not face behavior problems that worked against cooperation, but also did not make cooperation between lab partners or among class members an objective of the learning process. His only inclination toward promoting cooperation was to have lab partners submit one report for the pair.

Domain-Specific Skills

Ms. Adams and Mr. Price were both more concerned with teaching a process than on having students acquire specific domain skills. While Ms. Adams valued subject-specific skills and, for example, gave detailed lectures on fabrics in her interior design class, she never tested students on domain knowledge. Consistent with her belief that generic skills would be most important in students' future jobs, her teaching activities focused on imparting these skills. The class project on designing and furnishing a six-room Victorian house was a vehicle for engaging students in activities designed to impart generic skills--a project to design a house of any style would have worked just as well.

Similarly, Mr. Price could have taught writing composition by assigning students to write a documented critical essay on a body of literature different from Latin American fiction. In fact, in a previous course he assigned books by contemporary African American authors. While he taught students about rhetoric and the "eight ways of meaning" in the first semester, he intended these concepts to serve more as "tools" than domain content related to writing. His instruction was geared primarily toward teaching processes that would help students engage in reading and writing, promote understanding of the novels, and aid in producing a final paper.

Mr. Benson paid more attention to domain-specific skills, but still focused instruction on application of knowledge and skills to solve problems. The first part of his course was devoted to teaching basic "building blocks" that students would need to engage in more advanced work (e.g., the logic of electronic circuitry and drafting techniques). This sequencing supported his belief that the best way to motivate students was to make sure they had the skills they needed to solve more challenging or advanced problems. Mr. Benson also saw electronics and manufacturing as "integrated" disciplines that joined domain knowledge and skills from separate subject-matter domains, such as physics, mathematics, and technology. Thus, he was not interested in teaching electronics, *per se,* but on helping students acquire the necessary knowledge and skills needed to solve a concrete problem. Mr. Benson paid less attention to teaching process because, for him, it was not independent of the work. This was consistent with his notion of integration: Specific knowledge and skills must be applied to solve an electronics problem, to manufacture a product, or to make an architectural drawing. Put another way, his instructional domains are more well defined than with interior design or composition, because a circuit or a design for a toy truck or a building will either work or not work. Objective criteria for correctness are more elusive in ill-defined domains like interior design or composition, where success may rest on attributes such as talent, vision, or insight.

Whether dealing with ill-defined or well-defined problems, these teachers defined their instructional "domain" in broad terms that went far beyond domain-specific knowledge.[16] Most important, their view of relevant class "content" was not constrained by curriculum frameworks, learning objectives, standardized tests, textbooks, or specific bits of domain knowledge. One reason for this, of course, was that these classes were not prerequisites for any others, nor were students being trained for specific jobs after school. As a result, teachers had some leeway in choosing what content the class must cover. Mr. Benson pointed out that curriculum tracks constrained instruction in his algebra I class, where the program was "restrictive [in the sense that] students must master a certain body of knowledge to advance."

Another factor contributing to a broad conceptualization of a domain is teacher expertise. These three teachers, Ms. Adams, Mr. Price, and Mr. Benson, had deep knowledge and understanding of their respective domains, in addition to professional experience and/or an avocation for the domain that contributed to their expertise. They were able to draw on their knowledge, experience, and passion for the topic when they designed and executed instruction. This appeared to hold for all the subjects that they taught.

In contrast, Mr. Stone's vision of chemistry instruction in the academy program exceeded his ability to execute that vision. While he appeared to have solid domain knowledge in chemistry, he was a new teacher who readily admitted that he had not realized his goals for the class. Although he aimed to help students learn how chemistry is related to everyday life problems and situations, his instructional goals focused on learning terminology, certain principles (e.g., oxidation reduction), and basic laboratory procedures----what he referred to as "chemistry facts."

Mr. Price's landscape class included relatively low-level domain knowledge (e.g., how to water deeply to encourage deep root systems) or basic botany (e.g., the parts of plants). Students received a life science credit toward graduation, and the class was a "last chance" science course for many students who enrolled because they had failed the regular biology class. While Mr. Price had a botany degree and substantial practical experience and knowledge about landscaping that might have shaped a more sophisticated curriculum in landscape/ horticulture, the needs and abilities of this particular group of students--or his perceptions of those needs and abilities--appeared to work toward simplification of the curriculum and overall classroom design (discussed in more detail below).

Classroom Design

Ideally, teachers design classrooms to support their instructional goals, and it is expected the designs will vary to reflect alternative emphases among goals. We compared our eight classrooms along several dimensions of classroom design, based on the instructional model elaborated by Collins, Brown, and Newman (1989). These features include situated learning, culture of practice, motivation, cooperation, and competition. Because competition was not a factor in these classes, we do not elaborate on this aspect of classroom design in their model. We also compare the roles that teachers adopted to support classroom design and instructional goals.

Situated Learning

As indicated in the Introduction, many practitioners and researchers posit that learning through the work process itself is an effective method for acquiring work-related knowledge. In the absence of direct experience, new instructional models support "situating" learning in the context of real-life problems suggested by a culture of expert practice. This requires teachers to take different roles in teaching and for students to take a more active role in learning. In situated learning environments, students carry out tasks and solve problems that are realistic or "authentic" in the sense that they "reflect the multiple uses to which their knowledge will be put in the future" (Collins et al., 1989, p. 487). By working on authentic problems, students come to understand the uses of the knowledge they are learning and different conditions under which that knowledge can be applied. It is thought that this authentic environment increases both learning efficacy and motivation. They also learn how to transfer knowledge and skills learned in one context to new problems or domains (Resnick, 1987a; Singley and Anderson, 1989). Students are actively engaged in a process that requires them to interact with the environment and to deal with new problems that result from that interaction.

In a traditional didactic learning environment, students typically learn math by solving problems presented in a textbook. Such an exercise helps them practice mathematical operations they have learned. By contrast, in a situated learning environment, students would perform mathematical operations in the context of solving a more complex problem so that they would have to reason about the use of mathematics (e.g., Schoenfeld, 1983; 1985). John Dewey, for example, also created a situated learning environment in his experimental school by having students use arithmetic and planning skills to design and build a clubhouse (Cuban, 1984).

Teachers can also sequence situated learning activities in ways that coincide with the changing learning needs of students at different stages of skill acquisition (Collins et al., 1989). For example, tasks and activities can be sequenced along some dimension of complexity (e.g., construct simple electronic circuits before designing circuits to perform a specific function) or increasing diversity (e.g., intermixing reading for pleasure, reading for memory, and reading to find out some information).

In five classrooms, teachers had students carry out tasks and solve problems in environments that reflected the multiple uses to which their knowledge will be put in the future. Teachers designed project work that students carried out individually, in teams, or both. These projects were complex enough to challenge students to use new domain skills as well as many generic skills. Over the course of six weeks, Ms. Adams's students designed a contemporary interior for a Victorian-era house. Students researched the original house and its design tradition, drew the house, drafted floor plans, selected furnishings and colors, and prepared boards to display their proposed design. At the end of the semester, each team presented their design orally to the class. Most students worked in teams of four to six, but a few completed individual projects.

Project work dominated all three of Mr. Benson's classes. Electronics students first worked in pairs or small groups on a set of electronics labs. Lab work was followed by projects of students' own choosing that incorporated use of computers, a computerized numerical control (CNC) milling machine, and a robotic arm, and required students to identify the problem and find a solution.

The second semester of the manufacturing class was devoted to a whole-class manufacturing project--the design, prototyping, and production of thirteen wooden toy trucks. Mr. Benson organized the class like a manufacturing firm, where student teams performed different functions in the manufacturing process and worked interdependently to produce the product.

Architectural drawing students worked on individual projects to design a dream house, complete with floor plans and renderings, on an actual site in Oregon. Students had to organize their own schedule and tasks to meet preset deadlines.

In Mr. Price's English class, students read three novels by Latin American authors and wrote a critical essay on the use of "magical realism" and a topic of their own choosing. They did library research and worked in pairs or groups to critique each others' ideas or written drafts. This class was run like a seminar, not a lecture.

In all these cases, students carried out complex tasks in rich problem-solving contexts and were given the freedom to apply their skills, evaluate solutions, and face emergent problems. Moreover, these situated tasks were sequenced to guide the students through the successful learning of increasingly complex and difficult skills and knowledge. Later, more complex tasks built on and integrated the skills and knowledge learned in earlier, more basic tasks.

In contrast to these classes, Mr. Price organized his landscape/horticulture class on the model of a "road crew." This classroom environment produced minimal work from most students, who were expected to complete their job while maintaining appropriate classroom behavior. Mr. Price spent much of his time dealing with students' emotional behavior, which frequently interfered with teaching and learning in this class.

Similarly, Mr. Stone's chemistry labs were "cookbook" exercises that required students to simply follow directions, collect data, and use the data to solve math problems. These labs epitomized the kind of decontextualized learning experience that many reformers criticize. Although these students had requisite math skills and were primarily college-bound, the material did not appear overly to motivate students or to engage them beyond following the "cookbook" formula. These incremental tasks were not linked to broad concepts, work, or activities related to space technology, the academy's occupational focus. Mr. Stone expressed a desire to reorient the class toward project-based work, but had not yet implemented his ideas to redesign the curriculum and class activities.

Culture of Practice

A second characteristic of classroom design is the creation of a culture of expert practice in which participants "actively communicate about and engage in the skills involved in expertise, where expertise is understood as the practice of solving problems and carrying out tasks in a domain" (Collins et al., 1989, p. 488). Coupled with the authentic activities pursued in situated learning, a culture of practice helps students acquire the knowledge, skills, and attitudes typical of practitioners who work within that particular domain. Ideally, interactions between learners and "experts" will reveal underlying cognitive processes that experts engage in as they solve problems.[17] In an interior design class, for example, the teacher can relate a story from her own experience as a designer to explain why a particular fabric is a poor choice for drapes (Stasz et al., 1990). Such expert anecdotes ("war stories") appear to aid learning by providing students with concrete, memorable stories that communicate valuable knowledge or lessons (Orr, 1986). They also have a face validity that may increase credibility.

Research on effective work design potentially offers some added insights on classroom design. In particular, research from the sociotechnical systems perspective links the design of work to the satisfaction of the worker (Hackman and Oldham, 1980). This research suggests, for example, that the ways groups are organized (e.g., self-managing vs. coacting teams) and work is organized (e.g., boring, repetitive tasks vs. meaningful, challenging tasks) can affect the amount of discretionary effort that workers choose to devote to a task (Bailey, 1991).

Some classrooms in our sample implicitly or explicitly promoted different cultures of practice; some reflected the adult world of work in the particular domain. Ms. Adams's class invoked the practice of interior design professionals. Mr. Price's English class embodied several cultures of practice, including that of the reader, the writer, and the college student. His students most frequently identified with the latter. Mr. Benson's classes supported cultures where "hobbyists" with interest in the domain and varying degrees of expertise could work on projects and learn from each other or where workers on the "shop floor" collectively produced a real product.

Note that these cultures of practice simulated actual working cultures in varying degrees. Overall, Ms. Adams's class was most similar to its target culture of professional interior designers, perhaps because she was the only practicing professional among our group of teachers. This gave her special insight into actual working practices. Mr. Benson's creation of the "shop floor" in manufacturing class resembled that culture of practice, albeit on a small scale. What is key to these cultures of practice--independent of their resemblance to the culture of working professionals in a domain--is that each supported a situated learning environment where students could acquire high-level skills, including domain-specific and generic skills.

Three classes failed to establish either situated learning environments or to foster effective cultures of practice that would provide opportunities for learning high-level skills. Mr. Price's landscape class, for example, successfully supported the culture of the "road crew," but few would argue that high school is the place for teaching the low-level skills associated with basic gardening and landscaping. In spite of Mr. Stone's past employment in a seismology lab, his chemistry classes offered standard decontextualized science exercises, and did not support any recognizable culture of practice beyond that of the college-bound high school student.

Motivation

A third characteristic concerns motivation. While schools often use extrinsic factors to enhance student motivation (e.g., grades and teacher praise), intrinsic factors (e.g., challenge, interest, and degree of student control) are often more effective (Malone, 1981; Malone and Lepper, 1987). Although grades are a ubiquitous presence in schooling, teachers can design instruction that appeals to intrinsic motivators as well. For example, when a Latino student (in our previous study) objected to designing a Victorian house that he could not "relate" to, the teacher suggested he design a house for "a rich `Chicano' who made it in the barrio . . . who wants a really classy place to live and enjoy his money" (Stasz et al., 1990). This student began with a simple one-bedroom house and ended up with a sophisticated design in the Southwestern tradition.

The main motivational feature in the five successful classrooms--interior design, electronics, manufacturing, architectural drawing, and English--was the teachers' emphasis on intrinsic over extrinsic motivational factors. Teachers deemphasized grades and did not discuss performance criteria in terms of grades. Rather, they focused on finding ways to engage students to exert effort, recognizing that every student could learn and make a contribution to the class if he or she applied effort. All three teachers saw individual interest as the key to mobilizing effort. Mr. Price and Mr. Benson, for example, encouraged students to follow their interests in identifying themes for critical essays or for choosing electronics projects.

These teachers also used challenge as a motivator. Ms. Adams, for example, exhorted students to go beyond the status quo (e.g., painting walls beige) and make "bold" design decisions. Moreover, when she "saw students reaching," she "raised the ceiling." Mr. Price acknowledged the difficulty of the novels students read, and used that challenge to appeal to students' eventual sense of accomplishment as they came to understand them.

Mr. Benson recognized the intrinsic appeal of technology to many of his students and purposely integrated sophisticated technologies into his classroom instruction. He allowed electronics students, for example, to use these technologies as much as they liked to complete their assignments or projects. Some chose to use them exclusively, while others preferred to work with physical components in a more hands-on mode.

Teachers used student expertise as another motivational device. Mr. Price, for example, invited a French exchange student in the class to speak about the European view of the U.S. invasion of Panama. He also relied on Spanish-speaking students to translate words or passages in the novels. Mr. Benson acknowledged that some students were more expert than he on the computer-aided design system, and he gave them free rein to assist other students or experiment with the system itself.

In these classrooms, the mobilization of effort, interest, challenge, and expertise was an essential part of the classroom design, and teachers organized instructional activities with motivational goals clearly in mind.

In addition to teacher strategies for motivating students, students identified specific teacher characteristics as motivating factors. In every class we visited, even the less successful ones, students mentioned teacher enthusiasm for the topic or genuine concern for students as having motivational appeal. Students spoke, for example, of Mr. Benson's "infectious" enthusiasm for electronics and design work. Ms. Adams had a reputation as a "tough" but caring teacher; a feeling of mutual respect was evident in her classroom. Mr. Stone's students were drawn to enroll in the academy program because the teachers affiliated with the program "cared."

Although the landscape and chemistry classes were taught by enthusiastic and caring teachers, other factors seemed to hamper student involvement and motivation. In the landscape class, students who were at all inclined to work typically faced menial, uninteresting tasks, like watering a flowerbed or digging a ditch. In this case, the design of the classroom activities seems at fault.[18] When challenging tasks arose--like repairing a faulty sprinkler line--students seemed unable to proceed without the teacher's help. In this example, students seemed to lack the skills needed to solve their problem. Few students worked with enthusiasm unless the teacher was in view. As mentioned earlier, the teacher felt he needed to deal with students' behavior problems; attention to bad behavior seemed to overwhelm other instructional goals.

Few students in Mr. Stone's class seemed motivated to go beyond minimum performance. Students were focused on just "getting the work done" needed for at least a C grade, because the academy demanded at least C performance. Students who did not pass regularly administered proficiency exams in each subject with a C or better had to be tutored by their teacher and then retake the test. This "bureaucratic C" created an interesting dynamic where the students seemed to expect the teacher to "spoonfeed" them by giving them explicit directions--or even doing the problems for them--or just telling them the answer to any question whenever they asked. The teacher complied with these expectations by "handholding" the students. For example, he allowed students to do their "homework" while he went over the problems in class; he dismissed some student questions because the answers would just "confuse" them or give them information they did not need to know; and he did not challenge students to solve problems on their own.

Cooperation

Learning to work cooperatively with others is an important skill for the workplace, where group work and collaboration among team members or individuals is increasingly becoming the norm. Cooperation can also be a powerful motivator, especially if task completion requires different skills of different individuals. Cooperative activities can encourage students to share knowledge and skills, help each other, and support a culture of practice. Teachers can go beyond forming groups to designing specific activities that require students to engage with the task and each other in specific ways.

In most classrooms in our sample, students learned to work together in self-managing groups in which cooperation was important. Sometimes they worked in teams and were graded on team effort. Other times they worked alone, but engaged other students to help solve problems, sound out an opinion, or ask advice. Or they worked in pairs to do electronics labs or on a project of their own choosing. Importantly, the teachers behaved and were accepted as contributors to cooperative effort, whether they worked hands-on with the students (Mr. Benson) or more as facilitators and guides on the sidelines (Ms. Adams, Mr. Stone, and Mr. Price).

Ms. Adams taught specific techniques to enhance cooperation (e.g., consensus building), and also had groups evaluate their own performance and determine how performance could have been improved. While Mr. Price designed group activities to teach students to use each other as resources, Mr. Benson had a less structured approach. In electronics, for example, he let students choose their own partners and left them to work out any role difficulties among themselves. He intervened in extreme cases--as when two students ended up fighting--and suggested that students change partners as their own interests changed. In manufacturing, he assigned some students to specific teams because of their skills (e.g., students good in math to the drafting team), but otherwise permitted students to form their own teams and to negotiate any differences within or between teams.

The landscape class supported coacting groups that report to a teacher/ supervisor and where each student has an individually defined task, like picking weeds or pruning a rose bush. In the chemistry class, student pairs divided lab activities on their own but were basically just following a set of step-by-step instructions. In neither class did students have authority to proceed as they saw fit to generate a group product, service, or decision.

Even where teachers had students work in teams, we saw some negative effects that diminished cooperation. For example, we observed some student pairs in electronics where one student was the "learner" and the other was the "assistant." Students who stayed in the "assistant" role, for whatever reason, lost opportunities to become more independent thinkers and problem solvers. In these cases, the team is self-managing apart from the teacher, but one member of the team is "supervised" by another. In Ms. Adams's class, one group adopted a "military" style where one student emerged as the "leader" who delegated individual tasks to others. Another group formed a "loose anarchy" where a de facto leader emerged, but otherwise cooperative roles were not well defined. At least one member of this group typically contributed minimally, but the others rarely used peer pressure to control noncontributing members.

While such cooperative activities may be the norm in the industrial arts and design classes, they were somewhat of a novelty to students in the English class. Those students were more used to competing for grades and seeking help or approval from the teacher than helping each other on papers. Mr. Price particularly stressed how the group can provide social and emotional support for difficult tasks, in addition to task-specific skills or knowledge.

Teacher Roles

Different classroom design characteristics imply a different role for the teacher and different expectations about what students should and can learn. Specifically, a teacher who designs a classroom that embodies these characteristics is likely to establish a "master-apprentice" relationship with students, or act more as the students' coach or guide in the learning process. This teacher will expect students to be actively engaged in learning and to come to the classroom with knowledge, skills, and experience that the teacher can build upon. Teachers and learners can participate together in the learning process. In contrast, a teacher adopting a more traditional role would perhaps use lectures, discussion, and guided review techniques to impart knowledge and skills to students. The implicit expectation in this approach is that students lack necessary domain knowledge and skills and the teacher's job is to direct learning in ways that transfer knowledge from teacher to student.[19]

Relationships we observed arising between students and teachers in classrooms that worked were not the typical student-teacher relationships, but resembled those of masters and apprentices. The teacher was regarded as the expert or "model" practitioner of the craft, and he or she also possessed greater factual knowledge or skill. Students had a limited knowledge of facts and skill but were increasing both continually. Teachers did not hold the "master" role authoritatively, but rather conveyed the message "I am here if you need me."

Teachers did little lecturing. The few lectures we observed came just before students were beginning a new task, when the teacher either reviewed earlier material relevant to the current task or instructed them in new procedures (e.g., using the robot arm or using the card catalog).

One-on-one tutoring or master-apprentice interactions were the main methods by which Ms. Adams, Mr. Benson, and Mr. Price (in English class) distributed information and shaped the students' progress. These teachers often circulated throughout the classroom, stopping to visit each group. Ms. Adams was skilled at giving constructive local critiques of designs and dispensing important pieces of information on request. Depending on the student's or group's needs, Mr. Benson might draw a diagram to illustrate a point, reteach a mathematical formula, or just stand back and admire the work.

As with other master-apprentice situations there was no discrete distinction between student and teacher, but rather a continuous gradation of expertise from low to high. Teachers readily acknowledged that some students possessed superior skills. Teachers took advantage of student skill variation, and the fact that cooperative work was the norm, by encouraging more advanced students to help less advanced ones. This policy permitted teachers to spend more time with students needing most help. For the most part, students seemed comfortable with their roles, be they apprentice or "master" to another student. The English students appeared to have the most difficulty adjusting, because many had learned to view English teachers as the "authority" who determines how performance criteria relate to grades. Mr. Price had to work hard to legitimize a process where students ask questions and get advice from each other, rather than seek the teacher's.

Teacher roles in the other classes were quite different. Mr. Price was more like a "therapist" than a teacher to some landscape students. With working students he infrequently guided them and more frequently supervised them--gave specific instructions, checked their work, admonished them for faulty work. Mr. Stone was the "oracle" to whom students came for answers. His "missionary" attitude or role was one of giving constant help and "protecting" students from their own failings (e.g., collecting papers so students would not lose them).

Teaching Techniques

Teaching techniques refer to actual teacher instructional behaviors or tactics used to implement instructional goals. The techniques that teachers adopt are embedded in the context of instructional goals and the particular learning environment, and are best understood within that context. Chosen techniques can either succeed or fail; they may or may not bring about the desired change in student behavior or help students' learning.

Collins, Brown, and Newman (1989) provide one useful formulation of teaching methods that they believe are designed to give students "the opportunity to observe, engage in, and invent or discover expert strategies in context" (p. 481). That is, these techniques are designed to support situated learning and authentic practice, as discussed above. The six methods that they identify fall roughly into three groups:[20]

- **Modeling, coaching**, and **scaffolding** are designed to help students acquire an integrated set of cognitive and metacognitive skills (e.g., learning strategies) through processes of observation (via modeling), and of guided and supported practice (coaching and scaffolding). In addition to observable behaviors, teachers can model mental activities, e.g., as when a teacher models the use of heuristics, the general "rules of thumb" that domain experts use to guide their problem solving.

- **Articulation** and **reflection** are designed to help students both focus their observations of "expert" problem solving and gain control of their own problem-solving strategies.

- **Exploration** is designed to encourage learner autonomy, in carrying out problem-solving processes and in formulating the problems to be solved.

Teachers in successful classrooms relied heavily on modeling how "experts" carry out a task. In Ms. Adams's class and Mr. Benson's class, this often involved manipulating physical objects and demonstrating correct procedures. In English class, Mr. Price often modeled internal cognitive processes and activities as well (e.g., articulated his own thinking to generate themes in a novel and provided heuristics for terminating a library search).

These teachers also used coaching, scaffolding, and fading. Mr. Benson primarily used highly interactive coaching to help students through particular problems they faced when carrying out a task. Mr. Price provided scaffolds in the form of physical supports (e.g., diagramming three ways to structure a paper) and suggestions or help (e.g., reminding students to use personal events in their lives as a stimulus for identifying themes). He also provided emotional scaffolds, by acknowledging and accepting students' discomfort with "negative capability"--the notion that temporary confusion is preferable to quick judgments about the meaning of text. All three teachers demonstrated an ability to provide just enough help to allow students to progress without making a decision or solving a problem for them.

These teachers also employed techniques to get students to articulate or reflect on their knowledge, reasoning, or problem-solving processes. Mr. Price had students assume the critic's role in cooperative activities, thereby leading them to formulate and articulate their own thoughts about the novels. Ms. Adams had students reflect on their own performance as a group and discuss how group performance might have been improved. Finally, Mr. Benson also encouraged exploration in his advanced electronics students, who were "turned loose" to identify a project, set their own goals for it, and carry it out.

Generally speaking, all of these techniques are suited to a project-centered classroom where students are given considerable freedom to carry out individual and group tasks. Since students have different degrees of skill and are not proceeding in unison, teachers must be ready for flexible interactions where students place unpredictable demands on them. They tend not to follow lesson plans but instead follow individual student progress. This student-centered approach results in opportunistic, not planned teaching.

In the other three classes, teachers and students did not assume master-apprentice roles and, for the most part, did not use the methods discussed above. While Mr. Price did use modeling techniques in his landscape class to, for example, demonstrate the proper use of a tool, most of his time was consumed by managing inappropriate behavior--fighting, shirking work, truancy, and heated confrontations (both between students and directed at him personally). Mr. Price dealt with bad behavior because he genuinely wanted to help the students, some of whom were in danger of dismissal from school or assignment to the continuation high school. His genuine feeling for students, and his intense interaction with them, suggested a therapist-patient relationship. With those students who made some attempt to work (about half the class), his role was more of "supervisor" to "workers." Either way, it is safe to say that this class was atypical of most high school classes.

Mr. Stone spent much of his time lecturing or reviewing homework problems or laboratory exercises with the whole class. He made it clear to students that he was there to answer questions and help students, and said that he used student questions to gauge their learning. Mr. Stone used similar techniques in both chemistry classes, despite the fact that students in one class had higher math ability than students in the other. One might expect that the more "advanced" students would be given more responsibility--less spoonfeeding on his part--or more challenging work. Mr. Stone acted as though his students should not be pressured or challenged too much, because they "needed" care and nurturing.

School Context for Teaching and Learning

Teachers and classrooms operate within a particular context, beginning with the school and community environment and expanding to district, state, and federal levels. The broader context affects teaching and learning through such factors as resources allocated, policies, organizational structures, and processes (Oakes, 1989). Study of this context is needed, particularly at the school level, to understand the conditions or constraints that teachers and students face because these help shape the teaching and learning we observe in the classroom. Context is also important to policymakers because we have incomplete knowledge about how schools produce the results we want. Context information may provide clues about why certain outcomes prevail over others and how to change policy to alter classroom practice and thereby improve or produce different outcomes (Oakes, 1989).

We focus on three indicators of school context that research identifies as enabling conditions for promoting high-quality teaching and learning: student access to knowledge, press for student achievement, and professional teaching conditions (Oakes, 1989). Taken together, these indicators help define a classroom's "sense of place" within the school.

Access to Knowledge

Access to knowledge refers to the extent to which schools provide students with opportunities to learn various domains of knowledge and skills. Access can be quite directly linked to student outcomes. Access is influenced by basic resources, such as time, materials, staff, facilities, and so on. Access is also influenced by curricular emphasis and structure, such as classroom or course assignment practices (ability-grouped or mixed instructional groups) and the curriculum associated with each group, and by teacher qualifications or opportunities for staff development.

All three high schools in our study tracked students, and tracking practices influenced who enrolled in classrooms we observed. Some research suggests that a heterogeneous mix of students tends to raise the level of teaching and can also counteract negative affects associated with tracking students: Individual achievement and aspirations are lower among students in low-ability and nonacademic tracks at the secondary level (Oakes, 1986; 1989). In the classes we studied, the mix of students depended on the type of class (academic or vocational) and the kind of credit attached to it.

The vocational classes taught by Mr. Benson and Ms. Adams were elective courses and attracted a mixed group of students who were interested in the subject area, and, in some cases could use the class to fulfill a graduation requirement. College-bound students may actually have less access to these classes simply because these students need a certain number and type of credits for college enrollment: They take fewer elective courses and more courses whose credits are recognized by postsecondary institutions.[21] Thus, they lose a potential opportunity to learn generic skills taught in vocational classrooms.

College-bound students opted to enroll in Mr. Price's English class, while vocational or "general" students enrolled in landscape/horticulture. The college-bound students in Mr. Price's class had three fourth-year English classes to choose from. Most landscape students were either placed in the class by a counselor or needed the science credit for the course because they had failed biology.

Although the high school housing the academy program tracked students, the academy itself has a diversity policy to enroll a heterogeneous mix of students. The administrators strongly believe that all students can benefit from the academy, and thus all must have access. Nevertheless, most of the students in Mr. Stone's chemistry class were college bound. In addition, Mr. Stone could assign two types of credit: chemistry--accepted as a science credit for college--and "descriptive" chemistry--counted as science credit for high school graduation, but not college enrollment. According to the roster, at least four students in his two classes were receiving credit for "descriptive" chemistry.

A second factor affecting access is resources. Because their classes were sponsored by the state's Regional Occupational Program (ROP), Ms. Adams and Mr. Price (landscape) received extra funds to purchase materials (e.g., supplies for the house design project and gardening tools). Because of high class enrollments, and extra funding from the ROP, Ms. Adams had a larger budget than most regular vocational classes at the same school. Mr. Price had few resources for his English class, and often used his own funds to purchase books. Similarly, Mr. Benson purchased computer software and other materials for his industrial arts classes. He also had some sophisticated equipment (computers and the robotic arm) purchased by the school. Students complained, however, that the electronics equipment was often lacking or broken. Some coped by hoarding working equipment in their personal lockers. While Mr. Stone's lab seemed adequately equipped, students were using old chemistry textbooks begged from another school because there were no funds to buy them. He hoped that students would have new books next year.

Except for Ms. Adams, then, teachers generally felt that they lacked adequate resources; Mr. Price and Mr. Benson bought needed resources with their own money. While a school (or teacher's) resource level, in itself, does not guarantee a high-quality educational program, increased resources can make a difference if used effectively (Oakes, 1989).

Press for Achievement

Press for achievement is indicated by institutional pressures that the school exerts to get students to work hard and achieve. Programs with a strong press for achievement expect and value high achievement; teachers and students take teaching and learning seriously. Students are engaged in a rich and challenging curriculum with adequate resources. Teachers are evaluated according to their ability to engage students and by their pedagogical skill. Noninstructional teacher duties take second place; they do not interfere with or interrupt teaching lessons. Teachers expect that students are capable of high-level cognitive processes and mastering rigorous curriculum content.

The schools and teachers in our sample communicated different expectations and values about achievement to their students. Obviously, any school that tracks students does not hold the same achievement standards for all students. But it appears that individual teacher standards can make a difference for students.

Although vocational classes were less valued than academic classes in the schools where Ms. Adams and Mr. Benson taught, their personal views about students explicitly challenged the schools' views. Both of these teachers had high expectations for student achievement, which they believed was linked to effort. They worked with and supported any student who tried. They "designed in" interesting and meaningful learning activities, employing high-level cultures of practice. They expressed a personal commitment not to "throw back" any student. While Mr. Price had similarly high expectations for his English students (consistent with the school's expectations), his learning expectations for the landscape students were quite different. In landscape he wanted students to maintain a level of*behavior* that did not interfere with the class; this attention to behavior led to highly structured activities and boring tasks, in service of avoiding mischief, and seemed to override any expectations about achievement *perse.* School staff and other students voiced similar expectations for the landscape students.[22] It is true that the landscape students were of low academic ability and that many also had emotional or behavioral problems; nevertheless, we observed some of the same students, as well as students with similar characteristics, functioning more effectively in other classrooms where teacher expectation for learning remained high for all students.

The academy program's press for achievement was defined with a mastery criterion. Students took proficiency tests in each class until they achieved a grade of "C" or better. Teachers were expected to give extra help to students who failed. This "bureaucratic C" communicated a clear expectation but also seemed to have a dampening effect on less-able students. Students seemed to expect the teacher to spoonfeed all the answers to problems and often demanded direct answers to their questions. The environment did not appear to foster individual thinking or higher achievement or effort for most students. The teacher also had different expectations for the two classes, which had been formed based on students' math skills. In addition, as discussed above, some students earned credit for "descriptive" chemistry because it was believed that they could not succeed in regular chemistry.

Professional Teaching Conditions

Teaching conditions can empower or constrain teachers as they attempt to create and implement instructional programs, and they define how schools function as a workplace for teachers. Although professional teaching conditions have not been directly linked to student outcomes, there is evidence that a "professional" staff will work toward implementing strategies and programs to improve results (Oakes, 1989; Bodilly et al., 1993). At schools with professional teaching conditions, for example, teachers have some autonomy and flexibility in implementing curriculum and instruction, participate in schoolwide decisionmaking, and spend time on such activities as goal setting, staff development, program planning, curriculum development, and collaboration.

Teachers in our sample expressed different feelings about their relationship to school administrators, other faculty, and opportunities for staff development. As an ROP class, interior design was basically ignored by the school administration, although Ms. Adams was strongly supported by the ROP administrator on campus. The school's benign neglect actually proved advantageous to the teacher because it left her wide berth to experiment. On the negative side, Ms. Adams was isolated from the larger school teaching staff and did not participate in activities that can foster the exchange of knowledge, such as collaborative staff planning, intellectual sharing, and teamwork. On the other hand, Ms. Adams did not seem to feel disadvantaged or marginal in any way. As long as she could teach as she liked, she was satisfied.

Although landscape was technically an ROP class, the teacher had no affiliation with the ROP administration. As the school counselor explained, the size and number of ROP programs in this suburban school are comparatively small, so their affiliated ROP lets them do as they like. This freedom supports an atypical program that is arguably detrimental to students. Officially, the ROP offers entry-level job training for local job markets where the entry wage is above minimum wage. Their mission also extends to career exploration opportunities and preparation for higher education in a related field. They typically hire instructors with recent working experience in the areas they teach. As noted in our earlier report (Stasz et al., 1990), Ms. Adams's interior design class is a good example of the ROP's "schooling for work" focus. By contrast, Mr. Price's landscaping/horticulture class was widely viewed by students, teachers, and school administrators as a "dumping ground" for emotionally disturbed, special education, or academically weak students. One teacher described it as the "holding pen for Ivy Walls," the local continuation school. Although this class was clearly on the academic margins it was central to the school culture: It provided a place for "marginal" students. Mr. Price had strong support from the administration precisely because he was one of the few teachers who could handle "difficult" students. Thus, he had a good deal of autonomy in teaching both the landscape and English classes.

Mr. Benson found administrative support for his industrial arts classes, but for different reasons from Mr. Price. Mr. Benson had crafted a high-level vocational program that had high enrollments and attracted a heterogeneous group of students. His classes were a prime example of "good" vocational education in a comprehensive high school. Mr. Benson was also active in state-level industrial arts organizations that enhanced his professional contacts outside the school.

Mr. Stone's classes were in a special program that was strongly supported by the school and district. As a new teacher, however, he seemed to need more support than he got. Mr. Stone said he had been sent to a workshop sponsored by the Coalition of Essential Schools (cf. Sizer, 1984) that influenced his ideas about teaching but did not provide any practical methods for applying these ideas in class. He got some lesson plans and informal mentoring from a more experienced chemistry teacher at the school who had taught the labs. Because the academy program was in its first year at the time of our study, the curriculum has not been very well developed, and district officials admitted that curriculum and staff development are sorely needed. In the meantime, Mr. Stone appeared to struggle and feel frustration at his inability to carry out many of his instructional goals.

Although teaching conditions varied for teachers in these classrooms, they did not strongly affect teaching practices: All had autonomy in the classroom. Mr. Price seemed somewhat uneasy about his role in the two classes we observed. On one hand, teaching the landscape class gave him some leverage over the administration. On the other, he knew the class was a "dumping ground" for marginal students, and he put much effort into working with those students on nonacademic issues. Finally, Mr. Stone was clearly not getting the support he needed, but we are unable to determine if that support would have improved his teaching practices.

An Instructional Model for Generic Skills and Attitudes

Our comparison of the eight classrooms suggests several themes regarding what makes some classrooms successful in imparting generic skills and attitudes. The key domains for describing successful classrooms are summarized in Table 3.2. The fourfold framework outlined there--instructional goals, classroom design, teaching techniques, school context for teaching and learning--provides an analytic framework for discussing and evaluating the classrooms that we observed. The four components can be viewed as the parts of an instructional model for generic skills and attitudes. Teachers who wish to include generic skills and attitudes among their instructional goals can draw on this model to help them design and conduct their classes.

Table 3.2
Components of an Instructional Model for Teaching Generic Skills and Work-Related Attitudes

Instructional Goals	Classroom Design	Teaching Techniques	School Context
Complex reasoning skills	Situated learning	Modeling	Access to knowledge
Work-related attitudes	Culture of expert practice	Coaching	Press for achievement
Cooperative skills	Motivation	Scaffolding	Professional teaching conditions
Domain-specific knowledge, skills	Cooperation	Articulation	
Teacher roles	Reflection		
	Exploration		

Although we have discussed our findings in these domains separately, they are linked in practice and must be considered in an integrated fashion in order to design classrooms that work. Figure 3.1 indicates the way in which the components interact: Instructional goals influence classroom design and teaching techniques; classroom design and teaching techniques influence each other; and school context influences goals, design, and techniques. We traced these interactions in our analysis of the classrooms in our sample.

Figure 3.1--Lines of Influence Among the Components of the Instructional Model for Generic Skills

It appears that generic skills and work-related attitudes can best be taught in classrooms and programs that blur the traditional distinctions between learning in school and out of school (cf. Resnick, 1987b). This approach requires teachers to explicitly adopt instructional goals that include generic skills, in addition to domain-specific skills. It requires them to create classrooms where students can acquire and apply knowledge and skills to real-world problems, learn to work with others in a community of learner-practitioners, and develop intrinsic motivation for learning and working. It requires teachers and schools to adopt the view that all students are entitled to and can benefit from learning opportunities. All students need to acquire not only knowledge and skills but also a positive perspective on learning that includes their own responsibility for it. Finally, this approach requires schools to provide a context that enables, encourages, and rewards the effective teaching and learning of generic skills and attitudes.

Student Perceptions and Accomplishments

The model we have outlined focuses on teaching practices and policies that can support them: It does not address learning outcomes. What is the experience of students in classrooms where teachers purport to impart generic skills? In this study, we do not attempt to systematically measure learning through tests of knowledge or skills. However, we do gather data on student learning through our observations, responses to student surveys, and student focus group discussions. We use student perceptions to corroborate our observations about what the model posits as effective instructional practice.

Following the framework outlined by Collins et al., (1989), we can expect students in situated learning environments to be actively using knowledge in an applied way, perhaps in multiple contexts. Students would, for example, be engaged in a project that requires problem solving and exhibits several generic reasoning skills: problem recognition, problem analysis, generation of solution paths, evaluation/monitoring of solution paths, repair, and reflection (Stasz et al., 1990; Newell and Simon, 1972; Simon, 1979). Students engaged in a culture of expert practice should be engaged in focused interactions with other learners and experts for the purpose of solving problems and carrying out tasks. Cooperative learning and problem solving should be evident, with students sharing knowledge and skills or trying to help each other overcome difficulties. Since situated learning is expected to enhance motivation, students should appear engaged in their work and perhaps articulate the intrinsic value of learning a subject apart from just getting a grade or fulfilling a course requirement.

These expectations about classroom activity and student learning were met in classes that situated learning in authentic practice, but not in others. In Ms. Adams's and Mr. Benson's vocational classes, and Mr. Price's English class, our observations and students' perceptions indicate that students were independently engaged in complex problem-solving tasks that required them to identify problems, posit solution paths, evaluate their progress, and so on (see Table 3.2). The following three sections provide more details about student accomplishments in English, electronics, and manufacturing.

This kind of independent problem-solving behavior was not evidenced in the other classes. Mr. Price's landscape students had difficulty completing even the simple, procedural tasks that were assigned to them (e.g., weeding and pruning roses). With more complex tasks, like repairing a broken sprinkler system, students would reach an impasse and ask the teacher for help. As mentioned above, students appeared to need supervision and expect Mr. Price to answer their questions and intervene in their squabbles. It was not unusual, for example, for Mr. Price to find a student who was not working, who, when confronted, would then complain to Mr. Price that he had not been given a job. Generally speaking, about two-thirds of the students attempted any work at all; about half of these appeared to exert some effort.

Similarly, the laboratory exercises, followed by solving math problems, did not appear to engage or challenge the chemistry students in the same manner that we observed in other classes. In the lab period, their performance was rather rote--they focused on following steps, recording observations, and filling in answers to questions. The remainder of the lab period was spent using data from labs in math problems. The teacher and students worked problems together on the board; again students were focused not on solving problems, but on getting answers to write on their papers. During class time, many students did their "homework" as the teacher reviewed it. This behavior did not seem to bother the teacher or other students, who had taken the time to do the homework problems on their own. By and large, the students were passive problem solvers, who occasionally answered the teacher's questions about a lab or math problem, but more often waited for or demanded that the teacher give them the answer. This teacher, then, was the "oracle" to whom the students turned for knowledge.

In both landscape and chemistry, students seemed to adopt "disengagement strategies," i.e., strategies for shirking work, keeping a "lookout" on the teacher, or getting one's work finished with the least amount of effort. These strategies, however adaptive they may have been in the classroom, will not serve students well in future work or postsecondary education settings. Though unintended by teachers, these strategies were clearly lessons learned or reinforced in these classes.

Student discussions in the focus groups corroborated our observations.[23] Except for landscape and chemistry classes, students discussed and gave many examples of what they had learned and accomplished in class. A common theme in the vocational classes was the students' gradual acceptance of the class as a place where students had to work to succeed, but could expect the teacher's help in exchange for personal effort. Students who had initially taken the class for an easy grade or to fulfill a requirement became "enculturated"; they were sold on the teacher's conception of why the subject matter or classroom experience was important for them. Once they "bought in," they became more engaged and were able to benefit from the class as the teacher intended. This sentiment also rang true in the English class for many students, but at the end some still complained that they did not like the novels or found some of the work a waste of time. In landscape class, few students expressed a sense of accomplishment with what they were learning. The students who did cooperate and try to work noted that Mr. Price had to spend much of his time dealing with the "troublemakers." Mr. Stone's students were focused on finishing the work to get their grades but also liked the academy program generally because of its smaller class size and "caring" teachers. Unlike students in the vocational classes, the chemistry students did not discuss lessons learned in class about, for example, problem solving, personal interests, or feelings associated with accomplishing a task well.

In the next three sections, we use the design framework to organize descriptions of three classrooms that work. We attempt to illustrate how teaching goals and techniques, classroom design, and so on, come together in a classroom. We also describe student perceptions based on data we gathered in our classroom observations and student group discussions. These three classes are meant as concrete examplars of teaching practice that can foster teaching and learning of generic skills.

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4. AN ENGLISH CLASS THAT WORKS: WRITING AS THINKING

We begin with an English class that works by using writing to teach thinking. The flavor of a typical classroom session is captured in the following brief vignette based on field notes:

Price moves quickly from the xerox room, hands flowing with articles to share with his senior English students, keys rattling as he unlocks the classroom. He moves past the rows of desks toward his corner "den" overflowing with books, computer, and his beloved collection of music. Minimalist new age sounds soon fill the room... just enough time to collate articles and inhale a tuna salad. Air begins to breathe into the room. Outside the classroom unfolds major lunchtime partying for the 1,000 students populating the expansive campus of low and relatively new buildings. Chimes signal the end of lunch. Music off, the last article collated, stapled, *filed, and ready for class.*

Twenty-four seniors trickle into the first-floor classroom. Most energetically gab about the prom, others are getting ready to work. Articles, papers, and novels appear on desk tops. Mr. Price takes roll silently while students settle in. Another set of chimes sounds and he begins to quiet class with "Shhhhhhh . . . " A girl, seated mid-room, is still talking and stops abruptly. Mr. Price advises politely, "you can finish your sentence." Within a minute or two of the start of the class, he has their full attention.

The assignment to have students submit articles to a class resource pool is beginning to take shape. Susan volunteers and hurriedly reports on an article about Latin American culture in terms of "social status, power, money, and tradition." Pleased at this presentation, Mr. Price reinforces her point that understanding Latin American culture is yet another way to appreciate the assigned novels; he does not critique her rushed presentation. Students pen a few key words while listening. Susan can now add her name to the growing list of contributors on the wall chart of assignments.

With only two weeks to go before graduation, students begin to voice some panic at the coming deadline for completing their papers. Mr. Price elicits and suggests some alternative and useful strategies: making time for article presentations and coming to class with a specific purpose and things to do. Many students buy in to the plan with positive nods and note taking all around.

Questions about papers and novels begin in earnest. Students begin to perk up when helpful suggestions come from various corners of the room. Mr. Price paces from his normal place, front and center, perching on empty desk tops throughout the room as he contemplates, grins at the collaborative process gaining momentum, reinforces, and occasionally teaches some emerging aspect of writing or research. No dozing or socializing today!

Sensing that Mr. Price is "on a roll," Mitch draws him into reviewing ways to begin and end a paper. The class becomes restive. Two students come in 50 minutes late and Mr. Price simply rejoins that they should "please be on time." He refocuses the class with "here's a clue for all of you." Conversations stop and the attention returns to his conclusion that in order to "open" a paper, one could "ask whether your introduction serves to add to the reader's understanding or is it superfluous?"

The chimes sound. They're all out the door.

Instructional Goals

The second semester of Mr. Price's college-prep English class focused on critical reading and writing. Students read three novels by modern Latin American authors and wrote a documented critical essay on "magical realism" (a style of fiction represented by the authors) and a topic of their own choosing (e.g., magical realism and women, magical realism and time, etc.).[24] The assignment was both open ended (e.g., students chose a topic) and structurally defined (e.g., paper had to include a bibliography and follow a particular format). Mr. Price used the readings and essay as vehicles for teaching a variety of generic and domain-specific skills, with a strong emphasis on generic skills: His focus was *not* on imparting an understanding of the history of the novel or of Latin American literature. His general model was to use cooperative learning methods to teach a composition process that employed a nonlinear approach, discussed below.

Critical Thinking Skills

In the first semester, students learned literary forms that would help them identify the underlying structure in a piece of writing. For example, he instructed students on the "eight ways of meaning" (plot, character, symbol, imagery, diction, figurative language, mood/timing, sound devices) and on the elements of classical rhetoric. During the second semester, when our observations took place, he focused more on the writing process, around the theme of "thinking as writing." His model of the composition process was in some ways parallel to the general problem-solving model that requires complex reasoning skills, such as recognition of the problem, generation of solution paths, evaluation, and reflection. In the process of creative writing, however, these skills assume a different character.

Emphasis on Nonlinear Thinking. In contrast to a structured problem-solving approach--which seeks to narrow down the problem by identifying discrete parts--Mr. Price emphasized the opposite.[25] He felt strongly that linear thinking interfered with the creative aspects of the writing process. He wanted to "train them [students] to abandon linear thought" and to make students comfortable with "negative capability"--i.e., the notion that temporary confusion is preferable to quick judgments about the meaning of text. He defined "analysis" as first thinking broadly about the "problem" (e.g., the meaning of a symbol or significance of a character's action) as a way for students to gain inspiration from their own thinking and experience. This step was essential before honing in on a specific research topic.

EXAMPLE: Mr. Price reads aloud an excerpt from *Sometimes a Great Notion* by Ken Kesey that tells the reader how to read. Mr. Price: "the notion that we should look for linearity doesn't follow. It's not the way we think. It's not the way we learn, write, or think about things. Nonlinear thought. That's the big idea of my course. . . . If we are looking for causal things in Latin American authors, we won't find it."

EXAMPLE: The teacher acknowledges that the process of finding meaning in two paragraphs is difficult. "The more we read, the more secure we get with temporary understanding. That is what we learn in this class."

As these examples indicate, Mr. Price wants students to accept that thinking broadly and generating ideas, without reaching closure, can be difficult and frustrating. But he also suggests that students will come to accept temporary understanding as part of the process.

Generation of Ideas. While the problem-solving process involves generating possible solution paths, the writing process requires generating ideas. Mr. Price encouraged students to read broadly and to include their own experience as a source of ideas, even after they felt they had converged on a topic. He also wanted students to "unlearn" some habits or lessons that he considered ineffective.

EXAMPLE: Mr. Price discusses how to open the paper. "You were taught last year to open with an interest creating device. I think that's dishonest." He suggests that students begin with an anecdote about their idea, perhaps drawn from personal experience. Alternatively, he suggests to "just state your idea baldly."

Evaluation of Ideas. Mr. Price's "theory of thinking" was that ideas and inferences are generated by connections that develop during thinking. This involves making decisions about the ideas, and whether they are worthwhile and potentially useful. Evaluating ideas is similar to evaluating different solution paths generated to solve a problem.

EXAMPLE: Mr. Price gives students a heuristic for detecting what really interested them: "As much as you study and read, if something catches your attention then it is significant." He encourages students to select a topic that really interested them because they would be more motivated to write about something they cared about.

Thinking Heuristics and Strategies. Mr. Price taught students explicit heuristics and learning strategies. The preceding example illustrates a heuristic for detecting an interesting topic. He also taught strategies for generating ideas:

EXAMPLE: As students offer interpretations of a passage assigned for homework, Mr. Price lists them on the board. "If something occurs to you, jot it down. After a time, you can see the ideas recurring."

EXAMPLE: Mr. Price reads a sentence from the novel and writes a list of "themes" from one sentence. He says "by taking one sentence we can talk about what the novel is about. Is it a novel about a hero? About death?"

In the second example, the list-writing strategy to generate "themes" is coupled with asking questions. Taken together, the strategy he teaches is: Read a paragraph/sentence; make a list of ideas or themes; ask questions. Often, Mr. Price would try to get students to identify or articulate a strategy, but he was not always successful.

EXAMPLE: After making a list and eliciting questions from students, Mr. Price says "What am I trying to do?" He pauses for a moment then says, rhetorically, "I don't think I'll get an answer."

Mr. Price pointed out how the questioning strategy can help students evaluate their ideas and abandon less fruitful lines of inquiry.

EXAMPLE: "If you pursue an idea and it doesn't lead you anywhere, you think, oh good . . . I don't have to worry about *that*anymore."

Heuristics and strategies can be important tools for learners because they provide concrete ways and "rules of thumb" to go about learning--they help students learn how to learn.

Work-Related Attitudes

Mr. Price attempted to inculcate several attitudes and dispositions toward the thinking and writing process. His general approach was to discuss the relevance of these skills for college, where students would be required to read material and write papers.

Ability to Make Decisions. The writing task was ill defined in many respects and required students to be creative and to make their own decisions. The teacher also encouraged students to think on their own by not answering their questions directly.

EXAMPLE: Students need to choose a topic for their research paper. One girl asks if "time and chronology" was a good topic for her paper. The teacher says "yes, if *you* find it interesting." She responds by going up to the wall chart and recording the topic next to her name.

Mr. Price tended to deflect requests for information or help when he knew the students could or should answer the question themselves. He also stressed that students should not appeal to his authority or count on him to make the task easy. He rejected several appeals from one student, who wanted Mr. Price to explain the book so he could select an appropriate topic.

EXAMPLE: In a discussion of *The Storyteller* a student asks "why all these strange names? Are they real?" Mr. Price replies, "good question."

EXAMPLE: Mr. Price gives students three suggestions for presenting the ideas they identified in the three novels. He adds that he is not suggesting that students adopt any approach. Mr. Price: "I believe a structure will emerge from your ideas. Just start writing."

Here Mr. Price explicitly discounts a formula or analytic approach to structuring the paper and favors a nonlinear approach in which the structure emerges from the writing.

Boldness in Decisionmaking/Thinking. As mentioned above, Mr. Price emphasized a nonlinear thinking approach to writing. He encouraged students to choose any topic that held personal interest and to use their own experiences as a source of inspiration. He wanted them to "evade the obvious and go for their own ideas." Mr. Price felt that the majority of students' academic experiences or "what and how they learn in school teaches them to distrust their own ideas." His challenge was to help students learn to trust in their own thinking and ideas.

Learning Parameters of Workplace Situations. Mr. Price was concerned with helping students appreciate the contingencies of the work world outside school. Since students in this class were headed for college, he wanted to prepare students for college work, and more generally, for lifelong learning. Thus, in addition to specific thinking, writing, or research skills, he wanted students to gain an appreciation of literature and an understanding that only critical readers become good writers.

EXAMPLE: "My goal is to help you recognize elements of writing, and ask yourself, why does he do that? You might not ask, but if you ask, you risk losing the TV-level of reading. . . . Those who play the piano or violin are more critical listeners of music. If you are concerned with being a good writer, you will be a more critical reader. You will notice these things instead of being lost in the art."

He also expected students to assume responsibility for their work, as they would be increasingly required to do so in the future. He did not accept students' excuses.

EXAMPLE: Carla approaches Mr. Price at the end of the class and tells him that she can't do the assignment (the paper). He says, "I'm not willing to back off on the requirement." He offers to give her individual help. Carla, looking dejected, goes back to her seat.

Later, Mr. Price commented that he knew Carla was crying and seemed upset that he "drew tears." He showed caring and concern for the student, but upheld the requirement that she assume responsibility.

Encouraging Questioning of Authority. In the course of their research for the paper, students read articles and critiques about the novels that they had cooperatively gathered from local public and university libraries. Mr. Price encouraged students to question the interpretation that critics advanced. In class discussions, students freely challenged the teacher's or other students' interpretations as well. At the same time, he wanted students to respect others' right to have opinions, even if these differed from their own.

Persistence. Throughout the paper writing activity, Mr. Price frequently acknowledged that students were engaged in a difficult task that was often frustrating. He encouraged them to persist, not only by helping them accept a state of "temporary understanding," but by assuring them that the process of reading broadly, identifying themes, and thinking about one's own feelings and experiences in relation to those themes would produce results. The payoff for persistence is "feeling pleasure at mastering a subject."

Cooperative Skills

Although students wrote individual papers, Mr. Price encouraged cooperation among students in the reading and writing process. He had read extensively about research on the benefits of cooperative learning and conducted staff development workshops for teachers on this topic.

In particular, Mr. Price explicitly encouraged students to use each other as a resource for help solving problems. By doing so, he tacitly advanced the notion of "distributed knowledge"--every individual has some knowledge or skill that can be useful to a group task. He also had students work in small groups to accomplish specific tasks.

EXAMPLE: Students were required to give brief oral reports of any articles they read that might be of interest to the class.

EXAMPLE: Students push their desks together in groups of three or four to discuss a quote from *The Storyteller* and generate a list of ideas. Their assignment is to come to a consensus on the key idea. After about ten minutes, one student stands and orally presents the group's idea to the class.

Research Skills

Learning important library and research skills also had high priority for Mr. Price. Students were required to use the library to identify relevant articles that the class could use for their papers.

Library Procedures. Specific library skills that Mr. Price expected students to develop included using the card catalog, locating and obtaining articles, and finding journals. He also met students at the university library on several occasions to help them with their research.

Paper Format. Students had to follow a standard format for their papers, which included creating a bibliography and proper use of quotes and footnotes.

Heuristics. To help students learn research skills, Mr. Price offered heuristics for using the library.

EXAMPLE: "When you get to the area [the library shelf that contains a book the student wants], look around at other books and titles. Are there other books that might be valuable?"

EXAMPLE: "After a while, you will not come across new titles. Then you will know that you have covered the literature."

In the latter example, Mr. Price gives students a strategy for knowing when to terminate a literature search and move on. This way, students won't spend unnecessary time looking for new information that they are not likely to find.

Deemphasis on Domain-Specific Skills

The content domain of this class was Latin American literature. Although his instructional goals clearly emphasized generic thinking and writing skills, Mr. Price also attempted to show students how this literature fit within a broader cultural context.

EXAMPLE: The teacher begins class by discussing a newspaper article, "Cholera Compounds Peru's Economic Misery." He points out how one of the books they are reading, *Love in the Time of Cholera,* deals with a topic that's relevant to current life in Latin America.

As mentioned earlier, the first semester of the course also included domain-specific knowledge goals, such as understanding the eight ways of meaning.

Classroom Design

To carry out his instructional goals, Mr. Price designed specific activities and created a particular environment for learning important thinking and writing skills. The classroom exemplifies many of the characteristics proposed for effective learning environments (Collins et al., 1989).

Teacher Roles

Mr. Price's primary role was to facilitate and guide students through the reading, thinking, and writing process. Below we discuss several techniques he adopted in service of this role. He also often presented himself--accurately--as a learner, who was engaged with the students in the process of understanding contemporary Latin American fiction. In this way he put himself and the students on an "equal" footing, which served to set a tone of mutual respect and reduce the teacher's authority, while increasing students independence.

In addition to adopting specific teaching techniques to support these roles, Mr. Price had relevant experience that he could share with students. He had taken a sabbatical from teaching to study writing at a local university. This experience was important in helping him formulate his instructional goals and to implement them effectively. He also read about cooperative learning and had "conversations with people I respect" about literature. He believed that there is no model for what he was trying to accomplish--using cooperative learning methods to teach a composition process that employs a nonlinear approach. He described himself as "out there laying fence"--i.e., developing entirely new techniques and methodologies.

It was clear that Mr. Price is an avid reader. His classroom was stacked with books on various topics--computers, cooperative teaching techniques, architecture--and he had installed a sound system to play music when he was working on noninstructional activities in the classroom. Students could see that their teacher was a person who collected books and music. His animated reading aloud of the novels during class time--often punctuated by physical movements for emphasis--demonstrated his passion for literature and helped reinforce his messages: Read deeply and critically if you want to write well; acquire a love of good literature.

Situated Learning

In a situated learning environment students carry out tasks and solve problems that reflect the multiple uses to which their knowledge will be put in the future. In Mr. Price's class students were required to produce a documented critical essay on a topic that applies to the three novels and has "important meaning in our culture." This assignment gave students opportunities to actively engage in using the knowledge and skills they learned about writing, research, and themes in Latin American fiction. They learn to apply heuristic and learning strategies. They learn that particular skills and knowledge are transferable to a different context from Latin American fiction. To produce the paper, they must formulate their own problems and goals, and deal with difficulties that can thwart their progress (e.g., a key article is written in Spanish). Recognizing and delineating emergent problems that arise in the course of carrying out a rich, complex task is a crucial skill, often used by expert writers (Scardamalia, Bereiter, and Steinbach, 1984). Students also have opportunities to learn the constraints of the "embedding context"--in this case, the classroom--to help solve emerging problems, for example, by using other students as a sounding board for ideas.

Because students did not proceed in unison with their reading, writing, and research tasks, the class was organized to permit parallel work. Students recorded their progress on a wall chart, which permitted Mr. Price to track individual progress and organize classroom activities accordingly. During a single class period, then, he could give one-on-one help to students in need, while others worked alone or in small collaborative groups.

The situated learning was also sequenced to guide student growth from basic to more complex knowledge and skills. Mr. Price did not discuss sequencing principles explicitly or indicate that he thought about instruction in these terms; rather, he emphasized nonlinear thought and the fluidity of thinking and generating ideas as part of the writing process. However, his practices indicate a tacit understanding of sequencing. In the first part of the semester, for example, he taught classic rhetoric and the eight ways of meaning, and analyzed meaning in selections of poetry. Students also did "emulations"--an exercise in which students take a piece of good writing and mimic its sentence structure while writing on a completely different topic. He often began class by asking students to read aloud the emulation sentences that they had just written. Prose analysis using the eight ways of meaning and emulation exercises seem intended to prepare students for the reading and writing task that culminated in the critical essay assignment.

Culture of Practice

This class supported three cultures of practice: that of the writer, that of the reader, and that of the college student. Although it was not clear that students identified with each of these, most seemed engaged in their reading and writing during class and a few showed great enthusiasm. Discussions with students at the end of the semester (elaborated below) indicated that many felt the class initiated them into the culture of the college student.

Some classroom activities seemed to support one culture over the other. Activities and instruction focused on library skills and the format for the research paper, for example, were geared to developing college-relevant skills. Other activities, particularly those involving reading, thinking about, and discussing the novels were targeted toward the writing process. The many cooperative and group activities (discussed in more detail below) also seemed supportive of the culture of writing. Discussions about literature, the relationship of literature to culture, and the value of "reading deeply for understanding" supported the culture of the reader as a "connoisseur" of literature. But it is also clear that some activities supported several cultures of practice and, taken as a whole, complemented each other in the creation of a dynamic, challenging learning environment.

Specific activities seemed particularly interesting to us as guideposts to other teachers interested in teaching critical thinking or reasoning skills. One was Mr. Price's practice of explaining his own teaching techniques, or sharing his own experiences with writing, in ways that make visible the underlying skills and attitudes that form expert behavior.

EXAMPLE: Mr. Price models how to generate a topic from one's own experience: "If any of you were moved by *Dances with Wolves* and the trashing of a native culture, then transfer your thoughts and feelings about this to *One Hundred Years of Solitude* or *Love in the Time of Cholera.* Note that there are several things I did NOT start with to develop a topic: the authors, the books, critical reviews. Start with your own personal interests in order to make your paper a consuming interest rather than work."

In this example Mr. Price explicitly reveals his own thinking process in generating an idea. The availability of such models helps learners build and refine a conceptual model of the task they are trying to carry out (Collins et al., 1989).

Another time, he contrasted teaching methods to convey the purpose of a particular method:

EXAMPLE: "This is frustrating for you, isn't it? You're thinking, `why not just tell us what's going on Mr. Price?' I could use another technique. I could lie to you and make up a silly interpretation and make you argue with me. I think you'd like that better. How do you feel about this technique [i.e., not giving students an answer]?" The student replies, "Absolutely no clue." Mr. Price repeats, "And that's frustrating for you."

In this example, Mr. Price told students that another way to go about interpreting literature was to advance a "straw man" that the group could argue about. He purposely rejects that approach, even though he feels the students' frustration. Rather, the approach he takes--not giving his personal interpretation or a "straw man"--is better for having students experience temporary understanding. Getting comfortable with temporary understanding as a part of nonlinear thinking is a main lesson in his class: A lesson that reflects how "expert" writers accept uncertainty, and perhaps feel frustration, while engaged in the writing process. This technique also supports another instructional goal: to encourage students to do their own thinking without appeals to authority. Below we discuss Mr. Price's use of modeling to illustrate other expert practices.

A second interesting activity related to developing a culture of practice concerns discussions about group norms. The teacher and students discussed norms at several points during the semester, usually when some issue arose about how to accomplish their work.

EXAMPLE: With only two weeks left in the semester, it seems clear that classroom time must be used to work on the papers if several students are to finish. Everyone will have to keep on task. Mr. Price: "One last threat, or question actually. Some students will not work and will start late. What should we do about this?" Student #1: "Kick them out." Student #2: "Let the librarian babysit them." Student #3: "Let them sign themselves out and just not come to class." Most students indicate agreement with this suggestion, and the teacher moves on.

This example illustrates how the class defined acceptable behavior for the group: either come to class prepared to work or don't come at all. During this discussion students also rejected Mr. Price's suggestion that those who were off task be required to give progress reports. One girl protested that this approach was fallible because students could "BS their way through that" (i.e., make up the progress report).

In addition to discussing group norms, Mr. Price often requested students to adopt behaviors conducive to creating an appropriate environment for work.

EXAMPLE: During silent reading time, Mr. Price instructs students to "please create a quiet, contemplative reading environment." He counts down from ten until students stopped conversing. As students read, he circulates around the room and answers questions in a whisper.

A third way that Mr. Price enhanced the culture of practice was to invite "experts" to attend class and discuss different topics. Experts were regularly scheduled and appeared in class nearly every Friday. On one occasion Mrs. Verde, the Spanish teacher, discussed what she had recently learned in a university course on magical realism. On another occasion, a French exchange student in the class spoke about the French view of U.S. policies in Latin America, such as the invasion of Panama. This discussion was provocative, because students learned that other countries saw U.S. actions as imperialistic, not patriotic. By asking a student to speak, Mr. Price acknowledged that students can possess relevant expertise, not just teachers or other adults. In all likelihood, the opportunity to share his views as an "expert" enhanced this particular student's motivation as well.

Motivation

Mr. Price believed that students were motivated when they successfully accomplished a task. He also acknowledged that students are not highly motivated to write. His most evident motivational device was his insistence that students choose topics that interest them. He reasoned that all students could write if they took the time and effort to discover what was relevant to their own interests. In this approach, he emphasized intrinsic goals (e.g., the pleasure of the creative process or the accomplishment of producing a good essay) over extrinsic goals (e.g., write to get a good grade or please the teacher).

Mr. Price also praised students for good work when they selected a topic, raised interesting questions, or offered insightful interpretations. He also gave students opportunities to make individual, and sometimes unique, contributions to the class discussion.

EXAMPLE: Mr. Price asks Maria, a Spanish-speaking student, to pronounce a difficult Spanish word in the text. Maria pronounces the word. Mr. Price attempts to mimic her pronunciation, but fails. Throughout the rest of the reading, he pauses at the particular word, and Maria pronounces it for him. Each time the students laugh, and then Mr. Price continues to read.

Mr. Price expressed general distaste for grading and students who "push for points." His method for grading the critical essay was based on a scoring rubric. The rubric sheet shows grading criteria for the content, argument development, style and mechanics of the critical essay, with more specific criteria under each. It presents four specific examples, ranging from lower to higher quality, for fourteen different criteria. The "insight" criteria, for example, contrast "discussion lacks basic understanding" with "shows special insight or originality throughout treatment of the topic." The rubric sheet gives students a clear understanding of expected performance, which should aid in motivating them (Hackman and Oldham, 1980). Mr. Price took each student's best work and scored it against the rubric. He also took student effort into account and explained that "obstinate, nonperformers" would likely receive a "C" grade. While the rubric sheet provided a clear guide for students and supported grading for individual writing instruction, he was not focused on grades. His main goal was to get students to apply appropriate effort based on their skills. The way to harness that effort was through their personal interest in a topic, not by holding up standards for achievement.

Mr. Price's attitude about grades upset some students, especially those students who have learned to manage their grades effectively. When these students asked "what do I need to get an A?" he replied "I don't know." While students found this answer frustrating, his response communicated the view that a teacher cannot know what a student "needs to learn" because the student must determine and judge this for him or herself. This approach also places some responsibility for learning back on the students.

Cooperation

As mentioned earlier, Mr. Price showed students how to use each other as resources--for information about articles, for feedback on ideas, for figuring out the meaning of a passage. Students sought each other out for help in class and for rides to the local university library. He also used several group activities that yielded information that could be shared with the whole class (see earlier example of discussion groups to identify themes).

EXAMPLE: Students meet in small groups to read and study a single paper. Then groups are reformed to include one member from each of the previous groups. Each member in the new group then reports on the paper studied in the original group. In this way, all students hear about each paper.

Mr. Price gave students clear instructions about what to say in the second group: Take 3-4 minutes; don't talk about your confusion; speak clearly; use lots of facts; give the title and author of the article; give an overview. In this way, students learned how to share information with the group in an efficient manner, within the time constraints of the class.

In addition, students read and critiqued each other's papers. Students noted that this exchange was very helpful for their writing. They also learned to give constructive feedback without causing offense. One student explained that they were sensitive to the fact that roles changed back and forth between writer and critic as each student's work was discussed in the group. Having students switch roles has been shown to be effective for acquiring skills in reading (Palinscar and Brown, 1984) and writing (Scardamalia, Bereiter, and Steinbach, 1984).

Toward the end of the semester, Mr. Price formed groups composed of students who were at roughly the same stage in researching or writing papers so that they could help each other to proceed:

EXAMPLE: The teacher works closely with students who are floundering (e.g., still had no topic for their paper). Students who have made some progress are instructed to talk about their ideas and projects: "Saying it out loud will help you. When you are explaining it to someone you are rehearsing what you will end up writing about."

By adopting this strategy, Mr. Price gave students a heuristic for helping them form their ideas, and a cooperative audience to listen and provide feedback.

Teaching Techniques

We observed Mr. Price employing a variety of specific teaching techniques to support his instructional goals. Some were common methods typically associated with traditional teaching, such as lecturing, providing handouts with explicit instructions (e.g., for conducting library searches and compiling a bibliography) or giving direct answers to students' questions. These directed methods were quite infrequent, compared to other techniques.

In keeping with his goal to make students think for themselves, he rarely answered direct questions that concerned literary interpretation, choice of topic, etc. He did answer specific questions about doing library work (e.g., where's the best place to park at the university library? where are the xerox and change machines?) or the research paper (e.g., does it have to be typed? should we assume the reader has knowledge [of the novels]? do you want quotes and footnotes?). On occasion, Mr. Price would answer his own question when students seemed unable.

EXAMPLE: Mr. Price asks students to explain the difference between a sentence written by Llosa and one written by Garcia-Marquez. After much discussion, he concludes that the students are off track. "We are missing the point, so I am going to have to tell you what I am trying to get you to say. The meaning of the story is carried by the verbs, which are used descriptively." He then diagrams the sentences on the board to illustrate.

Another fairly common technique used by Mr. Price is to give students exercises that provide specific practice in a skill: for example, to "read the next two pages and come up with a list of new ideas. Then draw an inference about how the ideas relate to your topic."

In contrast to these more traditional methods, Mr. Price adopted a number of methods that can help students acquire and integrate cognitive and metacognitive strategies for using, managing, and discovering knowledge (Collins et al., 1989). These include articulation, modeling, scaffolding and fading, coaching, providing analogies, and providing individual instruction. Illustrative examples of these methods follow.

Articulation

Articulation methods get students to articulate their knowledge, reasoning, or problem-solving processes in a domain. Mr. Price asked specific questions or adopted other techniques to promote articulation. He often did so when reviewing material learned in prior lessons.

EXAMPLE: Mr. Price reviews the steps in the process of writing the paper by having students recall and share the principles they had learned earlier: "I want to review with you `how to do the paper' with you telling me how. I'll write down the good ones."

In addition, cooperative tasks involving role switching (writer or critic) led students to formulate and articulate their knowledge.

Modeling

The technique of modeling is used to externalize an internal (cognitive) process or to make an activity more explicit. Mr. Price frequently modeled and often explicitly told students that he was doing so. This provided students with a specific cue: Watch and listen to me and you will learn what to do.

EXAMPLE: Sue asks Mr. Price a question, which he suggests she bring to the class. Mr. Price: "Let me model what I'd do." Mr. Price then asks her question to the class. Several students answer. Sue replies, "That's good! Thank you."

In this example, Mr. Price models how to use other students in the class as a resource and reinforces one of his cooperative learning goals. In an earlier example, Mr. Price modeled how to generate ideas by using a feeling about a movie to direct one's thinking about the novels.

Scaffolding and Fading

Scaffolds are supports (verbal or physical) that a teacher provides to help students carry out a task. Fading occurs when the teacher gradually withdraws support until the students are on their own. Mr. Price used physical scaffolds by, for example, writing on the board three different possible structures for the research paper.

EXAMPLE: Sue is having difficulty identifying a topic for her paper. Mr. Price offers to help her: "First, we can generate some lists. What do you like to do in your spare time?" Sue: "I like to take photographs." Mr. Price suggests she try the topic of "imagery" and "develop a list of 30 `pictures' taken from the novels as examples of the author's use of imagery." After some discussion Mr. Price suggests she might "talk about them as a walk through a gallery." Sue: "What's my thesis?" Mr. Price: "You won't know until you make the lists."

In this example, Mr. Price gets Sue started by asking a question. After they identify imagery as a topic, he suggests ways for her to begin thinking about the topic (scaffold). Once he sees that Sue can carry on herself, he stops making suggestions and does not answer her question about a thesis (fade).

Another example is revealed in his design of cooperative activities, where he forms groups based on student progress with the paper. He works with the group of students who have not yet identified a topic (scaffolds); he instructs students in other groups to present their topic and ideas orally to the group (fades). Note that students in the latter groups have already had much practice in listening to and critiquing others' ideas; students have learned necessary skills to help each other.

Coaching

Coaching consists of specific feedback, hints, suggestions, and so on, relevant to a particular problem that arises as students are engaged in a task. Mr. Price used hints to get students started on a task. However, he was careful to emphasize that hints should not be taken as answers: Students had to generate their own ideas.

EXAMPLE: Students are assigned to read two quotes and generate ideas about their meaning. Mr. Price says, "I'm going to put two words on the board to guide those of you who are lost." He writes "cultural" and "evolution" on the board. "If you put them together, they may have an interesting meaning. If you are not lost, and have ideas, do not look at them or they will lead you down a path that is mine."

Providing Analogies

Mr. Price often illustrated specific points with analogies. Some were fairly general and others were drawn from typical school learning experiences.

EXAMPLE: The process of figuring things out is like a ball of yarn. The more you pull, the knots get worse, but eventually you figure out what to pull so the knot comes apart. Mr. Price drew a ball of yarn at the board while he talked.

EXAMPLE: In explaining a strategy for evaluating ideas, Mr. Price invokes science class. "In a science experiment, one strategy is to figure out the negative case--don't go after what you think it is, but what it isn't."

In Mr. Price's analogies, we see a parallel to Ms. Adams's "war stories": these were anecdotes from her experience as an interior designer to teach students a particular lesson, such as why not to use linen fabric for drapes (Stasz et al., 1990). The anecdotal retelling of experiences to one's associates on the job has been shown to be an effective means for teaching and learning diagnostic skills in a community of workers (Orr, 1986). Because Mr. Price is a teacher, not a writer, he had no war stories to share. His analogies are possibly weaker than war stories for teaching a specific fact or process, but they might help students by relating the writing process to an image that students can visualize (pulling on a ball of yarn) or to a process that they have experienced in another context (e.g., the science experiment).

Individual Instruction

Although many of Mr. Price's class activities involved group work, he viewed writing instruction as individual. He gauged student progress through conversations with each and tried to determine whether they had developed any "big ideas." If the student could discuss something he or she had achieved, such as reaching some new understanding, then Mr. Price concluded the student was on the right track. He often worked with students one-on-one. When class was not in session, he was frequently available to students requesting help. During the final weeks of the course, he scheduled individual consultation times for which students could sign up for help on their papers. Mr. Price said he "loved to grade papers" because it helped him focus subsequent instruction on individual students. Again, we see that his emphasis was not on grades *per se,* but on using signs of student learning to gauge student progress and suggest how learning could be facilitated.

Student Perceptions and Accomplishments

All of the students in Mr. Price's class who responded to the survey (N = 23) were college-bound, with three-fourths intending to go directly to a four-year college or university. The schedules of all but two students reflected the college preparatory track, taking courses such as higher-level math and science. One-third of the students chose the course to improve their writing skills. Only three indicated that they had chosen the class to avoid the alternative senior English courses.

Critical Thinking and Writing Skills

Survey responses indicate that about half of the students (52.2 percent) felt the class improved their writing skills "a lot," while over two-thirds (69.6 percent) said it helped them write a better paper.[26] In group discussions, some students reported that the writing exercises were most helpful in honing their skills and would have liked more of them. One student said the emulation technique was most helpful to him in writing the paper. These students generally felt the time spent reading the novels and writing the critical essay was less useful.

In the focus groups, students spoke about learning a concept that Mr. Price called "negative capability," an ability to tolerate confusion temporarily in the process of achieving insight:

EXAMPLE: Mitch said he "learned about negative capability--if you let yourself be scared by something and don't run away from it, eventually you will figure it out. It will come to you out of the blue."

EXAMPLE: Karen described herself as "a math person" who had to know if something was right or not. In this class, the teacher said "well, it could be this or that, or something else . . . what do you think?" As time went on Karen said that knowing was "less important" and she came to accept "not knowing."

In classroom observations, we noted many instances of students discussing ideas and interpretations about the books with each other while in small groups. During these sessions Mr. Price typically circulated around the room and unobtrusively listened to student discussions. In this way he was able to monitor that students had indeed learned to hone their thinking skills.

Reading and Appreciation of Literature

When surveyed, 70 percent of the students said the class taught them how to understand literature. In the focus group, Anna discussed how she learned to read better and was more confident in her reading ability after having tackled three "difficult" books.

Students were mixed about the choice of Latin American literature: David wished for "American writers on familiar topics like the family," while Anna "liked the unfamiliar topic" and Susan "found it fascinating." On the survey, nearly half of the students (47.82 percent) said they did not like the books they read.

Research/Library Skills

By the end of the semester, every student "agreed" or "strongly agreed" with the statement that "it's important to learn how to do library research." In focus groups students said they had learned to construct term papers and do research.

EXAMPLE: Susan: "I didn't know I could research before. I used research to learn it [the topic of her paper] on my own. I really mean this!"

Cooperative Skills

Ninety percent of the students felt that class helped them learn to work with other students. About 70 percent felt cooperation helped them write a better paper. In focus groups students commented that reading and critiquing of each others' work was a helpful learning technique. In class, we observed many instances of cooperation, where, for example, students shared library heuristics with other students based on their own experience. One student mentioned that many articles had subject indices in the back that helped determine if the article contained information on their chosen topic. Another discussed the use of the periodical index as a research tool.

Work Attitudes and Preparation for College

Three-quarters of the class believed they had learned skills in this class that would be helpful in the future. In focus group discussion, students said the class had given them a "taste of college" where courses are not structured, there is little busy work, and courses involve broad coverage of topics. This discussion of class structure was echoed in the survey, where nearly three-fourths of the students "disagreed" or "strongly disagreed" with the statement "this class had a lot of structure." But in discussions students were quick to clarify that lack of structure was not necessarily a problem: "Lack of structure doesn't mean the ideas weren't thoughtful"; the class was run in a "kick back" mode, but that "doesn't mean it wasn't challenging"; "in-depth handling of the topics provides the structure." Students also said the unscheduled aspect of the class and deemphasis on grades made for a "stress-free environment." Their comments suggest that students had come to accept the unstructured nature of the class and saw it as a positive experience and useful preparation for college.

Bob's experience in this class made him think differently about college.

EXAMPLE: Bob explained, "[I] normally want people to tell me what they expect from me and to move me along, piece by piece.

That's linear thinking--just what Mr. Price is trying to stop. I understand the problem I have. I'm just nervous that I'll get scared in college and go back to bad habits."

Other students expressed more confidence in their abilities as a result of the class.

EXAMPLE: Lila said she had been worried when they first got the assignment for the essay and was "shocked that the stuff just flowed out" of her. She learned that she could do all of it herself and that "it was all there inside of me."

Motivation

Students made several comments about how the class structure motivated them to learn. The deemphasis on grades, lack of "punishment" if an assignment was late, and the opportunity to improve grades with effort enhanced motivation and made students work harder.

EXAMPLE: Lila said she worked really hard on her paper and got a "B." In the past, she would have been upset by a "B," but had learned that a "B" did not mean that she wasn't smart. "It's okay not to know something right now, because if you continued to work on it, maybe next year, you would know it then." Gerry added that "if you got a grade you weren't satisfied with, you could revise the paper and make it better. . . . This is important for learning to write because when you write, you revise."

Students also felt motivated because their teacher cared about them as people, cared about their work, and really believed that students could learn to write. Mr. Price was "a father figure . . . no, more of an uncle" to them.

A few students felt that the deemphasis on grading made it easy for some students to coast through the class: "If you just showed up, you got a "C," or it was easy to "show up, [mess around], and get a B." But by and large, students felt motivated to work, despite the fact that, as seniors, most had already been accepted to college and their grade was, in some sense, irrelevant. This prompted one girl to note that it was a tribute to the teacher that so many seniors continued to come to class and work on a difficult assignment in their final semester.

School Context

Access to Knowledge

Mr. Price voiced several complaints about lack of resources. He had no dictionaries. He could not take the whole class on a "field trip" to the library. He had no computer terminals for accessing on-line library databases to identify and read relevant articles. He bought paperback copies of the novels with his own money. He would like to have an assistant to help him put together the materials needed for the class. Mr. Price also wished for more preparation time, which would, for example, allow him to plan more group activities in the English composition class.

Press for Achievement

Since Mr. Price taught a college preparatory English class in a school that emphasized academics and college placement, he received strong administrative support. The administration and Mr. Price had high expectations for the homogeneous group of "high-ability" students enrolled in his class. Interviews with school administrators indicate that college prep students have more course-taking options than other students. "Honors" classes also tend to have smaller class sizes (e.g., an average of seventeen students in honors English, compared to 33-38 students in other English classes). Pressure for honors classes is so high that the district instituted a waiver policy whereby parents could enroll students in honors classes despite placement advice that the class is too advanced for the student. Many parents are willing to pay for extra tutoring to keep a student enrolled in honors or college preparatory classes.

Interestingly, while Mr. Price's college prep class received much support from the school, parents, and students, he personally opposed "tracking" students and objected to "honors" classes. He felt that the push among some students (and their parents) for grades was often counterproductive to learning. In addition, he felt that students with vocational interests--as many as 40 percent of the student population in his view--were not being well served by the school because of the college preparatory emphasis.

Mr. Price's concerns seem well founded. Because of state and district graduation requirements, students often need prerequisites to enroll in advanced classes. Counselors use middle school grades to place students in, for example, Math A (pre-algebra) or Algebra 1, in the ninth grade. This placement effectively determines a student's "track" and acts as a gate to enrollment in other classes. To meet district graduation requirements, the school assigns academic credit to vocational classes whenever possible (e.g., landscape/horticulture counts as life science and electronics as physical science). Mr. Price disagrees with this practice and has argued that his own class in landscape/horticulture should not receive science credit. These tracking and crediting practices limit access to knowledge for many students by either preventing enrollment in future classes or by providing a less rigorous curriculum content in some courses.

Professional Teaching Conditions

Mr. Price had a great deal of autonomy in teaching the class: "the principal and the others leave me alone." Mr. Price said he originally felt some pressure from the English department and administration to teach in a more traditional manner and include grammar and vocabulary in the course. He said he would rather teach somewhere else than teach traditional content. He noted that his class went beyond the state's model curriculum guidelines and was at a higher level: In his class, "grammar is not separated from the study of literature."

Although Mr. Price's relationship with the school was not always smooth, he seemed able to conduct his classroom as he chose and to collaborate with other teachers (e.g., he team taught a ninth grade English class using a cooperative learning model). The school administration seemed respectful of Mr. Price's abilities and of his willingness to teach "difficult" students in the landscape/horticulture class (see class synopses in appendix). It appeared that Mr. Price had some leverage with the school administration by teaching landscape. His personal reasons for teaching the landscape class, however, clearly had more to do with his interests and concerns for students, than any desire to gain favor with the school administration.

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5. AN ELECTRONICS CLASS THAT WORKS: INTEGRATING SCIENCE AND TECHNOLOGY AT THE WORKBENCH

During the first semester Mr. Benson's electronics class divided into singles, pairs, and trios of students who practiced the "basics" of electronics. These basic lessons were organized around individual labs that produced an electronic device, e.g., digital monitor, silent alarm, and audible alarm, etc. Mr. Benson included math and physics lessons in the course of teaching concepts and facts needed to complete labs, and in some cases the labs themselves focused on integrating math, physics, and electronics. Upon completion of this "basics" phase, at the end of the first semester, students moved into an advanced phase involving project work and exploration. Working at an advanced level students made use of their "basic" electronics skills and developed interest in particular technologies to accomplish a wide range of individual and group projects.

The following vignette, based on field notes, is meant to convey a typical day in this classroom:

For twelve students class "begins" at 7:30 a.m. since they routinely start work before the official commencement of the school day. Using the main lab room as a "drop-off" station for backpacks, these boys head instinctively for the adjacent computer lab. Their en masse takeover of the small room places Choa and Jack at the CNC mill. Kent, Jack, and Tom make their home nearby at the robot arm computer, and Mitch soon joins them. The room quickly fills with the noises of chatter, humming computers, and lurching printers. Mr. Benson is quietly working in his little office down the hallway. Just before the bell, he comes out, saying "someone is pretty exuberant." These ninth grade boys are enjoying themselves, alternatively arguing over strategy and offering hints and encouragement to whoever controls the computer keyboard. Mr. Benson picks up on their excitement as be begins making rounds. Tom pulls out an issue of "Sound Canvas" announcing "they have all this cool stuff. Look how long this keyboard is." His computer mates marvel with him over the wonderful collection of electronic music components. Just then Kent makes the robot arm move and an impressed Tom asks if he has made a new program. Kent replies that he has modified the original one. Walking out of the computer room, Mr. Benson happily calls over his shoulder to "remember to save" since several of the boys had lost their work in the past few days.

A rambunctious foursome surrounds a corner computer, searching for the Electronic Workbench program. Frank, who was caught with candy just yesterday (for the umpteenth time) joins the group. Outstretched hands jammed with Snickers, he catches sight of Mr. Benson as they pass each other at the doorway. He quickly stuffs the contraband into his pocket. Just then the group lets out a "cheer" at finding the program. Earnest jockeying for the programmer chair begins, but Frank won't be moved as he has "something of value" to trade. They soon begin working through an advanced lab on OR gates with Frank in the programmer's chair and the others happily munching.

When the first period bell rings at 7:40, the twelve earlybirds continue on, oblivious to the fact that the bell is ringing. The day has already started for them. Choa and Jack are having some trouble getting the computer to work, and Mr. Benson suggests they boot it up; the screen soon comes alive with a diagram. No embarrassment here, they plunge forward.

The main lab remains empty, but the open door reveals a brown Z parked just outside the door. Arms and legs of three student installers stick out of the open doors. Benson is satisfied that the car will have a new stereo speaker by week's end.

Vince, a consummate loner, "messes around a voltmeter" since everyone else has already staked out the computers. He begins to make rounds "a la Mr. Benson," taking a general interest in whatever problem is occurring at the moment. The computer room remains alive with chatter and progress.

Meanwhile, four boys retire to the main lab room and take up Vince's abandoned voltmeter. Soon there is a puff of smoke and they all disperse laughing. Mr. Benson's "radar" sends him toward the general direction of laughter.

Within moments a bell signals first period to close. Several students working on the computer linger. Finally, Mr. Benson chases them out, good naturedly calling to them, "come on, you hackers get out of here!"

Mr. Benson quickly locks the room and heads down to the theater to check on the work of three advanced students who will receive credit for their work on the sound system for an upcoming schoolwide event. Since he is now beginning his preparation period, he takes his time to carefully trace the circuits designed by his students.

Instructional Goals

Mr. Benson's primary purpose was to teach electronics by integrating math, physics, and various forms of technology. His vision of electronics as an "integrated" discipline resulted in a set of instructional goals composed of domain-specific knowledge and skills, complex reasoning skills, work-related attitudes, and cooperative skills. Domain-specific concepts and facts are used as stepping stones for understanding electronics as an integrated domain. Moreover, there is no emphasis on domain skills over generic skills. For Mr. Benson's purposes both are important. These instructional goals set into motion conditions under which students thought about and practiced electronics at both basic and complex levels.

Complex Reasoning Skills

Problem solving became a primary instructional activity in Mr. Benson's classroom. During the last month of the class student projects provided many opportunities for enhancing complex reasoning skills. Whereas the "basics" labs offered many opportunities to troubleshoot, the longer projects, which students designed, permitted many opportunities to practice a fuller range of problem-solving skills.

Analysis of Problem and Generation of Solution Paths. Mr. Benson typically worked with students to define the problem and then would leave them alone to define their own solution space. Because the technology itself provides students with feedback on their success or failure, Mr. Benson was assured that students would be able to proceed on their own.

EXAMPLE: Kent is holding court at the computer surrounded by his fellow computer hackers. He has been fooling around with the electronics workbench software program and having a problem. Mr. Benson troubleshoots aloud and finds the problem. Before leaving Kent to complete the lab he says "you weren't using NAND theory.[27] If you would read the manual and see how you put on the generator it will be easier to work with." This was a very gentle admonishment, almost in a teasing tone, reminding the student that it's a good idea to pay attention to the concepts and facts discussed in the manual sometimes, rather than just messing around with the software.

EXAMPLE: Hasan comes over to where Vince is working, and Vince ignores him, as he is thinking hard about the CNC programming problem. Then he says, "Mr. B., I just figured it out. I have two dots. I made the correction, here. I never had the X coordinate here before." Mr. Benson muses, "The nice thing about this is that it lets you know you have made a mistake, right?" Vince nods.

Troubleshooting and Repair. Students learned repair and troubleshooting skills while working through multiple possible solutions to their problem. (Here "repair" refers to seeking a new problem solution when the current one has failed.) Generally Mr. Benson made rounds, stopping to silently observe work or answer questions. When students appeared stuck he would model troubleshooting (modeling is discussed below), but preferred to leave students on their own or let them use other students as resources:

EXAMPLE: A student working alone has connected his setup but it doesn't work. Mr. Benson walks through the diagram with the student and compares it to the setup, looks closely at one wire and says, "This may be bad. Let's change this one here. Let me give you another one." Mr. Benson goes to the cabinets and chooses a wire, which he gives to the student. The student goes back to his desk and replaces the wire.

EXAMPLE: Kent turns to Mitch and says, "OK, Master, what did I do wrong?" The robot has stopped midmotion, and Kent and Mitch are trying to figure out what had happened. Mitch says, "You send stuff to the robot . . . the robot sends back to you, right?" He and Kent go step by step through the whole sequence of events, trying to find the place where they have incorrectly programmed the robot.

Deemphasis on Evaluation and Reflection. We did not often observe particular strategies or efforts made to have students evaluate their circuits or reflect on their project; in fact, Mr. Benson deemphasized these activities. We suggest that there are two possible reasons for this. First, having ready feedback on the success or failure of a solution makes an evaluative emphasis less necessary. When the bulb lights, the alarm sounds, or the robot arm moves, students are signaled to move on. When nothing happens, students step back to perform diagnosis, generation of solutions, and repair. Only if this process fails must they then reflect. Second, in keeping with the "doing" emphasis of vocational education, instead of students entering into reflective postmortems or replays at moments of success they move on to doing a more "real world" project--e.g., installing a car stereo system--or designing a more complex project--e.g., solving circuitry problems via a computer network of four students.

Instances of evaluation and reflection did occur at times. Here a student receives positive feedback from his work but nevertheless seeks a better way to proceed:

EXAMPLE: Mr. Benson and Vince then walk through the logic of the "input" mechanism: the gates and inverters that they'll need. Mr. Benson draws a circuit on the back of one of their labs. Vince asks Mr. Benson, "Do you have to use two inverters?" Mr. Benson replies, "Now you think about that," and then continues to talk through the circuit design. Vince asks if that is "the simplest" way to make the circuit. Mr. Benson replies, "That's your job." On the next day Vince appears in a rush and slightly excited. He immediately reports to the fieldworker that he has "thought of a new way to do the logic." He can "do it with two ICs [integrated circuits] instead of three. I asked Mr. Benson if there was a simpler way and he told me to figure it out, and I did."

Work-Related Attitudes

Mr. Benson keenly focused students on adopting useful attitudes toward their labs and projects. Besides teaching students to apply logic to solving problems, he equally emphasized workplace parameters and responsibility. "Use the tools of the trade" or "take responsibility" were exhortations he used to marshall the students' cognitive and affective resources in the service of designing and assembling complex circuits. Mr. Benson emphasized a range of work-related attitudes for students.

Responsibility for One's Actions. During the exploration phase of instruction, students made many decisions as they designed their projects. This exploration required that they invoke skills that would decompose the main goal and make determinations about the purpose of the project, the technology to employ, and how to integrate the technology. If a student does not believe that he is responsible for making these determinations, he will often do the minimal amount of work possible to deal with it. The relatively open assignment to accomplish a project required students to think independently and to make decisions about the material and personal resources required.

EXAMPLE: A group of students discuss their project ideas with Mr. Benson. Hasan has decided to take on a difficult robotics project. Someone volunteered that "Hasan doesn't know how to program." Mr. Benson replied, "We'll find out if he knows it. He will turn in the program, and I will be able to tell what he knows and doesn't know because it will either work or it won't."

Use Personal Interest as a Guide. Mr. Benson did not require that all students learn the same materials; rather, he encouraged students to work on different projects and to "learn to study what they are interested in." To accomplish this, he waited for them to become interested in one of the simple labs and then suggests that they expand upon this interest using the computer, robot, or digital circuitry. He thought that following personal interest was important for two reasons. First, he thought that each student had individual needs, a belief he frequently expressed with the statement that "life is not a uniform test." Second, he thought that students would be more motivated to learn if they drew on their individual interests: According to Mr. Benson, students will persist when "their specific learning is relevant to [their] life." He exhorted students to search for the technology that interests them and to use that technology as the foundation for their projects. The "basics" labs permitted students to practice with many types of technology used in a host of ways, e.g., for design purposes, to engineer a particular product, and as part of an integrated circuit.

EXAMPLE: According to Mr. Benson, Alan came into class at the beginning of the year generally bored with school. Over time he became actively involved with writing up lab results and then doing more and more work. Mr. Benson said that he simply would not let Alan off the hook and he provided him a variety of opportunities. Alan got "turned on" to labs and then eventually became involved with the remote-computer-robot project. Alan was really fascinated with remotes. He had avoided the computer and robot early in the semester. But he saw the computer and robots as helping him explore remotes, so he worked with the guys who were turned on by the robot.

Focus on Functionality. Mr. Benson taught the students the importance of achieving the goal of functioning electronic devices. In evaluating student work, Mr. Benson used "functionality, not prettiness" as a criterion. He explained that "A" work requires that students complete all assigned labs, make an "honest" attempt to set up the circuitry, and create a device that functions.

Cooperative Skills

Mr. Benson encouraged cooperation among students. It was his belief that students could provide each other with supports for learning difficult material or persisting with a difficult or poorly understood task, and he saw cooperation as a way to have students provide each other with these supports. He preferred to limit group work to pairs to help ensure full participation by each member: "When more than two work together you are likely to get hangers on." He visited the groups to learn to what degree each student works as a "contributing partner." Being a contributing partner enforced the work-related attitudes expressed above, that students must learn to be "responsible for their own learning" and that they should use their personal interests as a guide since "life is not a uniform test."

EXAMPLE: With Alan's assistance, Stuart assembles the circuit. Stuart moves quickly with Alan's suggesting alternatives--"no, try that (wire) here" or "move it over one"; Stuart follows Alan's suggestions sometimes--"Yeah, good move"--but not others--"hey man, don't mess me up here." Both are easy and good natured in their interactions: Voices are low, posture relaxed, hands on chins. Bob is looking on, straightening and placing wires at Stuart's fingertips.

EXAMPLE: Hasan and Tom enter their program into the computer. They explain to the fieldworker that "you have to do this before you work the drill . . . you can view it before you use the drill." Jack comes over and watches them: "How far did you make it go down? That's not right." Tom answers him, saying, "That's what Mr. Benson said . . . OK, turn 250." Hasan asks him, "How do you know it's 250?" Tom answers, "I calculated it."

During the latter months of the class, Mr. Benson suggested that students find new partners if they have a new interest that their old partner does not share.

Domain-Specific Knowledge and Skills

Electronics as an Integrated Discipline. As mentioned earlier, Mr. Benson thought of electronics as a subject area that integrated several disciplines. He viewed this integrative aspect as providing an advantage for teaching electronics. He spoke of electronics as being a "wonderful discipline because it is not isolated" and gives students the opportunity to see how basic math and mechanics come together. He routinely taught across several domains because "when more math, physics, and the integrated material or electronics is accumulated the potential and possibility for higher learning becomes imaginable."

Mr. Benson taught math and physics with labs or a particular technology or tool as needed. As an experienced math teacher, he demonstrated a deftness at both the math and its correlation with electronics.

EXAMPLE: Mr. Benson distributes the last two sheets that contain problems ranging from simple to complex. The fieldworker recognizes the students will need some algebra, unless they can use some trial and error, including the Pythagorean theorem. Just then Mr. Benson explains to the class that "some students have already had this. Again, not all of you are in algebra; I'll need to teach this to some of you." He said he would show them "how to use the Pythagorean theorem in a practical problem-solving way."

The labs and projects permitted students to correlate what they had learned.

EXAMPLE: Vince has the power supply hooked up, but he gets no response from his circuit. He says that he has a problem and suggests a solution: "We need 10V for the speaker, but 5 for the logic. Let's put in a smaller resistor." In response to a fieldworker's query as to why he was reducing resistance, the student explains that "if you have high resistance, you have to use high voltage or low resistance and low voltage."

In this example the student is integrating his math skills and his electronics knowledge to solve his problem.

Use Circuitry Logic to Solve "Basic" Electronic Problems. The "basics" labs provided practice opportunities to learn the logic behind electronics circuitry and to use this approach to solve simple electronics problems such as using resistors and switches. Mr. Benson selected labs that demonstrated the "logic" of circuits and then used a guided approach to keep students on a purposeful path toward learning particular concepts and facts.

Circuitry logic was learned by students as a way to structure and solve electronics problems; using this logic, they could design circuits or diagnose and repair faulty circuits. In the example below, logic was used to diagnose and solve an electronics problem. Mr. Benson played a logic "game" to help students overcome an impasse.

EXAMPLE: Mr. Benson says, "let's play an "OR" game. When the gate is closed, both are on so the bulb is . . . what?" (Pause) "On. And when the gate is open, the bulb is also on. That's why we call it "OR"--it's an either/or situation. What can change this?" Stuart answers, "Add an inverter," pointing to the lower input position. Mr. Benson says, "What does this change?" Stuart is silent, screwing up his face. Alan provides the correct answer: "The same thing will happen."

Students were also encouraged to develop "truth tables" to reflect the logic of alternative gate combinations that can be employed in the design of circuits. These tables provided a tool for analyzing the circuit logic:

EXAMPLE: Mr. Benson works through a lab on "OR" gates and asks, "What can change this? Think about your truth tables." Stuart answers, "Add a second inverter," pointing to the output position. Continuing to sketch, Mr. Benson says, "Let's check it out. If you close the top [input] you have `low' and on the bottom [input] you have `low,' so the output is . . .?" The three boys answer "low" in unison. Mr. Benson continues: "If you open the doors on top, you have . . . ." He is silent, permitting the boys time to answer. Then he continues again: "And if closed on the bottom you have `high' and the bulb turns `on.' If you have a high on the bottom and a gate open on top, you will have a `high' above and the bulb still turns `on.'" They all answer correctly.

Mr. Benson used basic domain knowledge (circuitry logic) as a means to transition students into complex reasoning about electronics.

Technical Knowledge. Students are expected to explore technology and to practice with specific electronic components in order to learn about electronics. Over the years, according to Mr. Benson, he has discovered that "technical ideas" such as digital circuitry and robotic engineering are difficult to teach and learn unless they are placed in the context of concrete, hands-on experimentation and investigation. In support of this approach, Mr. Benson provides the students with access to a wide range of technology, including computer hardware and software, robotics, pneumatics, and digital remotes.

Classroom Design

Mr. Benson's classroom design grew not only out of his goals but also out of his expectations about students and how they learn, the school placement and curriculum policy, and his beliefs about teaching.

Over the years Mr. Benson had learned to design his classes based on the "chemistry of the classroom" created by the mix of students enrolled. He advocates flexibility in the schedule and class structure to manage "classroom chemistry," which may change from year to year and even month to month. In designing the electronics classroom, he incorporated a fair degree of autonomy in order to combat student boredom while he taught theory and electronic "basics."

By contrast, Mr. Benson said he is unable to incorporate the same degree of flexibility into the math class that he teaches because the program is "restrictive," i.e., students must master a certain body of knowledge to advance to the next class. In industrial arts he teaches the same students over several semesters and is not accountable to cover a standard set of concepts and skills before passing them on to other instructors.

Teacher Roles

Mr. Benson primarily took on the role of "master" to student "apprentices." He provided students whatever assistance they needed early on, but as they gained skills, he reduced this interaction with them or modified his role as closer to an equal, to acknowledge their increasing expertise. Moreover, he demonstrated his "love" and appreciation for electronics. He was enthusiastic about the work at hand, and even tolerated mild chiding for this from a few students, who would later acknowledge that "the infectiousness" of his manner contributed to their own interest in electronics.

Although he was openly friendly to students, he did not encourage students to question his authority as teacher. However, he did not pretend to be an unquestionable authority on electronics: As a teacher his watchword was to "expect to be asked things you know nothing about." He had learned that a teacher knows "about half of what kids can think up."

In keeping with the master-apprentice relationship, Mr. Benson adapted to his students' interests and their abilities. He set different standards for students, depending on their level of skill and knowledge. For example, he would encourage an advanced student's attempts to use the electronics software to understand underlying concepts. For another student who had difficulty simply working with computers, he urged the student to try an experiment with the computerized robot. Working with the robot was a prized opportunity for most of the class, and the student was motivated to learn enough about computer operations to use the robot.

Because he worked with each student based on their needs and interest, Mr. Benson naturally individualized evaluation. He believed that individual student evaluation required that the teacher become involved with student projects because "if you don't do these things you will be unsure about achievement in your classroom."

Situated Learning

Mr. Benson situated the learning of electronics--together with correlated physics and mathematics lessons--in a variety of tasks. During the first half of the semester most learning was situated in electronics "labs" that taught basic "building block" domain skills and knowledge: introductory vocabulary, facts, concepts, and technical skills. After the basics were in place, Mr. Benson situated the learning in more complex tasks that made use of students' basic knowledge (e.g., about current flow, diodes, and series and parallel resistors) and skills: Such a task would be to assemble and test a digital monitor. Advanced projects took 1-3 weeks to complete, and students worked in groups and individually. Projects included advanced work on the robot using the computer and remotes; using advanced electronic workbench software to further examine basic lab experiments; designing and building the sound system for use at school events; and designing and building electronic locks.

Mr. Benson expected that the "sharper" students would use the basic concepts and physical models to design representations using the computer or the robot as a tool. For example, one group became interested in counting mechanisms and built an adapter connected to a number of component systems. They employed a variety of arrangements for the component systems and the counting adapter. Another group, interested in the computer programs, linked four computers together to form a network and work simultaneously on the same program. They then used the network to explore and test gates. Finally they did group simulations of their original experiments. This process turned out to be a very effective way for students to identify new insights from their original experiments.

Although Mr. Benson carefully sequenced the instructional plan, he did not expect students to march through it in lock step. As mentioned above, he believed that students should be encouraged to learn in the ways that most interest them. He allowed students to learn even the basics using whatever appealed most to them, e.g., the labs, robot, or computer.

He also thought that sequenced instruction should be alternated with periods of exploratory learning. He used an architectural analogy to describe this teaching strategy:

"I build on the first and second floors and then I stop and stay on the second floor for awhile. This is when kids explore, get excited, and really work together . . . bounce off each other. They might even get involved with peripheral things . . . like air cylinder valves. This is also when I have to teach some algebra and physics. Then I move to building the third or fourth floors and again I stop and stay on the fourth so that kids can explore again."

Using only sequenced instruction was an approach that he associated with novice instructors "who [are] forever involved with building blocks" and do not permit students time to integrate those blocks of knowledge.

Exploration took up the last portion of the semester, which in fact was entirely unplanned. Mr. Benson did not assign a particular project or task, nor establish a project plan. Instead, he challenged students, bringing together students with similar interests, and maintained the expectation that students explore more technically difficult projects. He said that students learned that "simple experiments teach a lot and that when they [the experiments] are brought together more complex systems are possible." This approach required a student to take the time to develop and integrate the "building blocks" in the first part of the semester.

Culture of Practice

Mr. Benson's desire to involve students in authentic practice activities required that he find ways to mesh the "culture of expert practice"[28] with the "culture of schooling." He apparently intuits the usefulness of "expert practice" for carrying out his goals to teach a broad mix of skills and to create an experimental and workplace ethic in the classroom. He acknowledges that his approach is uncommon in schools because "there is a cost to inquiry. You have to set up broad conditions and make them work." He believes that situating learning in authentic practice helps build confidence in students: "I try to build in a problem, by having broad conditions, so kids will have something to deal with and they will develop a belief in their own abilities." He bases the design and conduct of his class on his own experience as practitioner and learner: "I don't know why I do what I do. I don't hesitate though because this is what I know should be done. I know it because I make furniture. I design circuits. I play with the robot. I fool around with room drawings and houses."

During the first semester of the class student work was not organized in ways that reflected expert practice. Rather, students worked in coacting pairs and depended heavily on the teacher's assistance.[29] Beginning students, then, were not fully autonomous but would look to Mr. Benson and a partner for help. The coacting teams imply a more teacher-centered classroom, where the teacher directs activities and students respond.

As students learned more concepts and facts and could discuss the logic of basic circuits, they entered the "expert" culture. As part of authentic activities, students not only became engaged in more advanced ideas and projects, but were expected to organize their own "self-managing" groups for accomplishing the project. Responsibility, freedom, and independent discretion was encouraged. The norms for "self-management" reflect a classroom where the teacher guides students as they independently work on projects.

The classroom norms promoted exploration and a high level of learning. Students were expected to search for a group of 2-3 other students with similar interests. Students were not required to worry about appropriate roles within a group but were expected to cooperate sufficiently to accomplish the project. Moreover, because students would be experimenting with new ideas, Mr. Benson emphasized that students strive for functionality over perfect design:

EXAMPLE: After introducing students to computerized numerical control software and explaining its use in manufacturing, Mr. Benson noted that "we're not striving for that accuracy, but to appreciate that accuracy."

EXAMPLE: Mr. Benson made a general announcement to the kids: "If you program only five lines, it's okay. If you got the essence of what you are supposed to have in it, that is the point. Now, if you can design a program that would allow this arm to run smoothly, instead of herky-jerky, that would be good. I saw a couple of robots last week that were the smoothest thing."

The culture of practice reflected Mr. Benson's best efforts to blend the electronics design and engineering world with the classroom. Since his "workers" were students with little knowledge when they entered the course, he accommodated their novice status by providing a practice-rich learning opportunity that did not necessarily simulate actual work in an electronics laboratory. Rather, the culture was more like that of the hobbyist or amateur motivated to enjoy, apply, and increase his or her expertise.

Motivation

It was Mr. Benson's experience that the majority of students in his class hailed from the ranks of the general track of students and tended not to be motivated by lectures on theory or lock-step progression through the subject. Mr. Benson took responsibility for motivating students and used classroom design for that purpose. Although he recognized that his students did not come into the course motivated to work hard or to learn at a high level, he did not accept the inevitability of low-level learning or passing out "easy As." Instead, he looked for a way to make learning more appealing.

He thought that his best chance was to keep them engaged with interesting technology and to avoid rules whenever possible. He believed that autonomy would appeal to his students. For example, he permitted student groups to determine their own pace on experiments, by assigning all twenty labs at the beginning of the semester. He requested that students generate about half using the computer software and the other half using actual physical components and testing units, but as the semester evolved and it became evident that some students were "really drawn" to one approach or the other, he permitted individuals to complete a majority of the projects using the one that interested them--say, the computer or the robot. He was demanding--"get it done"--but flexible--"in your own time and according to your interests."

Mr. Benson believed that students were best motivated by being prepared and supported to do a task, and he employed all aspects of classroom design to provide this source of motivation. He organized the learning tasks so "basic" skills would be used for more advanced projects. He was willing to accept a certain amount of "bad behavior," but not bad performance.

Additionally, Mr. Benson enhanced motivation through his enthusiasm for teaching "an integrated domain" and by providing students with advanced technology and equipment (his entrepreneurial skill in acquiring these classroom resources is described below). From his understanding about learning and teaching, Mr. Benson sees the teaching of complex subjects and teacher excitement as a way to ignite motivation in the classroom:

"I love the challenge of interfacing materials. This stems from a concept no longer taught in teacher education-- transfer of knowledge. Teachers are not taught the emotional side of learning--that kids need to have the emotional preparation to learn on any given day. Transfer of knowledge [may also] come from things beside the teacher . . . the materials, beautifully designed equipment . . . this helps to program the transfer of knowledge, because kids are ready to learn."

Students discussed Mr. Benson's "infectious" enthusiasm as similar to that of a "kid in a candy store." One student's explanation for Mr. Benson's interest in students and teaching electronics is that he "basically loves it."

Mr. Benson believed in the importance of support in the sense of the "emotional connection" between teacher and student. He explained his philosophy of this "emotional connection" in these terms: "Don't throw kids back; take action so they don't fail," and "let's make this kid a better person by challenging and supporting, not by handholding."

Mr. Benson graded on the basis of individual effort. He did not distribute grades on a curve. He did not challenge students to compete against one another but rather urged that they strive to improve their own performance.

Cooperation

Mr. Benson encouraged students to work as contributing partners on their lab assignments and advanced projects. In advanced projects, he permitted students to find new work partners if their original lab partner had different interests. Mr. Benson actively urged students to move on to new ideas and new partners because he wanted students to benefit from the knowledge resources and persistence on the task that group work encourages. In keeping with his hands-off approach during the exploratory phase, he did not form groups, but occasionally suggested that students with similar interests talk together about a group project. His simple guide was that friends tend to work well together and that people who "goldbrick get dropped," i.e., lazy students can't find partners.

Teaching Techniques

Mr. Benson employed a variety of teaching techniques to support his instructional goals and classroom design. He made use of brief lectures primarily to discuss the purpose and importance of a particular circuit or application and to present facts. As with many vocational education classrooms, many days passed without lectures. The reason for this is straightforward: The primary focus of the class was on "thinking while doing" electronics. Thus, much of Mr. Benson's time was spent circulating through the rooms of the class, observing and providing one-on-one instruction opportunistically. Below we describe some specific teaching techniques.

Articulation

Articulation methods were integral to Mr. Benson's instructional style. He used questions to help students verbalize their difficulties in problem solving and to help them make links between previous lessons and their current problem:

EXAMPLE: Mr. Benson walks over to two boys working together. One seated on a stool, the other lying across the table. Mr. Benson doesn't seem to mind. He gets his pen and draws a diagram right on the table. He talks about the diagram as he draws, then begins to ask questions. "Where should you put the inverter?" Student points correctly. Mr. Benson says, "Okay. Let's try that and see what happens. Suppose the doors open. Will this turn on the alarm?" Student says no. Mr. Benson says, "therefore, the inverter won't solve my problem. Let's put it here and see what happens." Student says, "so we need to use two inverters." Mr. Benson answers, "That's right."

EXAMPLE: Mr. Benson and Curt walked into the computer room. Mr. Benson says, "So far you have spent a lot of time on that same lab. I wonder why that is." Curt made a diagram of what he had been doing in the lab, showing Mr. Benson where the problems were for him. Mr. Benson watched, saying, "Yes . . . yes." Then the two of them went off into the other room together.

Modeling

Mr. Benson effectively modeled "logic" and "problem solving" for students. This was an especially effective way for students to observe how "experts" solved electronic problems. In the example below he models how to program the CNC milling machine:

EXAMPLE: Tom was working on a program, and brought it to Mr. Benson. "I found out how to get here . . . how do I get over here?" Mr. Benson questions and talks through the answer: "What is this? Change in X, change in Y . . . what is this radius here? Okay, from here you have to subtract." Tom pulled out a calculator and began subtracting. "Okay, 619 . . . okay, that's it. You go with that." "Do these numbers sound right, Mr. Benson?" Mr. Benson replies, "I don't know," as Tom filled in the lines of the program on the sheet. Mr. Benson says, "Okay, the distance from the starting point to there is what?" Tom answers "X is .95." Mr. Benson continues walking through the reasoning: "You defined this distance, right here? Isn't this .75? Only if this arc comes across. You know what this is . . . .58." Tom volunteered, "That gives you four." Mr. Benson says, "We know this point right here . . . .75. Okay, so we know this distance . . . you have to make a translation from this point to this point . . . You need to know this. What is this distance, from here to here? .158." Tom objected, saying, "We aren't even dealing with this. We go from here, to here." Mr. Benson corrects him, saying, "No, remember this point . . . the radius comes here. It is perpendicular. You did the calculation to find this distance. It is whatever this distance is here, from the radius." Tom figured it, and said, "So, .908." Mr. Benson replies, "That sounds familiar." Tom asked him if it was right; he replied, "I think so. That gives you 1750."

In modeling problem solving, Mr. Benson also models perseverance and ingenuity. During the exploration periods of his class, his students sometimes come across problems that he does not immediately know how to solve. In such cases, he admits, his first inclination is to delay an answer, but he forces himself to work through the problem with the students: "Sometimes I come up with the wrong answer initially, but eventually I figure out how to solve the problem. I don't mind when the kids see me stumble, because that is a good lesson about the real world--if you know the basics and you are willing to explore, you can figure most anything out."

Scaffolding and Fading

When students reached an impasse during the "basics" labs, he played the "logic game" as a scaffold until students could articulate the logic of the electronics circuit on their own.

EXAMPLE: Ali and Curt are working on a lab on OR gates and are having difficulty. Mr. Benson provides instruction: "Okay, now on the backside of the chip . . . how many LED segments light when pin 1 is connected to the ground?" The boys mumble in response, "One." Mr. Benson continues, "What are the applications of this? Why would you want to use this?" The boys answer, "Digital clocks, microwaves." "Right . . . counters of some sort . . . things that count up, and count down. Okay, which pin has to be connected to ground to light up?" Ali and Curt offer incorrect answers. Mr. Benson then asks, "How many LEDs are going on?" Curt answers correctly, "Five." Mr. Benson finally asks, "Okay, which pins do you use to light up?" The boys point. Mr. Benson goes on, "You want to create all the numbers from zero to nine . . . list all the pins you use to make A through F." Unsatisfied with Ali and Curt's working knowledge of OR gates, Mr. Benson examines the boys' lab writeup, and says, "Listen to my words . . . I'm going to eat a lollipop, or a cupcake." The boys reply, "One OR the other." Mr. Benson asks them, "Can I have a lollipop AND a cupcake? If I have both of them, I'm smiling. What happens if I don't have either?" Ali answers, "Not smile." Mr. Benson nods, saying, "Look at this . . . the outcome is smiling. If you have a lollipop, do you smile?" The boys nod and say "yes." He goes on, "if you have a cupcake, do you smile?" They nod. "Now look at this thing. . . . What does the truth table say?" he asks them. The boys look at it awhile, and Curt says, "It's backwards," somewhat tentatively. Mr. Benson [fading now] says to them, "Go back, and check to see what you did. See if you read it correctly." He moves on to the next table.

During the later exploratory phases of the class, when activities are less teacher directed and students organize their own "self-managing" groups, he "fades" by reducing his assistance. Students are expected to use each other as resources and to draw on knowledge and skills learned in the basics phase of the class to assist their own project success.

Coaching

Mr. Benson used coaching to hint to students how to apply their knowledge to the problem at hand. This was an important technique for him because the majority of instruction occurred one-to-one with students rather than in lectures. In the course of these individual and small group instruction efforts, he would often suggest that students attempt alternative paths to solving a problem, moving either toward greater complexity or diversity. He persisted with this technique even when students voiced irritation that he was not explicitly answering their questions:

EXAMPLE: Lorenzo and Vince report to Mr. Benson that they are trying to make the SCR (silicon controlled rectifier) keep the alarm on, but it is not working. Mr. Benson engages them in a series of questions about the alarm circuit. Vince shows Mr. Benson the pieces of the circuit that they have already built. Mr. Benson suggests how to divide up the task, but the pieces have already both been built, apparently by Vince. They next walk through the logic of the "input" mechanism: the gates and inverters required. Mr. Benson suggests that Vince find a simpler way to accomplish the circuit. After Mr. Benson leaves, Vince complains that Mr. Benson didn't answer his original question about the SCR. However the following day, Vince simplifies the alarm circuit, thereby solving the problem. The SCR now functions.

Mr. Benson also coached in the motivational sense of the word, exhorting students to persevere ("keep trying, son") and praising success. Perhaps the strongest coaching message he communicated occurred during walking rounds when he would pause several minutes to observe some students who had overcome a faulty design problem or successfully debugged a circuit--the feedback for students was his ready grin and a wink of approval.

Exploiting "Real World" References

Although Mr. Benson had not worked as an electronics engineer, he was familiar with the applications of electronics in industry and everyday uses in homes. He offered these references during lectures to reinforce the relevancy of classroom lessons to the real world. At other times he would discuss an application or industrial use of a circuit when students became "stuck" during a logic game. These more concrete examples seemed to assist students to think more globally about a concept or application, helped them solve the circuit before them, and energized their efforts.

EXAMPLE: A group of students is having difficulty understanding the logic behind OR gates. He "plays the logic game" and then explains that "this is how to use three gates to do the same thing. That's the role of the engineer. To figure out ways to monitor and keep track of things under different conditions. Finish your experiment and complete the truth tables. Okay?" He walks away, returning later to look at the circuit and truth tables. Satisfied with the results, he energetically declares, "Now you can be masters of burglary . . . but listen sons, I don't want you to go out there and try this stuff, so let's hook up a siren to this." Stuart says seriously, "A police siren, sir?" Mr. Benson grins and continues. "Think about it. You can use transistors to trigger--like what you did last semester." Alan says, "Remember the sound generating. . . ." Mr. Benson cuts in, "Right. Take one and build it in. It's processing system, input, output (he recites the order of the circuit). You can use a 550 time circuit, or use an LED if you want." Mr. Benson's suggestions go beyond what is asked in the experiment.

Student Perceptions and Accomplishments

The students had diverse goals for attending the electronics class. While a few had specific learning goals and/or work interests related to the class, many thought it would be an easy class (especially the junior varsity football players who made up one clique in the class). Others had no personal goals but were simply placed there by the counselor. After the first semester of class, however, students reached a near consensus on their expectations for the class. They knew that they could do well if they made a personal effort, because individual attention was available from a knowledgeable and fair teacher. The mix of instructional goals, classroom design, and teaching techniques coalesced, such that students reached a common understanding of the classroom and their roles in it. In short, they became engaged and "enculturated" (Collins et al., 1989).

Students also achieved a variety of specific accomplishments in the practice of electronics. We discuss each below.

Electronics Knowledge and Skills

Students produced electronic devices that integrated various forms of technology. Because their learning was situated rather than decontextualized, they learned increasingly complex knowledge and application through the practice of authentic electronics activities. Some students focused on hands-on learning throughout the class; these wanted always to build a more complex device, adding an additional component to produce a new function. Others focused on more abstract representations. These students used the computer to design electronic devices and then explored extensions or alternatives by manipulating the computer representation.

Over the school year, students became facile with the technical language associated with electronics. Mr. Benson marveled at their gains in this area: "I'm totally amazed to see kids go from having to learn simple electronic terms in the fall to building logic devices and using the proper language at the close of the school year."

Skills became meaningful for students because students perceived and understood their use. When surveyed, over three-quarters of students indicated that the class taught them to "use electronics." The opportunities to practice and build applications in class reinforced this relationship for students:

EXAMPLE: Mitch offers that "logic" and "math" are useful skills that can be applied. Asked to further discuss "applied math," Mitch responds that people "use math" in commonplace, everyday reasoning situations. He links the "logic" entailed in electronic circuitry problems to other "math" [reasoning skills] required for everyday problem solving. Vince agrees with Mitch's description of this application from electronics class.

Cooperative Skills

Students learned that not all groups or group members are equal and that certain behaviors are less helpful than others in contributing to group goals. In focus groups, students voiced divided opinions on the value of group work. One opinion holds that students who do not participate because of lack of knowledge or unwillingness will hold back the group because they engage in nonproductive activities ("messing around") that distract other group members. The other view accepts that because the material is difficult, students find that a working partnership, where information and effort are shared, can help the group. This second view is similar to that discussed by Collins et al. (1989) where they stress the benefits of group work: Group synergism, better task understanding, confrontation of ineffective strategies, and development of collaborative work skills.

Students elaborate further:

Vince: "Some groups are not working well. They are messing around. `Participation is the key for a group to work well' [quoting a principle Mr. Benson had enunciated many times]." This comment seemed to refer to Curt's work group. Several others in the group looked at Curt when Vince volunteered this. Curt reacted slightly by shifting in his chair; but, he said nothing in response. Alan added, "We share information in the group. We know different stuff and this makes the group work well." But then he offered a reservation on how group work constrains individual exploration: "The groups can't let you investigate the finer points (of electronics)." Stuart counters that group work can make it easier for some individuals to participate in electronics: "It [electronics] is difficult. This is the first time I've ever had electronics." Alan supports Stuart's contention that electronics is a difficult subject for some, implying that for such persons group work is especially valuable: "People have different levels of knowledge. It is harder for some."

These comments indicate that students recognize the concept of distributed knowledge: Different people can bring different knowledge and skills to a task for the good of the whole group.

Some students took on the role of "helper" rather than contribute to solving problems. Unfortunately, these students lost opportunities to learn more complex ideas or technologies. Often they did not fulfill their helper role, requiring that the more engaged partner intercede. From Mr. Benson's view, these students "could" take a more responsible role, but refrained. He simply required that each student maintain some involvement with the project, but generally the partners were left to contend with whatever effort each determined to put forth:

EXAMPLE: When the lecture is over, Lorenzo takes off to get some materials. He returns and struggles to get the first piece of wire cut and stripped. He is looking pretty pathetic. Vince gets up and walks to the supply and tools closet, returns with another pair of wire cutters and says "This might work better" and gives the newer cutters to Lorenzo. Vince continues to explain his circuit logic to the fieldworker. Lorenzo continues to struggle. Vince reaches out to Lorenzo, who hands him the wire cutters and wire. Lorenzo goes off to get more wire. Vince quickly cuts and strips five pieces of wire, each about four inches long. Lorenzo returns with more wire. Vince announces, "Now we need a power supply to see if it works." Lorenzo goes off to look for a power supply in the cabinet and returns empty handed. Vince has finished his wiring idea and is frustrated by this news. Vince then tries to negotiate with the students at the next table to borrow their power supply. He strikes a deal whereby his group can use it until the table three group needs it, then table three gets it back. As Vince is plugging it in he says: "Lorenzo, next time if you're the first one in, get a power supply."

As Vince and Lorenzo's interaction demonstrates, the more engaged students often helped take responsibility for instructing and motivating the less engaged members of their groups.

While the focus group discussion revealed complaints about individual group members, survey results indicated a generally positive evaluation of cooperation. Most (80 percent) said that "working in groups is a good way to learn," and the class "helped (me) learn to work with others" (66 percent agree).

School Context

Access to Knowledge

Mr. Benson's classroom design and his instructional goals required that he have both simple and sophisticated materials and equipment available. His constant press to improve the level of instruction convinced the district to invest in equipment for his labs.

He was able to obtain equipment (e.g., computers and a robot arm) through a district-financed lease/purchase arrangement with local businesses. Additionally, he invested personal funds (one to two thousand dollars) to purchase materials that he could not lease. Moreover, the students themselves in the course of their learning were able to develop materials to support further learning: For example, during the first semester students built breadboards for the electronics labs. Students even helped fund projects with their own money at the beginning of the year.

Press for Achievement

The electronics class was an elective class and attracted a mixed group of students who were interested in the subject area. Mr. Benson was viewed as a "no nonsense" teacher who expected students to work. Students who chose the class with a different expectation dropped it early on. Mr. Benson enjoyed the "mix" of students and was pleased when several of his "low-motivation" students became strongly engaged during the second semester, developed a "love" for technology and electronics, and decided to return for a second year.

Mr. Benson had high expectations for student achievement, which he believed was linked to effort and the freedom to explore. He worked with and supported any student who would try. Students came to understand this. During focus group discussions, students explained that they worked hard, not to please Mr. Benson, but because of their own personal interest and desire to achieve.

Professional Teaching Conditions

Mr. Benson found administrative support for his industrial arts classes, but for different reasons from those of Mr. Price. Mr. Benson had crafted a high-level vocational program that had high enrollments and attracted a heterogeneous group of students. His classes were a prime example of "good" vocational education in a comprehensive high school.

Mr. Benson was much more of an "insider" than other teachers we observed. He spent much of his free time in the teacher lounge socializing with other teachers. He received the "Teacher of the Year" award from the local chamber of commerce during this last school year. The district sought his assistance in planning for integrating academic and vocational education efforts, and he arranged for speakers to provide inservice training to the entire teaching staff about integration. Despite his many efforts to advance vocational education in the school, the school's strong college preparation focus made it difficult to generate sufficient enrollment to offer separate sessions for both beginning and continuing electronics students.

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6. AN INDUSTRIAL ARTS CLASS THAT WORKS: MANUFACTURING IN THE VOCATIONAL LAB

By the close of winter semester, Mr. Benson's mechanical drawing class of fourteen students had divided into groups of two to three students, forming semiautonomous manufacturing teams, each focused on a different aspect of a single manufacturing project. In the previous semester, they had completed instruction and extensive practice in mechanical drafting, design, and mathematics, correlated to the vocational material, and now they applied these skills to a manufacturing project. The entire second semester involved the challenging, whole-class project of manufacturing a model toy tanker truck from raw materials (wood, plastic, metal) to prototype and then "mass" producing thirteen toy trucks.

Again, we begin with a vignette based on field notes to convey a sense of this classroom on a typical day:

Mr. Benson dismisses the architectural class in the adjacent room, just as members of the manufacturing teams stream into their lab. Beginning early is the recent "rule" for the thirteen boys and solo girl working on the manufacturing project.

As soon as Mr. Benson frees himself from a lingering architecture student, Trent, from the woodworking team, flags him down to discuss the "undercarriage" of the tanker prototype now under production. Anticipation over completion of the prototype provides the impetus for the manufacturing "teams'" early appearance and particularly Trent's (a boy with well-honed skills at loafing) newfound enthusiasm with the project. Another student walks by carrying boards. There is activity all around as pairs or triplets of students carry out tasks. Mr. Benson moves about between the computer room, wood shop, and drafting lab, where he stops to consult and to pose and answer questions.

Ann, seated at a keyboard, and her partner Carl work at the CNC milling machine from the design team's drawing of a ladder for the side of the truck cab. They are in command mode in the CNC programming language and do a demonstration run of their program: it draws the pattern that they have programmed on the screen. The result is not perfect--only the outline of the ladder comes out--and they begin reprogramming.

The design team, waiting for the drafters to finish a drawing, discusses another student who "got admitted to UC Berkeley but is going to UCLA." The conversation continues about how hard it is to get into Berkeley and how this guy is blowing them off to go to UCLA. Ann and Carl join the conversation with some interest and then get back to work as the drafters join the group and turn the subject to Kung Fu, knives, fighting, and proper ways to kill things. Mr. Benson slows down the conversation with a glance in their direction.

Back in the wood shop, the two-member woodworking team engages in a discussion about the angle cut that needs to be made on the roof piece of the truck. They compare the piece to the drawings of the truck, and then place it directly on the piece of drafting paper to see how it lines up.

Mr. Benson approaches the design and drafting teams with a reminder that they need to complete the "3-D" views or produce a "pictorial" of each part of the cab. Mr. Benson points out that the woodworkers have almost completed the front piece, so they should hurry with their design and drawings because the woodworkers will want to start prototyping the tanker body. With repeated consultations between themselves over details in the design, these teams are well on their way to completing the preparation needed.

Mr. Benson whistles for cleanup just before the bell rings for lunchtime. He returns to the computer room to help Ann write out the CNC file.

With all the labs empty, Mr. Benson excitedly works on his kiosk for the upcoming grant fair being sponsored by a local firm. Mr. Benson works especially hard since he will compete with nearly 400 schools, which, like his, are seeking grants to help their special projects.

Instructional Goals

The instructional goals we discuss below were not explicitly taught or identified as teacher goals. Rather, we observed that the classroom design and assignments required students to learn and apply generic problem-solving skills and work attitudes, cooperative skills, and domain-specific skills.

Complex Reasoning Skills

This class provided many opportunities for students to exercise complex reasoning skills. Mr. Benson assigned the class to build thirteen tanker truck models and he provided rough drawings completed by students in the previous class. Students were left to specify the designs and identify and solve the engineering and manufacturing problems inherent in their decisions. They defined, planned, and solved problems largely on their own, with occasional tips or advice on request from Mr. Benson.

The following example involved a group of three boys who were assigned to design the carriage for the truck. The interaction began with Mr. Benson defining a problem for the group, providing some materials, then leaving. In his absence they proceeded through problem analysis and then continued to work through the problem.

EXAMPLE: Mr. Benson asks them: "One other question: how to fasten this (pointing at cradle) to the base?" [Mr. Benson does initial problem recognition for the team.]

One student suggests using screws. Jered wants to know what the screws look like. [Generation and assessment of solution path.]

Benson brings Jered drywall screws of various lengths and then leaves. Jered suggests using two screws for holding the cradle onto the base. [Generation of alternative solution path.]

Randy comes up with the idea of using a single screw to go up through the base, the cradle, and then into the plastic pipe to hold the whole thing together. Other team members express approval of Randy's solution. [Generation of alternative solution path and evaluation.]

Benson walks by while making walking rounds, and Randy tells him about the idea of using one screw. Benson thinks about this. He appears to have a problem with the plan and says: "Stop and think what this presents. . . ." Benson thinks some more and suddenly says, "Beautiful. That is a beautiful move. It saves materials, but what do you have to do?" [Evaluation and reflection.]

Jered: "Make sure the holes line up." [Recognition of problem.] Benson: "What would you do to allow for alignment?" Randy: "Build a tool." [Generation of solution path.]

Having come though a full cycle of problem solving, progress was made. Progress brought opportunity to solve additional problems. With each successive problem solved during the design cycle, students were faced with contingencies from their previous solutions.

EXAMPLE: As the design group talks over the design, Carl notices that the measurement they are using for their cradle design is actually the diameter of the cap and not the pipe. They had determined earlier that the pipe's diameter was the measurement they needed. Randy and Jered agree that they are making an error. Carl changes the diameter of the design and proceeds to finish the drawing. [Reflection, problem recognition, solution generation, and repair.]

Work-Related Attitudes

Learning in the "manufacturing" classroom was similar to working on a shop floor. Students used the power tools on their own, planned their own work, and communicated progress and delays among teams, all in the service of completing the final product. Mr. Benson monitored students and their activities as he roamed the three-suite classroom, but self-managing student-teams were generally on their own.

Because this was an active work-laboratory, students faced realistic workplace parameters, such as needing to proceed despite a key team member's absence or forced downtime when others were behind schedule. These workplace parameters provided students with opportunities to develop useful work-related attitudes.

EXAMPLE: Student says that the class has generally helped him prepare for work because he understands the process of design, and if he goes into a job he won't be surprised or "get my head bit off."

Make Decisions. Mr. Benson taught students to make and evaluate their own decisions.

EXAMPLE: Concerned, Randy questions Mr. Benson to learn if he suggested the "wrong" solution, or if he was "supposed to" think of some different solution. Mr. Benson responds that "there's no question of `supposed to' as long as you have thought out all questions." Mr. Benson leaves, and the design team appears to feel positive about their design and Randy's solution.

In the above example, Mr. Benson surrendered his role in evaluating students' decisions. Instead he provided a guideline for evaluating one's own decisions.

Take Responsibility for Actions. About three of the fourteen students have reputations as troublemakers, loafers, or "yahoos." They presented a special challenge to Mr. Benson in teaching responsibility for one's actions. Mr. Benson insisted that students be responsible for their team's assignments.

EXAMPLE: Trent, a student who recently overcame a poor attitude and general apathy, is showing some anxiety that his team partner is absent and says that he "sure hopes that Arthur shows up today." Mr. Benson replies that "if Arthur's not here, you'll have to carry the ball."

EXAMPLE: Student is working through a difficult fabrication problem for most of the period. Asked by the fieldworker when he plans to check in with Mr. Benson, he says that he doesn't have to consult with him.

Another aspect of being responsible was associated with personal behavior. Even though Mr. Benson expected students to carry out their work, he did not overmonitor their activities.

EXAMPLE: There is activity all around as pairs and triplets of students carry out tasks. I (fieldworker) hear the tablesaw start in the woodshop room and am surprised to see Mr. Benson standing calmly in the CAD lab. He is undisturbed by the kids using the saw in the other room and doesn't seem to notice.

Cooperative Skills

In keeping with his practice of having students take responsibility for making and evaluating their own decisions, Mr. Benson taught cooperative work teams to distribute evaluation responsibility among the group. By doing so, he clarified his expectations for teamwork.

EXAMPLE: Mr. Benson says to other members of the design group: "You guys have to police each other. You have to check each other. That's part of working on a design team."

Mr. Benson wanted students to settle their own differences of opinion. He stated that resolution was needed, but he did not explain how they might resolve their differences. Unlike Ms. Adams (cf. Stasz et al., 1990), he did not teach procedures or have students practice consensus exercises:

EXAMPLE: Carl asks Mr. Benson if they should make the outside of the cradle into an angle, or make it straight. Randy interjects that he prefers a different design. Mr. Benson says: "Okay, somewhere along the line somebody gives in. You guys have to work with it."

In the above example, Mr. Benson put dispute resolution in the hands of two students who were having a difference of opinion over a design decision.

Domain-Specific Skills

As in the electronics class, Mr. Benson strove to integrate multiple domains in manufacturing. Manufacturing the model truck required students to integrate domain-specific skills. They routinely used math and drafting for designing. Woodworking skills were needed for the tooling and fabrication task. Mr. Benson also taught students to use computer-aided design (CAD) and the computerized numerical control (CNC) mill.

Classroom Design

The manufacturing classroom had a very comfortable, open feel to it. Students circulated, mixing work and some socializing. It had the look and feel of a manufacturing "shop floor" where design prototype teams work. There is no sense of urgent rush, nor any real sense of just goofing off. Students appeared to like and trust Mr. Benson. They readily helped each other. This lent a feeling of comfort to the class--students didn't seem to mind learning and working here. Students generally knew their tasks and worked with their groups to accomplish them. Mr. Benson circulated, monitoring and making himself available as a resource.

Teacher Roles

Mr. Benson moved flexibly between the role of "master" for student "apprentices" and the role of "general manager" of the manufacturing classroom. The master-apprentice approach proved useful when he concentrated on teaching and modeling problem solving to students with limited skills. He was an able "master" who took every opportunity to model his thinking process when he perceived that a team might be floundering. During such moments, he attempted to instill appreciation for the integrated domain.

More frequently he took the role similar to that of a general manager in a small manufacturing plant. In this role, he was far less directive with students. He served as technical consultant, questioner, and devil's advocate. He was able to do this because his teaching assistant, a second-year student, supervised "the floor."

Mr. Benson assumes the traditional role of classroom disciplinarian when needed. As with the electronics class, Mr. Benson was tolerant of students' socializing and joking, and even a small degree of "goldbricking." He was, however, actively confrontational with students who fought with other students or placed others in danger.

EXAMPLE: Jed returns to class to "beg forgiveness" from Mr. Benson. Jed had fought with Ed earlier in the period because "Ed thought I threw a bee on him," and both were thrown out of class. Both students claimed to be sorry. Mr. Benson fires back that what Jed and Ed did was wrong and dangerous and that they were "totally unconcerned with anyone else's safety." After a few more exchanges, Jed asks, "Am I still able to be in the class?" Mr. Benson replies, "Yes, but if you screw up one more time you are out."

Keeping with his approach in the electronics class, Mr. Benson did not hold a grudge once students made an effort in class.

EXAMPLE: The day following Jed and Ed's fight, Ed puts in a full period of work on the drawing team. Toward the close of the period, Ed shows Mr. Benson the red spot on his hand and says, "Bee sting." Mr. Benson accepts the joke as he replies good naturedly, "Good! You've taken the life of that bee. You'll have to carry that burden to the grave."

In keeping with his philosophy that schools should avoid "throwing away students," Mr. Benson also played "counselor" to his problem students. One student came into the class with attendance problems. Over time Mr. Benson noticed a "strangeness" in his behavior and had hints that the student's family embraced social beliefs about racial superiority. The student's attitude typically swung between general apathy and open disapproval toward learning skills or cooperating with team members. Rather than threatening the student with a failing grade or dismissal, Mr. Benson chose to counsel him:

EXAMPLE: After several weeks of observing Henry's "strangeness," Mr. Benson decided to talk with him one-to-one about "the need to stop the [strange behavior] and realize he's human. Human people need to think about where they are going and develop skills so they can contribute to the world and their own family." After several of these discussions, Henry began to drop his strangeness. When the fabrication team ran into problems, Henry applied himself and came through for the group by designing a tool for fabricating the cab section.

Situated Learning

As in the electronics class, Mr. Benson situated learning in the manufacturing class in authentic tasks. During the first semester these were mechanical drafting and design activities that taught basic domain skills. In the second semester, he situated learning in the context of a classwide manufacturing project. Manufacturing required students to create production designs and make a prototype. The project also required students to produce jigs and tools to build the toy trucks, using both standard and computer-controlled tools.

As this description suggests, Mr. Benson sequenced learning tasks. For example, during the first semester he taught drafting skills and corrected student drawings and math deficiencies. Students executed a series of steadily more difficult perspective drawings of threedimensional solid figures. With these "basic" domain skills introduced and mastered by the majority of students, he moved into integrated manufacturing during the second semester.

Culture of Practice

Students were engaged in a "manufacturing culture." The work in the second semester was explicitly team based. Most students worked as members of the production team. Since teams carried out different parts of the process, each was responsible for keeping the work moving to the next team in the assembly line.

Mr. Benson treated the project as business and held student teams accountable for progress. Students routinely communicated their progress or unexpected delays to others. Students who slowed down the project, because of their "bad behavior," were not tolerated by most. Typically, "bad behavior" involved horseplay or excessive joking that slowed others' progress. However, if the reason for the slowdown was a matter of someone lacking the skill or experience to complete the task, other students readily came to their assistance.

Motivation

As with the electronics class, Mr. Benson echoed his judgment that the best motivator is to prepare and support students for a task. This judgment is reflected in his sequenced instruction and in his supportive roles as teacher.

Mr. Benson also used technology as a motivating component of classroom design. For instance, he used computers to motivate and engage students: "Kids love them. It's a way to get kids involved with the subject matter."

The interdependency of teams in achieving the common goal appeared to deflect students from competing with each other. Moreover, because students received individual grades, rather than team or project grades, students focused on their personal contribution to their team's task.

Cooperation

In this class Mr. Benson also relied strongly on cooperation among students to foster engagement and motivation: Unlike in the electronics class, students in the manufacturing class were all engaged in a single common goal, like workers in a small firm. There was a strong feeling that each work team had to work with the other teams to "get the project done":

EXAMPLE: Ann says, "But you can't do that [mess around] because the groups depend on each other. One group has to wait for another [in the sequential manufacturing process]."

EXAMPLE: Trent explains his effort: "The groups have to be in sync. You check your group's progress with other groups. You find you can get ahead or fall behind." Randy elaborates further that "when I make a modification to a drawing, I have to tell everyone."

Mr. Benson promoted cooperation among his students, and they frequently sought and provided help to one another. Students moved freely between drafting tables and classrooms, asking and helping.

There was not only a strong cooperative element in the design of the project, but Mr. Benson also placed the responsibility for negotiating the cooperation onto students themselves. He did not manage their groups, they managed themselves. Overall, students appeared to thrive on the high degree of responsibility that interdependence implies. Activity and involvement with meaningful tasks apparently contributed to this positive work environment. However, one student indicated the fragility of this arrangement:

EXAMPLE: Bob says, "If you like the work, you do it." Randy agrees, "Yeah. If there is a `work ethic' in the classroom, then you want to work. If there is messing around going on, then you want to do that too."

Teaching Techniques

Mr. Benson employed a range of teaching techniques to teach generic and domain-specific skills. We did not observe the full range of techniques that we observed in his electronics classroom, perhaps because of our shorter (five days) observation period in this classroom. However, the style of instruction in both classes was similar. Mr. Benson used modeling, coaching, and several other techniques outlined in the previous section.

In keeping with the manufacturing task, he did not lecture, but rather provided one-to-one instruction to individuals and to teams. Typically he monitored progress by circulating through the three lab rooms, stopping occasionally to critique and advise teams or to assign a task. Conversation between the teacher and students was relaxed and easy:

EXAMPLE: Mr. Benson stops at Bob's desk and asks what he's doing. Bob looks like he's out of work, so Mr. Benson gives him the task of working on the hitch drawings, and they discuss how to position the screw holes in the drawings. Mr. Benson then moves to the next desk and assembles the pieces of the prototype, talking to the group of students as he goes: "We'll have to figure out how to glue this bugger together." Trent: "Glue the whole thing . . ." (laughing with Mr. Benson and other students). Mr. Benson: "We need to make one. That's why we're building the prototype, so we can figure out how to assemble it." He proceeds to talk through the gluing process with students adding their ideas.

Modeling

In keeping with his attempt to have students take responsibility, Mr. Benson offered problem-solving heuristics to students:

EXAMPLE: Mr. Benson scans Peter's drawing and tells him that "you want to bring the dimensions together in one place on the paper, as much as possible." After discussing another matter on the drawing, he asks, "Why should you group the dimensions together?" When Peter fails to answer, Mr. Benson supplies the answer: "So you don't have to look all over the drawing to find the measurements you want."

Here Mr. Benson models the kind of thinking (general rules and their rationale) that underlies the expert practitioner's actions.

Articulation

While evaluating students' work, Mr. Benson asked specific questions and requested that students attempt to solve specific problems. This permitted students to articulate or demonstrate their knowledge, reasoning, and problem solving:

EXAMPLE: Then Mr. Benson points out redundant information on the drawing and waits for Peter to decide which to erase and which to keep. Peter decides to keep the best placed one, and Mr. Benson compliments him on his choice.

Scaffolding and Fading

Mr. Benson provided physical and verbal supports for students. For example, with his guidance a team of students produced a series of drawings of the assembly process. These drawings provided instructions to other teams on how to proceed. Likewise, Mr. Benson provided detailed and clear support when students seemed to lack a full understanding of some procedure or process.

EXAMPLE: A student is trying to figure out the radius of the circle that forms the wheel well of the toy model. The radius is not recorded on the drawing and he can't remember what circle his team used. Mr. Benson asks him if he remembers how to find the center of a circle using a compass. The student does not remember. Mr. Benson reteaches the method of drawing two secants, constructing perpendicular lines to the secants, using a compass and ruler, and then finding where the lines cross. The student uses this method on his problem, with Mr. Benson providing just enough assistance to accomplish the task.

Student Perceptions and Accomplishments

The manufacturing students had a diverse set of reasons for attending the class. The majority needed the math credit that came with it. Three advanced students saw it as preparation for engineering careers. Others thought they were signing up for an easy class. A few students headed toward vocational careers (e.g., plumbing or tooling) thought that they would learn generally useful skills that would transfer to their trade. Finally, several had no goals for the class and were placed by a counselor. Like the electronics students, the manufacturing students eventually recognized the class was a way to receive individual instruction from a knowledgeable teacher.

During focus groups and survey, we learned what students accomplished as a result of the class, including thinking through complex problems, planning skills, and cooperative skills, as we discuss below.

Complex Reasoning Skills

Students expressed an appreciation for and demonstrated new ability to think through complex problems. Mr. Benson observed that even the "toughest guy" beamed over the thirteen trucks as they rolled off the line. Students had "wide-eyed appreciation." He reflected that this class was one of his more successful groups because they really became "hooked on thinking" when they could see the results of their efforts.

EXAMPLE: Carl says that he learned a "way to think"--he learned that he could learn to see objects from many different views and calls this "spatial visualization." When asked to compare this class with others, Carl replies, "No comparison. This class is different. It is using your brain instead of memorizing."

EXAMPLE: David says the course has changed the way that he looks at the world. Until he took the course he had no idea how complex things are and how much thought, design, and work goes into things. He points to the paper cutter as an example and says that there must be a hundred drawings of the parts of a simple tool.

On the survey nearly all students (38 percent agree, 48 percent strongly agree) indicated that "it is important to learn to figure things out for yourself."

Planning Is a Useful Work-Related Skill

Students also discussed planning as an important work-related skill. Planning, of course, is also part of problem "analysis," e.g., determining a sequence of steps to take. Students had learned to plan in the process of working in teams and interdependently accomplishing the final project with other teams. They learned planning in a "situated" fashion and understood planning in terms of accomplishing work.

EXAMPLE: Arthur says, "I learned to work things out in my head, to think ahead when you're doing a job."

EXAMPLE: Trent says that in mass production "there's a lot of planning. You have to think ahead. It's fun." He had done odd jobs for money recently, and had applied "think about what you do before you do it," which he learned in the class.

In the above examples, the students described learning to use mental models. They also acknowledged the sequential nature of problem solving. Finally, they implied that the challenge was fun.

Value of Cooperation

Late in the semester, students reflected on the value of group work over individual work:

Trent: "The switch from individual to group work has helped." Other students agree that the class is more interesting now that the manufacturing groups are set up because Mr. Benson provides more individual attention and the team assignments are more interesting and challenging. Randy agrees: "In the beginning of the year we drafted out of a book. It was busy work." Bob adds: "But, now, the class works."

School Context

Access to Knowledge

Students had the opportunity to learn across several domains in this classroom. Having the class span over two semesters permitted Mr. Benson to concentrate on teaching drafting and math "basics." Math was correlated to mechanical drafting. Students also employed woodworking skills learned in previous vocational classes to build tools and fabricate parts. Moreover, the final project required that students work within these domains in an integrated fashion.

Resources were important to learning. Mr. Benson had been able to enrich his students' opportunities by upgrading equipment and designing a class around the manufacturing project. The three-classroom/lab suite and the equipment were shared between electronics, the mechanical drawing/manufacturing class, and an architectural drawing class. Because Mr. Benson was the only teacher for these subjects, he had full discretion to use these resources according to his purposes. However, he was the only teacher because the school's curricular focus was college preparation, not vocational education.

Press for Achievement

The school and district expected and valued high achievement, but the focus was on the college-prep curriculum. As a result, students in this classroom felt little press for achievement from the outside. Students were placed in the class for different reasons. Those with poor math grades were placed to pick up the math credit. Those with "known discipline problems" were shunted from more academic classes to "practical" vocational classes. A few college-prep students with interest in technology and engineering elected to attend. The class, then, was an elective for some and for others it proxied as a required math class. (Although the school tracks students by "ability group," Mr. Benson made no effort to maintain grouping by ability in his classroom.)

Professional Teaching Conditions

Administrators gave Mr. Benson high marks on teaching and praised his efforts to challenge his students, who are generally perceived as the less-able cohort of students. His broad training and experience were recognized and valued.[30] Although the school provides very little in the way of staff development, he was able to attend professional meetings and workshops several times yearly.

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7. CONCLUSIONS AND IMPLICATIONS

In this final section, we discuss implications of our findings for designing classrooms that are able to impart generic skills and attitudes. Our review of the literature and our analysis of classrooms point to many lessons that could be followed by those attempting to design classrooms that work. We view these lessons as general indicators of the policy environment that would be conducive to teaching generic skills, rather than specific recommendations. Our sample is too small to generalize to the wide variety of classrooms and school environments at large. Many basic questions remain unanswered about the effectiveness of teaching generic skills, both in our sample and in other classrooms where such instruction is carried out. Despite claims about the importance of generic skills for workplace success, for example, hard data to support such claims are lacking. On the other hand, for reformers who believe that students can benefit from instruction in generic skills and useful work-related attitudes, our study has implications that can stimulate and inform their efforts.

Generic Skills Can Be Taught in Academic and Vocational Classrooms

Generic skills and positive work-related attitudes can be taught in both academic and vocational classrooms. The first step is simply to include the teaching of generic skills as an instructional goal in addition to domain-specific knowledge and skills. Once identified as an instructional goal, teachers can further specify which skills can be feasibly taught in their particular domain. Similarly, schools that desire to improve generic skills instruction for their students must begin with an articulated vision that can be communicated to teachers and must follow up with the resources and support that teachers will need (discussed below).

Of course, teachers face constraints in incorporating generic skills into subject-matter instruction, including their own lack of knowledge as to how to go about it or school policies that dictate curriculum content. As we discuss below, however, many constraints are amenable to intervention. And while every attempt to incorporate generic skills teaching into classroom instruction will be faced with a unique set of barriers, the nature of the subject domain itself should not be one of them.

Designing Classrooms to Provide Authentic Practice Is Key

Once a teacher decides to incorporate teaching of generic skills and attitudes, he or she must design classroom activities to support this instructional goal. Our data indicate that one successful approach is to design classroom instruction around project work that situates learning in a specific context and provides opportunities for authentic practice in a domain. The project that students engage in should permit them to apply domain-specific knowledge and skills to a real, complex problem. Students should begin with enough basic knowledge to get started and be permitted to work on their own. Teachers should guide and facilitate learning, while encouraging students to experiment and to work through emergent problems the students may encounter.

Situated learning can be enhanced by creating a culture of practice in the domain. Depending on the goals of the class, the culture of practice may or may not need to mimic a culture of "expert" practice in the adult world of work. If the class is part of a program that intends to prepare students for work directly out of high school, then creating a relevant culture of practice might be an important teacher goal. In the classrooms we studied, however, few students saw the class as training for immediate employment. Except for Ms. Adams, teachers in classrooms that worked were not experts (e.g., a professional writer or an electrical engineer) and had no actual work experience in the relevant culture of practice. But they were skilled and experienced adult practitioners with enough expertise to create a situated learning environment where students could acquire high-level skills, including domain-specific and generic skills. While Ms. Adams's professional experience as an interior designer clearly influenced classroom design and the explicit teaching of relevant workplace skills, her experience seemed more a useful asset than a necessary condition for creating a culture of practice.

Situated Learning Enhances Student Learning and Engagement

Many educators and the general public voice concern over students' disengagement from learning. While we did not formally evaluate learning, the students we observed in classrooms that worked were on-task and involved with their learning. Focus group discussions and survey responses reinforce this view; students clearly articulated what they had learned, how their attitudes about learning had changed, and so on. By contrast, students in other classrooms were clearly less motivated and challenged. They either did not appear to learn much at all (as in the landscape class) or focused their energy on just "getting a task done" (as in the chemistry classes).

An important outcome of classrooms that worked was that students became "enculturated." While many came into the class with vague or nonexistent learning goals, they came to accept and become a part of a culture of practice. In our view, the situated learning approach, coupled with the teachers' emphasis on appealing to intrinsic motivation (interest and challenge), were most influential in engaging students' participation. While student abilities and interests undoubtedly affect learning, effective classroom design can make a difference in students' attention and engagement in the learning process.

Teachers Need to Hold High Expectations for Students

A clear difference between classrooms that work and those that did not rests with performance expectations that teachers and others held for students. This difference was especially startling in the two classes taught by Mr. Price, English and landscape. Mr. Price ably demonstrated skills for designing an English class that offered students a challenging and rewarding experience that went beyond requirements outlined in the state curriculum framework. For this group of college-bound students, he and others in the school had high-performance expectations.

In contrast, the class for landscape students provided menial, often boring work and few academic lessons, despite the science credit that came with it. School officials, teachers, and other students viewed these students as academically marginal and behaviorally problematic.[31] While Mr. Price himself did not malign his students, he did acknowledge that some had nonacademic problems that needed to be dealt with. He saw it as his responsibility to help these students in any way that he could. This explains, in part, his adopted role of "therapist" to troubled students. His expectations for these students--that some would behave badly, not cooperate, not work very hard--influenced the decisions he made about what to teach and how to organize the class. To be fair, we did observe some student behavior that seemed intolerable in a classroom setting. Again by choice, Mr. Price decided to deal with this behavior--and perhaps try to change it--rather than simply throw the student out of class. The point here is not to judge the wisdom of Mr. Price's decision to carry on as he did, but that expectations for students, once made, will shape other decisions about instructional goals, classroom design, teacher roles, and so on. In this school, the overwhelming feeling was that landscape class was indeed the "dumping ground" for marginal students.

Like Mr. Price, Mr. Stone viewed his chemistry students--mostly minority students in an urban school--as needing help and nurturing. He adopted somewhat of a "missionary" role toward students, which appeared to suit the students as well. Mr. Stone was the "oracle" of knowledge, who provided students with answers to problems. He also gathered up their papers after class "so they would not lose them," and admittedly had different expectations for the two classes, which had been formed on the basis of students' math ability. Because of the bureaucratic "C," students knew he would tutor them or help them until they passed. Since teachers were expected to help students achieve a "C", students felt the academy teachers "cared" more than other teachers. On the downside, these students--many of whom had college aspirations--went through the motions of doing work to get a grade. The "C" mastery criterion seemed to set a floor of performance that most students did not try to exceed. These students did not acquire generic skills (to read, think, and write critically) in the ways that those in Mr. Price's English class were able to. Mr. Stone's inexperience may have also contributed to this.

Ms. Adams and Mr. Benson stand out as teachers with uniformly high expectations for students, in spite of the low view of vocational students (and even of vocational teachers) in their schools. From their perspective the students who enrolled in their classes were "what they had," and it was important not to "throw them [students] back." Both teachers defined clear relationships with students: They would be a friend to students but would also fail them. They cared about students' personal lives (Ms. Adams spoke knowingly of former gang members in her class), but they did not accept laziness or bad behavior. Every student who applied effort could count on a knowledgeable teacher's help--apprentices to the "master" teacher.

Unlike Mr. Price's landscape class, Mr. Benson's and Ms. Adams's classes had a more heterogeneous group of students who took the class for various reasons. This mix--of both skill and interest--was anticipated by these teachers, who designed classroom activities to both accommodate and take advantage of student differences and viewed each student as an individual for evaluation purposes. This mix, coupled with the teachers' high expectations, differentiated these classes from the others.[32] One example of how this difference affected classrooms is the contrast between Mr. Price's and Mr. Benson's view of how to structure the class. Mr. Benson believed the class should be structured to enhance students' motivation by teaching basic skills needed for more complex tasks, and by incorporating technology to capture students' interest. Mr. Price structured the landscape class more to control students than to motivate them: He developed a point system for student performance on well-defined tasks, a divide-and-conquer strategy to separate and contain consistent troublemakers from the rest of the class, or gave students a choice of menial tasks. Some students responded by demanding "paychecks" instead of points or grades for the work. Many students in landscape class (even some of the "troublemakers") said they would have preferred longer projects to short, simple tasks.

The interplay between expectations, mix of students, and classroom design is particularly interesting in Mr. Benson's case, because some of his students were also in the landscape class, or had similar "profiles" to landscape students. One student in particular, who seemed to relish his role as a troublemaker in landscape, was more cooperative and engaged in the manufacturing class. We cannot generalize from a single student's behavior, but this example illustrates that simple explanations that blame the student or the teacher or some other factor for failed instruction are likely to miss the mark. Many factors conspire to make effective or ineffective classrooms. This study suggests that expectations about students can markedly affect instruction: Administrators' and counselors' expectations influence course development and class placement; teachers' expectations affect instructional goals and classroom design decisions. Differential expectations tied to tracking practices still pervade public education, and their ill effects are widely documented (cf. Oakes, 1986; Oakes et al., 1992).

Teacher Training and Staff Development Need to Change

Traditional teacher training and staff development practices pose a barrier to widespread adoption of the classroom design principles and teaching practices defined in classrooms that work. New teachers are rarely trained to acquire the skills they will need to design classrooms that work. Much of teacher education involves perfecting the skills of writing behavioral objectives, lesson plans, and worksheets. Once graduated and working, newcomers are likely to receive staff development that deals with schoolwide issues, i.e., drug and alcohol problems and changes in state policy. This leaves them largely unprepared to experiment with mixing domain-specific and generic skills, designing situated learning opportunities, or taking on innovative and flexible teacher roles.[33]

Staff development for teaching generic skills was sorely lacking across our three sites. As seasoned teachers, Ms. Adams, Mr. Price, and Mr. Benson had come to expect that school-level staff development would neither address their disciplinary and domain interests nor their focus on fostering student ingenuity and exploration. Each sought their own staff development opportunities outside the school. In contrast, Mr. Stone, in his first year of full-time teaching, struggled to implement his philosophy in the classroom. He had no mentors (i.e., someone like Mr. Benson) or staff development to help him incorporate his ideas. He instead sufficed by employing the same traditional methods, i.e., "cookbook" labs and question drills, used by other science teachers.

Recently, research in cognitive science has begun to influence the content and methods of instruction in some subject areas.[34] But new models of curriculum and instruction have not widely influenced preservice teacher training. The teachers in classrooms that worked relied on intuitive models of learning based on their long experience. As discussed above, their teaching of generic skills and work-related attitudes was often implicit rather than explicit. Research supporting the Collins et al. (1989) model, however, emphasizes the importance of bringing tacit cognitive processes, like problem recognition and evaluation, into the open where students can observe, enact, and practice them with help from the teacher and other students. If Mr. Benson had followed this principle in his teaching, for example, he might have named the different problem-solving steps in designing a circuit and discussed how these steps might generalize to other problems as well. It is possible that a formal model might have helped Mr. Stone, who lacked the experiential background that the other teachers relied on. It is our view that formal models of learning and instruction from cognitive science research would be an important element in a teacher training program that aims to help new or current teachers design the kinds of learning environments outlined in Sections 4-6.

In addition to changing teacher preparation, new teacher evaluation strategies might encourage changes in teaching practices that accompany classrooms that work. Typically, administrators evaluate teachers on the basis of "parental or peer complaints," or lack thereof, and a couple of visits to the classroom. Proper evaluation of the teaching behaviors that we suggested as important in our study requires more attention and time than is commonly allocated. It would also require administrators to link staff development with evaluation, such that teachers needing improvement would get needed assistance. Although the teachers in our study received positive evaluations from administrators, these evaluations were, with one exception, completely based on their "reputations," rather than actual knowledge of their instructional goals, classroom design, teaching techniques, student learning, or the degree to which teachers' professional development efforts had in any way positively transferred to the classroom.[35]

Another implication of our study is that teachers may benefit from entirely new forms of staff development, beyond the typical one- or two-day workshops, on topics such as cooperative learning techniques or new curriculum frameworks. Ms. Adams's experience in the world of work, for example, clearly contributed to her desire and ability to teach work-related attitudes. Mr. Price attended a one-year writing course that placed him in the company of experts. Although vocational teachers often have occupational experience--sometimes as a requirement for teacher certification (cf. Lynch and Griggs, 1989)--academic teacher training typically follows the baccalaureate model, which emphasizes subject-matter preparation with the addition of courses in teaching methods.

Further staff development for teachers might include, for example, summer internships in firms that would broaden teachers' understanding of work outside of school in their chosen domain. The trend toward closer relationships between schools and the business community indicates that both see benefits for closer connections between schools and workplaces. The forum for discussing staff development needs and possible business involvement in teacher training exists in many communities implementing school to work programs. For example, the academy program that employs Mr. Stone is attempting to structure a closer relationship between students and business through mentoring, summer jobs, and job shadowing. Thus far, however, there has been little exploration in the United States of ways to "partner" teachers and business.

In short, what is currently missing in traditional forms of teacher training and staff development is the opportunity for teachers to come in contact with "expert practitioners" in business and industry or in college departments who are engaged in a culture of practice. While teacher education programs employ "teaching experts" to enhance teachers' professional development, they do not provide the link to a culture of practice outside schools. Further research is needed to develop and evaluate methods for teacher training and staff development that depart from current tradition and explore ways to expand teachers' views of and contacts with the world of work.

Teachers Need Autonomy and Additional Resources

Teachers in classrooms that worked had a great deal of autonomy in developing their curricula and classroom activities. This freedom to innovate, however, was more a by-product of other school policies than a belief that teacher autonomy would lead to improved instruction. As vocational teachers, Ms. Adams and Mr. Benson taught elective courses to primarily non-college-bound students. Their courses were not prerequisites for any others. The schools in which they taught placed value on college-bound students, which tends to create the standard of worth both for students and teachers (cf. Little and Threatt, 1992). School administrators paid little attention to these vocational classes, as long as they met enrollment standards and served the needs of students who proved least successful in the academic curriculum. In contrast, Mr. Benson spoke of how his teaching differed in his algebra class because the required content constrained what and how he could teach.

Mr. Price's college-prep English class was one of three that students could choose to satisfy a fourth-year English requirement for college entrance. Having convinced the English department that his course went beyond the state curriculum guidelines, Mr. Price was given leeway to teach literary criticism. Importantly, students viewed this class as nontraditional, but also low risk, because most had already been accepted to college by second semester and their course grade did not really matter.

The policies that influence autonomy have to do with course prerequisite requirements, graduation requirements, and credit standards set by the state college and university system: All are tied to the college-preparatory curriculum. If teachers don't teach college-prep courses, these policies don't constrain what they teach and how they teach it. Mr. Price had to fight for permission to teach his English composition class, even though it was unlikely to affect students' college going.

These cases raise an important issue about teachers' ability to innovate, particularly in traditional academic disciplines, where there is a trend toward more proscribed curricula. Similar issues have arisen in other curriculum reform efforts as well. The integration of academic and vocational education, for example, is a curriculum reform mandated in vocational education through the 1990 Amendments to the Carl Perkins Act. One barrier to integration concerns crediting of "applied academic" courses for academic credit. Even when applied courses are taught by academically certified teachers, school districts, state departments of education, and postsecondary institutions debate course accreditation (cf. Bodilly et al., 1993). The trend to increase high school graduation requirements in many states further muddies the waters. In the process of reviewing any new course or program, history suggests that courses that smack of something new or nontraditional run the risk of failing to garner credit that either attracts students or satisfies college entrance requirements. Student enrollment, in turn, is often tied to course offerings and can determine if a course is taught at all. Given this picture, one can easily surmise that a teacher's *failure* to innovate may in fact be a wise choice in a constraining regulatory environment.

In addition to regulatory constraints associated with accrediting courses, teachers often lack the resources they need to design classrooms that work. Except for Ms. Adams, teachers complained about lack of basic materials, like dictionaries and books, let alone the more sophisticated tools needed in electronics and manufacturing classes. Without the promise of additional resources, there is little incentive for teachers to design more innovative instructional activities of the type described earlier. Lack of resources in education is a familiar story that becomes more and more alarming as states, which bear the greatest share of costs in public education, face increasing fiscal constraints. This problem and its solution, of course, go well beyond the issue of providing resources for teaching generic skills. On the other hand, even if adequate funds become available, teachers must be attuned to the materials and equipment required by "authentic" activities. It is not resources *per se* that make the difference in a quality educational program, but the use to which the resources are put (Oakes, 1989). Teachers may still need training in the best uses of available resources.

Assessment Needs to Measure Generic Skills Learning

Assessment strategies employed at most schools do not serve the needs of generic skills instruction. Popular forms of assessment test students' knowledge of facts, concepts, and processes in a particular domain. They rarely assess students' ability to solve problems, reason, cooperate with others, or demonstrate other capabilities and skills learned in situated learning environments. Currently, new assessment standards, and the influence that such standards might have on improving curriculum, are widely debated nationwide.[36] While these new standards encompass the types of assessments needed to evaluate generic skills instruction, new tests are just in the process of being developed and piloted in schools. While testing reforms appear to be going in the right direction, it will be several years at best before new measures are widely available. In the meantime, a patchwork of teacher-made, nonstandardized assessments could be adopted, but such a move is unlikely. For a variety of reasons, schools rely on standardized testing regimes or qualitative assessments to evaluate program goals associated with student outcomes.

Teaching Generic Skills Connects to Other School Reforms

With the exception of chemistry classes, the cases we identified and described in this study were individual teacher efforts not linked to any broader schoolwide reform effort. Nonetheless, the result of their efforts and, by extension, the model we define for designing classrooms that work, can apply to other reforms.

As discussed in the Introduction, reforms attempting to improve the transition between high school and postsecondary education and employment address curriculum changes that seek to improve preparation for work and to make academic learning more meaningful. While these programs vary in detail, many include teaching generic skills and work-related attitudes as instructional goals. Results from this study can inform those ongoing efforts.

This study also clearly connects with recommendations for skill learning advanced by SCANS (1991, 1992a, 1992b). As mentioned earlier, our conceptualization of generic skills aligns with the SCANS foundation skills. While the SCANS work provides a vision for teaching new skills and competencies, and resources for identifying skills and tasks related to various jobs, this research provides a conceptual framework for designing classrooms that teach a broad range of domain-specific and generic skills. This framework presents a strategy for teaching high-level skills with both a schooling-for-career and college emphasis. It complements the SCANS work but focuses more on effective teacher practices. The framework suggests that teachers should use project work or exploratory labs, not single session tasks or labs, as the central activity for authentic practice in a domain. It stresses socially organized work in groups or interdependent teams over individual activity. It aims to create a culture of practice where the classroom becomes a flexible "workplace"; students work in parallel on a variety of tasks and projects. The goal is not one of narrow vocationalism, the preparation of students for entry-level jobs. Rather, the goal is to foster student engagement, ingenuity, and exploration in a learning process that incorporates the teaching of both domain-specific and generic skills and knowledge and useful work-related attitudes. Classrooms are still places for learning, not simulated work sites.

Focus on Generic Skills Can Help Integrate Academic and Vocational Education

Finally, teaching and learning generic skills can be viewed as a "model" for integrating academic and vocational education. Research on integration has identified several models in practice that involve changes in curriculum, pedagogy, and the school organization (Grubb et al., 1991; Bodilly et al., 1993). One prominent feature of integration--and one of the significant barriers to its success--is the (often forced) collaboration between academic and vocational teachers. As a vocational education reform mandated by the 1990 Perkins Amendments, the thrust of integration has been to enhance the academic content of vocational programs by having academically certified teachers teach "applied" academics that, for example, correlate math instruction with a specific occupational focus. Because academic teachers lack relevant vocational training and because vocational teachers are typically not certified to teach academics, the solution has been for these teachers to pool their knowledge and skills in designing curriculum. This is an uneasy collaboration: Vocational and academic teachers, curriculum, and students have been separated in our educational institutions for decades (for further discussion see Little, 1992; Little and Threatt, 1992; Bodilly et al., 1993; Oakes, 1989).

Our study of teaching generic skills offers a different perspective. The instructional goals of classrooms that work aim to integrate the teaching of a variety of domain-specific and generic skills in a situated learning environment that actively engages students in learning. These goals mirror the spirit of integration of academic and vocational education. But this model does not require the teacher-to-teacher collaboration that creates a stumbling block for implementing many other models of integration. Rather, it requires a teacher to enter the company of experts, become a learner, and then translate a culture of practice into the design of classrooms that work. This focus has the advantage of bridging schooling with working and, thereby, improving the school's ability to prepare high school students for a future beyond school.

Appendix A
SYNOPSES OF CASE STUDY SITES

Interior Design

The interior design class was an elective course taught in a comprehensive high school under the auspices of the state's Regional Occupational Program (ROP). A heterogeneous ability group of tenth to twelfth graders was enrolled. The ROP affiliation meant that the class was taught by a vocational teacher and was geared toward providing entry skills employment training, career exploration opportunities, and preparation for higher education in a related skill (e.g., architecture). In addition, the class fulfilled a fine arts credit that students needed for graduation.

We studied this class during the 1989-1990 school year as part of our previous research project on generic skills (see Stasz et al., 1990). We observed students carrying out a class project that involved completing a contemporary interior design for a Victorian-era house. Students were told to research the original house and its design tradition, draw the house, draft the floor plan, select furnishings and coordinate colors, and prepare boards to display their proposed design. The majority of students worked in groups of four to six, although several students worked individually. Grades were awarded for the project, with the expectation that while some tasks would be completed by individual members (e.g., the floor plan and the drawing), other tasks (e.g., the furnishings selection) would be a group product. The project grade served as the final exam grade. Students were given six weeks to complete the project.

Landscaping/Horticulture

Like the interior design class, the landscape class was an elective class in a comprehensive high school under the auspices of the ROP. The eleventh and twelfth graders in this class were in the lower quarter to third of the school's student ability distribution. This class did not have the typical ROP profile. It was taught by an academic teacher who had an interest in landscaping and a botany degree. The class combined landscape with lessons in horticulture, which permitted students to complete a science credit toward graduation. Several students needed this class to graduate because they had failed the regular biology course.

The horticulture portion of the course was taught in a lecture format and covered topics such as elementary botany and plant propagation. The bulk of class time was spent outdoors performing various landscaping tasks on the school grounds (the mild southern California climate permitted this activity even during the winter months). After student-selected groups proved unsuccessful, the teacher assigned students to work groups. Sometimes groups selected tasks, but more often the teacher assigned them. After assignment, students gathered the tools they needed and dispersed to various parts of the campus, depending on their job for the day. The "work crews" of two to four students typically had a simple, single task, such as "lollipopping" trees, watering plants in the greenhouse, or weeding around plantings in specific areas. The teacher made the rounds, visiting each work crew during the course of the period to answer questions, demonstrate proper technique (e.g., pruning roses), and monitor students' behavior. The majority of students did very little work and some did none at all. The teacher spent much of his time dealing with students' emotional behavior; several could be counted on to act out in ways that interfered with the teacher's ability to teach and other students' ability to learn or complete their work. Students were graded for their work on a point system, which seemed inconsistently awarded. Students could be awarded points individually or as a group; they often argued with the teacher about points received. These points were allegedly used to determine a class grade, in addition to a written exam at the end of the course. Students did not appear to take this exam seriously. The potential this class might have had to teach generic and job-specific skills was squelched, in part, by students' behavior problems, low motivation, and lack of interest and by the teacher's and school's low expectations for them.

English

The English class was a senior-level college-prep advanced composition class in the same comprehensive high school as the landscape class. It was taught by the landscape teacher, who was also certified as an English instructor. Thus, we had the unusual opportunity to observe the same instructor teaching two completely different subject areas to different groups of students. This was a required class, but students could choose among several English classes. The course met graduation requirements as well as the state college/university requirement.[37]

The instructional focus of the second semester of this class was literary criticism. Students read several books by modern Latin American fiction authors and were required to write research papers on the use of "magical realism" and a topic of their own choosing (e.g., magical realism and women, or magical realism and time). Over the course of the semester students read three books, did library searches, and wrote a paper. The paper counted for most of the class grade. The teacher had several high-level goals for the students, including the development of critical thinking skills and learning to be comfortable with their own ideas and the writing process. Students also learned to conduct library searches, use class members as resources, and construct a bibliography. All of these skills were aimed at preparing students for writing assignments in college. Although each student wrote an individual paper, students worked in groups to discuss themes in the literature (e.g., magical realism), get feedback on their ideas, and share articles they had located at the library. The teacher did not lecture during this semester but conducted the class like a seminar or discussion group. His role was to guide and facilitate students through the writing process and, in his words, "to instill a love of literature."

Electronics

The electronics class was a vocational class in the same comprehensive high school as English and landscaping. A heterogeneous mix of ninth to twelfth grade students enrolled, with varying amounts of electronics background. All of the students were male. Students taking this class fulfilled an elective requirement for graduation but did not receive any academic credit. The instructor had over twenty years of experience teaching industrial arts, complemented by master's degrees in fine arts and industrial arts. He was certified as a mathematics teacher and taught algebra I.

In electronics, students engaged in two basic types of activities that built on what they had learned the previous semester. All students completed about twenty laboratory assignments, which typically consisted of assembling various components to construct an electronic device (e.g., a digital clock circuit), testing the assemblage, and answering questions or solving problems. The series of experiments were designed to show the students how all the component parts and circuits of computer electronics work. The experiments taught the basic or enabling skills that were used later in more advanced work in the class. Students worked in pairs or small groups on these labs. They could work on them in any order and at their own pace, provided that they finished all experiments within the specified time frame. A second activity involved more advanced electronics: Students solved problems that they were given or had to identify the problem and find a solution. For these activities they worked on computers, a CNC machine, and a robotic arm. The different activities accommodated the students' diverse skill levels and backgrounds and permitted the teacher to teach both basic and advanced electronics in the same class. Students also completed projects that varied according to their skills and interests. The teacher circulated through the class to check on each group's progress, offer help and suggestions, provide instruction, check their lab sheets, and so on.

Mechanical Drawing/Manufacturing

The electronics teacher also taught mechanical drawing/manufacturing and architectural drawing (see below). A heterogeneous group of ninth to twelfth grade students were enrolled in this vocational class. The class counted for math credits toward graduation but not toward college admission requirements.

During the first semester, the class learned the techniques of mechanical drawing, or drafting, and completed a curriculum of progressively more difficult technical drafting assignments. The second semester, the entire class participated in a manufacturing project--design, prototype, and production of thirteen complex wooden toy trucks. The class was organized like a small manufacturing firm, with students taking roles of team members on a design, drafting, prototyping or production team. Some students with particular skills were assigned to specific teams; other students selected a team to join. Each student worked on a single team; teams were required to interact in various stages of the process. The teacher basically assumed the role of a general manager, who worked with groups and individuals at various stages of the process to help them solve problems, design tools, evaluate their work, and so on. A second-year student assumed the role of shop floor supervisor. He had taken the class the previous year and had worked on the truck's early design and initial rough drawings during the first semester. During the second semester, he acted as a consultant and informal liaison between groups, answered questions, and sometimes helped groups to finish tasks. Students generally looked to the teacher and student "floor supervisor" for leadership and expertise. Students were graded during the first semester on their drawings and during the second semester on their participation in and contribution to the manufacturing project.

Architectural Drawing

The architectural drawing course, like electronics and manufacturing courses, was a vocational elective. Students received a practical arts credit that counted toward graduation but not toward college admission requirements. A heterogeneous group of ninth through twelfth grade students composed this class.

The course was structured to teach students about the practice of architecture and to challenge first- through fourth-year architecture students. During the first semester, first-year students learned basic skills (e.g., how to design a simple, one-story house). In the second semester, each of these students designed a personal dream house on an assigned plot of an actual development in Oregon and completed a full set of floor plans and renderings. Once the assignment was given, the student has to organize his or her time to meet teacher-specified deadlines and complete the project. A small number of veteran (second- through fourth-year) students worked on more complex design problems, primarily self-defined. Some second- and third-year students worked in groups as in larger architectural firms. These projects included public-use buildings (e.g., a preschool or community center) and required building a model.

Although students typically worked independently, first-year students often used more advanced students as resources, much the way that junior and senior workers might interact in a firm. The teacher assumed the role of a critical client, who challenged students' design decisions along the way. The atmosphere was such that students were free to make design choices, and that either the teacher or other students could criticize those choices. Students were graded on their design ideas, quality of drawings, effort, and amount of individual growth or improvement.

Chemistry

The two separate chemistry classes we observed were taught in an academy program in a comprehensive high school. The academy is a school-within-a-school that offers a special three-year program organized around an occupational or career area (e.g., health, finance, or space technology). (Academies typically have smaller class sizes [about 20 students] than the rest of the school and a small cadre of teachers who work with the students over the three years of the program.) Students in this academy had mentors and work experience in a local firm and were required to engage in community service. The students were a heterogeneous group of tenth graders; this was their first year in the academy. The chemistry class met college entrance requirements. The teacher determined that a few students were unable to complete the course at the college-prep level. These students received science credit toward graduation, but not toward college admission.

These two classes were block scheduled to meet twice a week for two consecutive periods and once for a single period. During the two-period block, the teacher went over the homework assignment in the classroom and lectured on any new material. Then students went to a lab to work on standard chemistry experiments. The labs were short, well-defined tasks with detailed descriptions of both the equipment/materials to use and the procedures to follow. Students worked in pairs on the labs, recording observations on their lab sheets, and following other instructions. The teacher typically stayed out of the students' way but was available to answer questions or hand out materials. When students finished the lab assignment, they worked on answering problems that used data from the lab. The teacher walked students through these problems. Those problems not finished in class were assigned as homework. Performance in labs determined part of the students' grades. In addition, the academy also used a mastery criterion: Students must take proficiency tests until they pass with a grade of "C" or higher.

Appendix B

SAMPLES OF INDEX TERMS FOR TAGGING FIELD NOTES

We indexed or "tagged" field notes' text segments using a list of low-inference index terms (approximately 90 terms) for each classroom. These index terms reflect the range and variation in teacher and student activities and behaviors. Below are examples of index terms in selected areas from two classes, Mr. Price's landscaping and English.

1.3 Classroom Activities

1.3.1 Planned activities--included here are activities that are proactive or possibly preemptive.

1.3.2 Seat-of-pants or winging it.

1.3.3 Off-task activities--instances when students or teacher are engaged in off-task activities and there is no negative consequence to the perpetrator for their off-task behavior.

1.3.4 Off-task/class relevant--instances when the behavior is off the specific task but related to the subject of the class; there is domain-relevance to horticulture, landscape, or plant science.

1.3.5 Off-task/work relevant--instances where behavior is off the specific task but related to working and employment issues.

1.3.6 Socializing--instances where "major partying" is taking place and there is no negative consequence to the perpetrators for their behavior.

1.8 Classroom Methods--includes examples of or references to strategies used by the instructor to achieve goals. The category may be broken down further into the following index categories:

1.8.1 Modeling--teacher carries out a task so students can observe the action and build a conceptual model.

1.8.2 Coaching--teacher makes observation, offers hints, etc. that are immediately related to a specific problem that a student is encountering. May involve directing student to a previously unnoticed aspect of the task. "Involves highly interactive and highly situated feedback and suggestions."

1.8.3 Scaffolding--scaffolds can be suggestions or help or actual physical aids. Teacher does part of the task, then fades (fading to be coded separately as 1.8.10). Involves cooperative effort between student and teacher in which the expressed intent is for the student to assume as much of the task as possible as soon as possible.

1.8.4 Articulation--any method teacher uses to get students to articulate knowledge, reasoning, or problem-solving processes in a domain. Example in paper: Teacher systematically questions students about why one summary of the text is good but another is poor, to get students to formulate an explicit model of a good summary.

1.8.5 Reflection--enables students to compare own problem-solving processes with those of an expert, another student. Enhanced by techniques like having students do a postmortem of their own problem-solving processes or recording students as they think aloud and then replaying the tape for comparisons with others.

1.8.6 Exploration--teacher pushes students into a mode of problem solving on their own. Teacher sets general goals for students and encourages them to focus on specific subgoals of interest, perhaps even revising goals if their interest changes. Examples given in text: Send students to library to investigate a particular question; encourage students to write an essay defending an outrageous thesis or to keep a diary of their best ideas. "Goal is to find general tasks the students will find interesting and to turn them loose on them, after they have acquired some basic exploration skills."

1.8.7 Confrontation.

1.8.8 Ignoring unacceptable behavior.

1.8.9 Analogy--use of analogy to teach a particular domain-relevant concept, process.

1.8.10 Fading--when teacher obviously provides support, then hands off the task to the student to carry on his or her own.

1.8.11 Rhetorical questions.

1.8.12 Teacher "reflects" student statement, by repeating what student has said either exactly or with paraphrase.

1.8.13 Encourage students' own problem solving--teacher makes statements that place the responsibility for the task back on the students.

Appendix C
DOMAINS FOR UNDERSTANDING THE EIGHT CLASSROOMS

1. Complex reasoning skills
2. Work-related attitudes
3. Cooperative skills
4. Domain-specific aspects
5. Postsecondary focus
6. Teacher goals
7. Student goals
8. Teacher expectation of student
9. Student expectations
10. Teaching tactics
11. Teaching approach
12. Student evaluation

13. Design of classroom work

14. Classroom environment

15. School context

16. Teacher experience

17. Classroom resources

18. Student's background

19. Student outcomes

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[1]We also surveyed students to gather background information and information on their beliefs regarding their own ability to learn and to engage socially, and we linked these measures to student outcomes and background information. The results of this survey are being documented in a separate report.

[2]We identified domains of two types: "folk" domains, which were meaningful to the participants in the classroom; and "analytic" domains, which were meaningful in terms of the theoretical frameworks we drew upon in education research, cognitive science, etc.

[3]Another aspect of access is that these highly successful courses were not available to all students because of constraints imposed by tracking and by course crediting practices.

[4]As part of the present study, we also surveyed students to measure relevant individual characteristics (background and self-efficacy for learning) and related these to learning outcomes. The results of this survey will be reported separately. They should offer an improved understanding of the correlation between generic skills and attitudes as they relate to task performance.

[5]It is widely recognized that, from a cognitive perspective, skills such as reading are themselves complex; it is from the perspective

of their role in work that they are considered "basic" and "enabling."

[6]Our definition of generic skills is similar to the three-part foundation skills identified by SCANS (1991). Our conceptualization places a stronger emphasis on work-related attitudes and focuses more on the interplay between skills and attitudes. The SCANS (1991) formulation also includes five "competencies" that effective workers can productively use (resources, interpersonal skills, information, systems, technology).

[7]Several psychological models distinguish motivation and skill or ability as separate, but interacting antecedents of cognitive performance, e.g., Beach and Mitchell's (1978) contingency model; Chaiken and Stangor's (1987) systematic processing model; Petty and Cacioppo's (1984; 1986) elaboration likelihood model. While it is beyond the scope of the present study to examine these with respect to generic skills, we accept their basic premise.

[8]See Stasz et al., 1990 for a review of the literature on changes in the nature and structure of work that underlie the demand for generic skills and on school reformers' rationale for teaching them. See also Resnick, 1987b; Berryman, 1991; Raizen, 1989; Capelli, 1992.

[9]For a review see Stern, 1990.

[10]To ensure anonymity, teachers and students have been given pseudonyms throughout this report.

[11]In the class we observed, he taught several contemporary Latin American novels in English translation.

[12]We treated our initial conceptual framework and research literature as a source of alternative hypotheses to be confirmed or rejected in the field. For instance, instead of judging a classroom to be poor or ineffective on the face because it did not conform to these priors, we sought to understand practices as participants understood and made use of them. This approach provided an *interpretive*lever for our analysis--understanding factors that drive practices, in this case instructional practices associated with learning generic skills and work-related attitudes. For additional reading, see Chapter 1 in Geertz (1973) on thick description and the interpretive theory of culture and Chapter 6 in Guba (1978) on the evaluation of hypotheses.

[13]Each fieldworker took brief notes during observations from which he or she produced an extensive 6-8 page field note that covered the fifty-minute classroom period. Observers' comments (speculations, hypotheses, preliminary analyses, and comparison) were also included, but set off from the observations. Field notes were produced within a week of the observation.

[14]Because the fieldworker is the tool of the ethnographic method, we focused on role management during fieldwork to ensure the reliability of findings. Our social role in the classroom was generally that of adult participant/observer. We took on special roles when our observational agenda directed us to do so. For instance, when our focus centered on group work, we would ask students to permit us to become a working member of the project team, or when we wanted to understand better the teacher's role, we would shadow the teacher for several sessions. Our meetings also helped us to maintain role, avoiding "going native," i.e., becoming overly sympathetic to or identified with participants and thereby reducing the reliability and validity of findings.

[15]We did not conduct focus group discussions in the landscape class because the teacher advised against it given disciplinary problems in the classroom. As an alternative we individually and informally interviewed students in the closing weeks of the observation period.

[16]A problem is well defined if a test exists that determines whether a proposed solution is in fact a solution. Ill-defined problems need further specification before they can be solved (see Hayes, 1981; Newell and Simon, 1972).

[17]It is unclear whether an expert is needed to cultivate what Collins describes as a "culture of expert practice." It may be that a competent and experienced adult practitioner is sufficient. This question has important implications for teacher training and certification, and we will address it further in the concluding section.

[18]The number of students with behavior problems--so many that the teacher had to focus on noninstructional goals for some students--may also represent a failed counseling function at the school. At least, it raises the question of why a classroom teacher was left to cope with such problems, to the detriment of students who were at least willing to cooperate in class or who desired to learn something about the subject area.

[19]For further discussion on teacher roles and their relation to expectations about student learning see Berryman (1991) and Raizen (1989).

[20]See Collins, Brown, and Newman (1989) for further discussion about teaching methods to support situated learning.

[21]In California, courses with "A-F" credits are those accepted by the state college and university systems. Other classes may receive credit (e.g., math and science) that count toward graduation, but are not counted toward college. In fact, a student's grade-point average is often calculated without "elective" credits, thereby decreasing its value to the student. In some cases, this creates a disincentive to students to engage in class and try to perform well.

[22]To illustrate, Mr. Price recounted a discussion he had with the principal, where he objected to some of the students who were assigned to the landscape class. He won his case by asking the principal if she was willing to take responsibility for these students "walking around campus with power tools."

[23]We did not plan to conduct a focus group in our initial study of Ms. Adams's class (Stasz et al., 1990) but had many conversations with individual students. We did not conduct a focus group with the landscape students because the teacher felt that the students would not contribute enough to make it worth our while. We did not dispute the teacher's judgment. In retrospect, this comment reflected his low expectations for the students. However, in individual interviews the students proved capable of providing information about their perceptions and accomplishments.

[24]The books were *One Hundred Years of Solitude*and *Love in the Time of Cholera*by Gabriel Garcia Marquez, and *The Storyteller*by Mario Vargas Llosa.

[25]The first steps in problem solving include problem recognition and analysis. If the problem is well defined, the problem solver can represent the problem in a way that lends itself to solution. This involves specifying the parts problem, i.e., identify start state, determine goal state, determine constraints, and so on, in a fairly linear or stepwise fashion (see Stasz et al., 1990, Section 2 for further discussion).

[26]Students responded to statements on a scale from 1 (strongly disagree) to 5 (strongly agree). Unless otherwise noted, percents represent those students responding "4" or "5."

[27]NAND, short for "not AND," refers to a circuit whose output is the inverse of that produced by an AND circuit.

[28]Although "culture of expert practice" is the term usually used for this approach to classroom design, "culture of adult electronics hobbyist" would better describe the reference culture that Mr. Benson modeled his classroom on.

[29] Sociotechnical systems theory coins useful terms for worker arrangements in the workplace. A coacting team works together, but on individually defined tasks, and reports to a supervisor. Teams with fewer managerial controls over their work are labeled "self-managing." For additional reading in this area, see Hackman and Oldham, 1980.

[30]As indicated in the preceding section, Mr. Benson has no industry experience, but he works on a hobby level on all aspects of industrial arts. He is certified in math, physics, and vocational education. He is also involved in a statewide consortium on teaching manufacturing in secondary and postsecondary schools. He is an avid learner, having earned an MS in industrial technology and an

MFA in furniture design.

[31]The view that landscape class was for "troubled" students was held almost universally. In fact, when students in the English class asked the fieldworkers whether they were observing any other classes, students expressed disbelief that landscape was our other choice. One student's response was, "That's too bad."

[32]Oakes (1986) and others would argue that the heterogeneous mix of students was beneficial both because it enhanced the learning of all students and circumvented institutionalized labeling and stigma often associated with vocational education.

[33]In a recent RAND study of integrating academic and vocational education (cf. Bodilly et al., 1993), for example, a 1990 teacher education graduate reported that her former university instructors were surprised to learn that her first teaching assignment (as a math teacher) required her to correlate math with occupational lessons. Despite the fact that integration of academic and vocational education was a statewide reform mandated by the State Department of Education, the faculty in the teacher training program at the state's major public university had not even heard of curricular integration and could offer their former student little practical advice.

[34]See, for example, *Curriculum and Evaluation Standards for School Mathematics,* The National Council of Teachers of Mathematics, Reston, VA, March 1989.

[35]The exception was Ms. Adams, whose immediate vocational supervisor was well versed with her methods and professional development efforts. However, the school-level administrator gave a positive evaluation of Ms. Adams based on her reputation alone (Stasz et al., 1990).

[36]See, for example, *Raising Standards for American Education,* The National Council on Education Standards and Testing, Washington, D.C., January 24, 1992, and *The New Standards Project: An Overview,* Learning Research and Development Center of the University of Pittsburgh and the National Center on Education and the Economy, 1992.

[37]All of the schools in our study are in California. In this state, many courses like math, English, and science are "two tiered." A "lower"-tiered course may count toward high school graduation but not be counted for admission to state colleges or universities. Those that do count typically meet college and university requirements for public and private institutions in other states as well.